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INTRODUCTION

Even though the primary purpose of this manual is to provide a single source of reference on the upgraded systems and equipment installed in the Water Plant Building 198, and the new Emergency Pump House Building 194, many of the existing systems and equipment were also included depending on the availability of information.

This manual is an introduction to the operation & maintenance (O&M) of building-specific systems and equipment and is not meant to supersede the manufacturers' specifications or information. The drawings and references contained within this text may or may not be “As-Built” records edited from original construction documents depending on the condition of the reference materials used at the time. The intent is to reflect the actual, or as close as possible, to the installed condition of building systems and equipment. Original manufacturers' drawings, schematics, specifications, and information have been used to the fullest extent.

This manual is divided into four (4) major sections:

- Section 1 — **DESCRIPTIONS**: Plain language descriptions of the building infrastructure and various systems contained within the building.
- Section 2 — **OPERATIONS**: Basic overview of the operational characteristics of the building, equipment, and systems.
- Section 3 — **MAINTENANCE**: Specific maintenance requirements for equipment and systems.
- Section 4 — **APPENDICES**: Provides manufacturers' O&M data, drawings, schematics, wiring diagrams, parts identification, and contractor information.

Italic and **bold** entries indicate switches positions, panel positions, or indicators the operator must use to run facility equipment or systems.

This manual should be considered a living document, and as such it should be enhanced throughout the life of the building. Therefore, operational characteristics, maintenance procedures, and O&M data for building equipment and systems will be updated as equipment / systems are developed, deleted, modified, and / or upgraded.

Danger, Warning, Caution, Note and Notice

Danger, Warning, Caution, Note and Notice, as deemed necessary by the documentation department, appear at appropriate intervals throughout this manual. Below are explanations for each:

Danger - Warns of hazards that **WILL** cause serious personal injury, death or major property damage.

Warning - Warns of hazards that **CAN** cause serious personal injury, death or major property damage.

Caution - Warns of hazards that **CAN** cause personal injury or major property damage.

Note and **Notices** - Indicates special instructions which are very important and must be followed.

Manufacturer / vendor warnings and notices as they appear in their documentation are re-produced in this manual.

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1 DESCRIPTIONS

1.0 GENERAL BUILDING DESCRIPTIONS

1.0.1 Building Design

The original water desalination plant was completed and tested during the 1985-1986 summer season. Once commissioned in 1987, the Water Plant became the sole source of fresh water. The facility is located adjacent to both the power plant and the ocean, and is housed in a steel framed building that is approximately 80x60 feet.

The original building housed an 18,000 gallon sea-water surge tank and two 55,000 gallon fresh water storage tanks, spare parts, chemical storage, a steam boiler, and evaporators. Later upgrades added a third 55,000 gallon fresh water tank inside the building, a larger fourth fresh water tank just outside the building, while converting the boiler from steam to water and removing the evaporator and associated plumbing.

Seawater is piped to the building through an insulated pipeline approximately 3,000 feet in length, while waste brine water is returned to the ocean, again through an insulated pipe, which is several hundred feet long. The incoming seawater pipeline passes through two buildings before arriving at the Water Plant. The first building, the Intake House, is located directly above the vertical riser of the intake structure, while the second, the Pump House, sits 200 feet downstream. The Intake Building houses the top portion of the intake structure, as well as an air compressor which supplies an air bubbler system. The original Pump House contained two seawater intake pumps, pump controllers, heat tape circuit panels and a transformer. The seawater intake pumps draw the water from the ocean and push it to the seawater surge tank located in the Water Plant.

The seawater intake pipeline is insulated and heat taped with two separate heat tape traces. The pipeline is also equipped with an alarm system to alert maintenance personnel of low pipe temperatures which signify heat tape failure.

The intake structure is almost entirely hidden by water and or dirt. The structure is fabricated from reinforced concrete pipe that rests on the ocean floor 60 feet below the surface with a vertical riser in the center of the two arms. Stainless steel screens cover the two pipe ends to prevent large marine life from entering the structure.

The present fresh water storage capacity provides a buffer of fresh water, allowing the system to be shut down for maintenance and repairs for a limited time without interrupting water flow to the station. This storage capacity also allows peak water demand to be greater than the distillation process output, as well as providing a source of water for fire fighting purposes.

The fresh water is distributed to the buildings in McMurdo using an above ground insulated piping system, with pressure and flow being maintained by a constant pressure pump unit that is also located within the Water Plant building. The fresh water can be chlorinated if deemed necessary, as a chlorination system is installed.

The use of the 18,000 gallon seawater tank provides a buffer for the system and allows the seawater supply pumps and pipeline to be shut down for several hours at a time, The remaining equipment in the original Water Plant design is used in the process of producing fresh water or is ancillary to equipment needed to support the system.

In summary, the original Water Plant, completed and placed in service in 1987, was capable of producing over 70,000 gallons per day (gpd) of fresh water at times of peak demands, though the system was only designed for a continuous output of 40,000 gpd. The production rate of 70,000 gpd cannot be sustained for more than several days due to excess demands on auxiliary equipment. Seawater is transported to the plant by a pipeline from the intake site, approximately 3,000 foot distant, while the brine, or concentrated waste, is dumped into the ocean directly downhill from the facility. Fresh water is provided to the buildings of McMurdo by a pumping unit, located in the Water Plant, which pressurizes the distribution system.

The concept intent for the newest upgrades is to replace aging water treatment equipment and to provide a redundant power plant system in the Water Plant for use in stand-alone situations, and install a new fire suppression system with CO_2 coverage in certain areas. This was accomplished by adding room for two new power generators, cooling radiators for the generators, switchgear, and a fuel oil daytank. The water treatment process was also improved by replacing the seawater surge tank with several expansion tanks and eliminating the reverse osmosis (RO) high pressure pump.

The most recent upgrade also added a new pump house to accommodate additional equipment for the reverse osmosis (RO) unit #3 to operate as a stand alone system.

The exterior architecture of the additions were designed to match the existing plant facilities, clad in pre-insulated metal sandwich panels, raised to the same finished floor elevation, with insulated or thermally-broken door assemblies, and metal grate access stairs and walkways. Salvageable demolition materials were reused where practical to match existing facilities.

An addition to the west along the road was added to provide room for two new generators, radiators and their associated equipment, a day tank, and the switchgear required to provide a stand-alone secondary Power Plant. The new generator room will extend into the existing Water Plant area where the RO#3 and its media tanks were located. The RO#3 and its media tanks were relocated to the Power Plant.

The existing exterior wall panels, girts, and cross bracing of the Water Plant building was removed and extended outward to make additional room for the new Generator Room. Certain lateral supports were re configured elsewhere as necessary for the expansion.

An expansion joint was provided at the transition between the existing concrete floor planks and the new steel plate flooring in the addition. The foundations for the new generators were extended under the existing floor. New insulated exterior wall panels, of the same design as the original panels, were installed around the new additions, and exterior overhead doors was provided in line with each generator. New interior wall construction of steel studs and gypsum wallboard was installed, and finished to match the existing interior.

The new Water Plant Day Tank room was provided with an exterior door to a new extension of the existing loading dock along the road. The new tank is double-walled eliminating the need for perimeter containment.

The new Water Plant Switchgear room includes battery and CO_2 bottle storage. Due to various requirements, the room is protected by 2 hour area separation construction and is provided with a direct egress to the elevated walkway to the north. This room not only provides for connections to the Power Plant for everyday use of the generators, but will also provide for independent systems connected to the Station distribution system for use as a stand-alone Power Plant. For daily use, surveillance cameras are used to monitor the Generator and Switchgear Rooms remotely from the Power Plant Switchgear Room. For operations use, a vision lite with fire-shutter is used between the Switchgear and Generator rooms. Size is limited by the 25% opening restriction in the area separation wall.

The new Water Plant Radiator Enclosure, at the south end of the existing structure, is accessed from a new platform extension on the west.

In the main room of the Water Plant, a new egress doorway and exterior access stairway near the northeast corner was required to remedy the existing code violation of maximum distance to exits. The original access door to the south was relocated during construction of the addition to the south to allow for compliant egress in that addition, but the original building was not brought into compliance. Per NFPA 101, 40.2.5.3 a common path of travel can be 50 feet. If industrial bridging is installed over piping between FWS tanks 1 and 2, this obstruction is overcome and no common path of travel exceeds the allowable.

A new Pump House was constructed south of the radiator addition to house the circulation and booster pumps, and controls as required for the RO unit relocated from the Water Plant to the Power Plant.

1.0.2 Building Occupancy

The Water Plant is classified as Special Purpose Industrial Occupancy and as such the occupant load is defined as not less than the maximum probable number of occupants present at any time. Under anticipated operations this number is not expected to exceed six (6) occupants in the Water Plant (two mechanics, two water plant operators, one electrician, and one supervisor).

Ancillary facilities in special purpose industrial occupancies where delayed evacuation is anticipated (such as in utility control rooms) must maintain a two (2) hour fire resistance-rated separation from the predominant industrial occupancy.

The Water Plant Switchgear room is separated by two (2) hour fire resistance-rated construction from the predominant industrial occupancy for delayed evacuation. This required a direct egress from the protected areas that does not pass through the 2-hour walls. Construction of the two (2) hour wall against the existing exterior panels is similar in construction to the two (2) hour Area Separation Wall along Water plant grid 1.

NFPA 37 requires minimum one (1) hour fire resistive rated walls enclosing the engine room. The remaining walls separating the Generator Room from the Original Water Plant and the Water Plant Addition will be one (1) hour rated. The Day Tank room also has a one (1) hour rated wall separating it from the Water Plant Addition. An extension of the existing two hour wall separate the Day Tank room from the Generator Room.

1.0.3 Building Site and Utilities

Electrical, plumbing, and communications utilities are routed to the facility from various other locations at McMurdo.

In the event of a disruption of services from the Power Plant (Bldg. 196), emergency power lighting and heating are incorporated in the Facility's design.

1.0.4 Building Room Schedule

WATER PLANT UPGRADES	ROOM #	SQUARE FOOTAGE	
		Existing	New
Original Water Plant		4800	3960
Water Plant Addition		2420	2420
Addition Mezzanine		835	835
Exterior Addition		170	0
Generator Room	xxx	0	1400
Switchgear Room	xxx	0	675
Radiator Enclosure		0	216
Day Tank Room	xxx	0	160
WATER PLANT TOTAL		**8172**	**9666**

NEW PUMP HOUSE	SQUARE FOOTAGE
PUMP HOUSE TOTAL	**190**

1.1 ARCHITECTURAL / STRUCTURAL SYSTEMS

1.1.1 Building Systems

The new additions to the Water Plant are steel framed with metal floors, enclosed with a metal faced pre-insulated sandwich panel roof, wall and underfloor soffit to match the existing facilities, but with greater R-value than the existing panels.

The building additions will be elevated above the ground with an air separation to allow dissipation of heat from the building and prevent thawing of the ground. The elevated walkway between the Water and Power Plants was constructed to minimize drifting and allow for snow blow-through and improved drainage. Access from this walkway to the east side of the buildings was provided.

It is anticipated the building additions and pump house should serve a normal economic life of at least 40 years given current understanding of prevailing design and construction practices and normal maintenance.

1.1.1.1 Foundation System

The planned upgrades and additions to the structure used those systems which have proven successful in Antarctica, as well as in similar climatic zones and for comparable uses.

The building additions are founded on conventional pad type spread footings of pre-cast concrete, re-using existing footings where available. The basic framing is conventional steel braced frame. The floor is elevated above grade, to match the existing floor level, with an airspace to reduce heat flow into the ground and to prevent drifting snow from blocking access to underfloor utilities. Stairs are provided for access between grade and finished floor elevations.

For the new generator foundations new precast concrete blocks were used. Also, the new footings for the additions are precast. The existing foundation was designed for a 2,000 pound per square foot (psf) bearing pressure. The upgrade also required that the bearing pressure be increased to the current standard for compacted structural fill of 4,000 psf. The fill placed for this building performed adequately. If settlement has not occurred in the twenty years since the plant was constructed, then the increase in bearing capacity of the fill should not be a problem. The existing footings were adequate for this increased bearing pressure.

1.1.1.2 Floor Framing System

The floor framing for the existing Water Plant is made up of solid precast concrete planks without a topping slab supported by a steel frame for the first floor. The existing floors were designed for at least a 125 psf live load.

With proper distribution of the loads, this is adequate for placing of the new gensets. Despite this, the floor between the gensets and the building exterior was modified for moving the gensets in and out of the building.

The new generator foundations required removal of portions of the existing floor and the placement of new footings to support the remaining framing.

At the joints between the precast concrete planks there is a vertical offset due to variations in the thickness of the planks. A temporary steel "rail" system was constructed used to move the gensets. The rails were shimmed over the varying thicknesses of the floor planks to provide a level surface on which to move the gensets.

A steel frame was used to support the floors and roofs of the new radiator enclosure. The floors for the new radiator enclosure and the addition are made of steel plate. The steel plate provides excellent durability in this industrial space. The floor beams were enclosed within the thermal envelope with a thermal break at the connection to the foundations. This is different than the existing floor system where the bottom flange of the floor beams are outside the thermal envelope. The thermal mass of the precast floor slabs counters the tendency for frost buildup on the upper surface of the floor.

1.1.1.3 Roof Framing System

The construction of the roof framing system is common of pre-engineered metal buildings. All of the columns for the roof are bearing on and attached to the precast floor slabs.The new roofs will be insulated metal roof panels.

Each section is constructed of a modular floor-soffit, roof and wall panels are made of insulated structural panels faced with pre-finished medal cladding.

The roof framing uses R-Control insulated panels, with I joists integrated during fabrication. The R-Control exterior wall panels will support the roof panels.

1.1.1.4 Wall Framing

To resist lateral loads the exterior wall framing has moment resisting space frames in one direction and an ordinary steel braced frames in the other direction. This is typical for pre-engineered metal buildings. The governing lateral loads are wind loads at McMurdo. Since the area exposed to the wind in one direction does not change with the addition at the Water Plant, it will be possible to connect to the existing pre-engineered building structure for lateral loads in that direction. Some additional bracing was needed in the other direction, and reinforcing of the existing bracing.

Removable wall panels were provided in the insulated enclosure walls to provide maintenance removal access for the radiators and generators.

1.1.1.5 Building Structure

This project uses fabricated steel and prefabricated modular insulated building panel systems that are energy efficient, coordinate with the anticipated transportation systems, and have performed successfully in remote areas of the Arctic as well as other facilities in Antarctica.

The major building systems required the use of heavy equipment such as forklifts, cranes and front end loaders for unloading and erecting steel framing materials, and prefabricated insulated panels. On site welding was minimized and bolted connections maximized due to construction site conditions. Scheduling of the Water Plant additions was coordinated to minimize blockage of the access road by heavy equipment during construction, as well as to minimize interruption of operations.

Steel wind girts and furring carry the loads on the roof, wall and soffit panels to the building steel frame and down to the pre-cast concrete pad foundations. Relocated cross-bracing and wind girts were coordinated for the new penetrations in existing braced walls for the generators in the Water Plant.

New walls were constructed as required for Type II-N. Existing walls remained basically unchanged. The existing building construction is of non-combustible framing. The wood decking and most of the blocking and furring remained, especially at the soffit around the foundations.

Existing exterior walls disturbed during the upgrade process were provided with new insulated exterior panels to match existing style, but meeting current R-value requirements, and new structural framing will be provided as required.

1.1.1.6 Stairs

The access stairs, landings and walkways are constructed of prefabricated metal grating. Doors which swing over the landing do not project more than 7 inches into the 36 inch landing depth when fully open. Openings in treads or landing are less than 1.125 inches clear. Treads and landings are protected from snow accumulation. Handrails were provided on each side of the stairs and landings for the safety of personnel.

Stairs used only to attend equipment are exempt from the standard maximum rise and minimum tread design requirements.

1.1.1.7 Raised Walkway (Inter-Building Link)

The elevated walkway between the Water Plant and the Power Plant is constructed of prefabricated metal grating. The elevation allows for snow blow-through and improved drainage. Access from the walkway to the east side of the buildings was provided.

1.1.2 Windows and Doors

All exterior personnel doors, cargo doors, and overhead doors are made of pre-fabricated heavy-duty, insulated, rated or thermally broken systems. Door type and sizing was determined by the equipment and clearance configurations within the facility.

Location and orientation of doors were coordinated to optimize the thermal envelope while protecting the door operation mechanisms. Selection of doors was coordinated, where possible, with established Station standards. Interior personnel doors and frames in the facility are made of standard hollow metal construction.

Exterior overhead sectional doors were added to the new generator room to facilitate locating the generator sets, and interior sound baffled doors were added to reduce noise.

All interior windows, where required, are 120 minute fire rated.

1.1.3 Thermal Envelope

The exterior envelope is insulated to an approximate value of R-40 in the roof, floor, and exterior walls. The radiator enclosure is not kept at the same internal temperature as the existing building, although it is provided with some heat. Thermal breaks between this structure and the balance of the facility is required to minimize thermal bridging. All exterior materials are factory pre-finished, with no requirements for field painting. Siding is metal sandwich panels, with an interior and exterior metal skin bonded to a foam insulation core. The color, texture and profile of the panels was selected to match or compliment the adjacent existing panel systems. Roofing is similar to the insulated panels at the walls, of unventilated “hot-roof” design, with slopes arranged to protect personnel and overhead door access. New overhead and personnel doors, frames, and hardware are made of heavy-duty, insulated construction.

1.1.4 Exterior Finishes

All exterior materials are factory pre-finished, with no requirements for field painting. Field installed siding is pre-finished textured metal cladding. Siding is made from metal sandwich panels with an interior and exterior metal skin bonded to a foam insulation core. The foam insulation provides an approximate insulated value of R-40. The roof is similar to the walls with cladding on insulated panels, of unventilated “hot-roof” design. Joints between the three modules are protected from moisture infiltration and differential settlement by weatherproof seismic joint covers over replaceable vapor retarder splines.

1.1.5 Interior Finishes

1.1.5.1 Wall / Ceiling Support Systems

Roofing will be similar to the insulated panels at the walls, of unventilated "hot-roof" design, with slopes arranged to protect personnel and overhead door access. New overhead and personnel doors, frames, and hardware will be of heavy-duty, insulated construction. The roof and walls are supported by the insulated wall panels. Suspended ceiling systems in the Water Plant use a 15/16" exposed tee system.

1.1.5.2 Floor Finishes

New interior floor construction is made up of metal plating covered with an epoxy anti-slip coating to match the rest of the Water Plant.

1.1.5.3 Wall Finishes

Existing interior wall finishes disturbed were re-finished to match the existing.

Interior surface finishes were selected for cold temperature durability in the cold and for ease of maintenance throughout the facility.

The inside face of the structural panels have a fully adhered vapor retarder, splined from the walls to the soffit and roof, and between modules to provide continuous envelope. A gypsum wail board thermal barrier layer is used to protect the interior environment from the foam panel insulation. Joints of structural panels, gypsum wall board, and FRP are staggered lo minimize vapor transmission.

1.1.5.4 Base Finishes

The wall base used throughout the facility is a 1/8 inch thick type TS Thermoset Vulcanized Extruded Rubber Wall Base. The base is constructed of first-quality materials properly vulcanized. The texture is smooth and free from imperfections which detract from its appearance. The base conforms fully to the requirements of Standard Specifications F-1861, Group 1 Solid. All base was applied using a high performance contact adhesive.

1.1.6 Interior Specialties / Fixtures

1.1.6.1 Fire Protection Specialties

A variety of hand portable and wheeled extinguishers are located throughout the facility:

Class A: Fires in ordinary combustible materials (such as wood, cloth, paper, rubber, and many plastics). Class A fires are generally extinguished by the heat absorbing (cooling) effects of water, and the coating effects of certain dry chemicals that exclude air to extinguish smoldering fires, or the interrupting of the combustion chain reaction by halogenated agents and dry chemical agents.

Class B: Fires in flammable or combustible liquids, petroleum, grease, tars, oils, oil-based paints, solvents, lacquers, alcohol, and flammable gases. These fires are generally extinguished by inhibiting the release of combustible vapors, or interrupting the combustion chain reaction.

Class C: Fires in live electrical equipment where there is a potential for electrical shock hazard. Agents used on these fires must be non-conductive, such as dry chemical, carbon dioxide, or halogenated agents.

Class D: Fires in certain combustible metals (such as magnesium, titanium, zirconium, sodium, and potassium). Class D fires require a heat-absorbing extinguishing medium that does not react with the burning metals.

Class K: Fires in cooking appliances that involve combustible cooking media such as vegetable oil, animal oils, and fat. These fires require agents that can extinguish the fire, prevent re-ignition for 20 minutes, or until the temperature of the liquid is at least 60° F (15.6° C) below its auto-ignition temperature, and do not cause splashing.

In addition to its suitability for a class of fire rating (in letter form as noted above) each extinguisher rated for Class A and B fires is also given a numerical rating. (There is no numerical rating applied to extinguishers suitable for use on Class C or D or K fires.) The numerical rating provides information on the relative effectiveness of the extinguisher on that class of fire. The number does not denote units of measure, but is a relative rating as determined by the extinguisher's performance on standard, reproducible test fires. For example, an extinguisher with a 10D rating is not necessarily twice as good as one with a 58 rating.

Extinguishers suitable for several classes of fires are marked with their rating separated by colons. For example, a multipurpose dry chemical extinguisher might have a rating of 4A:10B:C.

Safety cabinets were provided for type I and type II safety containers up to five (5) gallons throughout the facility. All cabinets have high visibility, tri-lingual labeling, fail safe closing mechanisms, vents, and spill catching shelves.

1.1.6.2 Collateral Equipment

This section includes furniture, appliance items, as well as both electrical and mechanical equipment items to be used in the facility.

In keeping with the industrial nature of the building, furniture and equipment was chosen to be abuse resistant and versatile.

1.1.6.3 Signs

Signs are mounted throughout the facility displaying instructional and building information such as room names and numbers. Acrylic sheet material or aluminum compatible with the applied sign stock is used.

1.2 CONVEYING SYSTEMS

1.2.1 Monorail Hoist

The monorail hoist is used to simplify the task of moving heavy and/or bulky items around, into, or out of the South Room. The electrically powered, trolley mounted, cable hoist is mounted over reverse osmosis unit # 2. Optional tools can be used with the hoist, such as a pallet lifter, to make moving and lifting tasks easier. Hoist operation is operated using a pendant control system. The hoist is insulated and electrically heated. It is designed to operate at temperatures as low as -20º Fahrenheit (F).

The hoist trolley is motorized and has a maximum rated travel speed of 30 feet-per-minute. The hoist has a maximum lift capacity of 1 Ton, a maximum lift distance of 54’, and a travel speed of 14’ per minute.

1.3 MECHANICAL SYSTEMS

1.3.1 Heating Generation and Recovery Distribution Systems

1.3.1.1 Fuel Fired and Electric Boilers

The manufacturers of standard heat exchangers typically recommend to not deliver air or solution to the heat exchanger colder than 40 degrees F for maximum life of the heat exchanger. Even using a stainless steel heat exchanger, the colder air temperatures required in the spaces could reduce the life expectancy of the heat exchangers to less than 5 years. Given the requirement for a 40 year facility that would require replacing the heat exchanger in each furnace six (6) times over the life of the facility. This would also put the personnel at risk when the heat exchanger cracked since the leak may not be noticed immediately and would expose the personnel to potentially hazardous products of combustion. Given the varying temperature requirements and the limiting factor of air temperature on the heat exchanger, it was determined to use an oil-fired boiler system.

The boiler system allows for individual hydronic heating units to be installed in each area to provide the unique temperature for that area. The unit heaters allow each area to maintain the temperature by cycling the fan and opening a control valve to provide heat as necessary.

The fuel fired Boiler located in the Water Plant Room A100 designed WHB-1 was initially designed to provide steam to pre-heat the incoming sea water. Since then the boiler has been modified from steam to a 50/50 mixture of Glycol solution. The conversion simplified the controls and also reduced maintenance tasks. The boiler is now used to supply tempered Glycol solution for unit space heaters, heating coils in the air handler units, heating of the fresh water in tank #4, and as a backup heating system for the incoming seawater.

The electric boiler designed EB-1 located in the pump house is used to provide secondary heat to the exterior fresh water tank #4.

1.3.1.2 Perimeter Heating System

The primary heat source for the facility is the sealed hydronic heating system which uses 60% ethylene glycol, Dowtherm 4000 commonly found in other buildings throughout the station. This 60% ethylene glycol solution is heated by the fuel fired boiler A100 and then is piped to various types unit heaters located throughout the facility.

Since the facility requires varying levels of temperature control, the use of both vertical and horizontal unit heaters is required. Vertical heaters are used in the taller areas and the horizontal heaters are used in lower areas.

The advantage of locating the vertical heaters higher is they are out of the way but still allow for the warm air to be blown to the floor. The vertical heaters selected have low discharge air temperatures to minimized spot heating on the vessels below.

Heat throughout the facility is generated by the use of vertical and horizontal hydronic Unit Heaters (UH-12 through UH-15), cabinet heater (CUH-5), and a ceiling cabinet unit heater. The boiler located in the Water Plant Room A100 supply a heated mixed glycol solution to the heaters. Isolation valves on both the supply and return lines provide a means of taking the heaters out of the active loop for maintenance or replacement purposes.

To prevent shocking the boiler, a three way mixing valve located on the return supply to the boiler mixes the cooler return solution with the hot discharge solution, leaving the boiler to maintain a minimum return solution temperature to the boilers of +140° F.

Prior to dis-assembling and moving the modules, the sealed glycol system will have to be drained-down, disconnected, and capped. After the modules have been moved and connected again, the system will have to be also connected, filled and the air removed prior to usage.

The unit heater designed EUH-1 is used to maintain a certain temperature level in the pump house. An electric heater was selected over a solution radiant heater because a constant supply of heat is not required.

1.3.1.3 Waste Heat Recovery & Distribution System

The typical heat recovery system gathers and uses wasted heat recovered from other systems. Not only can this recovered heat be used to heat the interior of the facility it is located in, in the case of the McMurdo Station, it can also be added to the Station's main waste heat recovery system. This main waste recovery system then flows through the remaining Station supplying heat for other facilities.

The upgraded Water Plant has three such heat recovery systems all connected to the Station's main waste heat recovery system. The first system is the typical Glycol waste heat recovery loop including the boiler and unit heaters. If the heat recovery system cannot meet the heating needs of the interior spaces, then the unit heaters cycle on/off to maintain a pre-determined temperature.

The second and third waste heat recovery systems involve gathering wasted heat from the cooling systems and exhaust systems for the generators. In the second system, heat is extracted from the water jacket system through plate type heat exchangers HX-1, HX-2, and HX-12. In the event the main waste heat system should fail or does not need the wasted heat from the generator cooling system, remote radiators located outside the Water Plant are used to expel excess heat rather than let the generators over-heat.

The radiators cool the jacket water solution before it is routed back to the generators by the use of a fan and motor. Each radiator have variable frequency drives (VFD) to control the fan speed. The VFDs allows the fan speed to be modulated to balance heat rejection to engine load.

Each generator is piped to a separate heat exchanger and remote radiator. The separate cooling system approach allows for safety should one system fail catastrophically, the other generator would be able to operate.The remote radiators were enclosed to minimize the snow infiltration and ice buildup problems associated with the previous exterior remote radiators.

In a similar manner, waste heat in the third system is extracted from the generator's exhaust system and fed into the Station's main waste heat system. Heat recovery silencers were installed on the exhaust of each generator. The new heat recovery silencers are vertically mounted at the end of each generator engine. The new heat recovery silencers were mounted on the floor with exhaust gases entering the top of the unit circulating down through the heat exchanger and then exiting vertical up through the roof. The packaged units have a motor operated damper on the inlet that will bypass the exhaust gases by the silencer and directly to the exhaust stack if the temperature of the heat exchanger gets too high. The bypass damper is fully modulating to better control the temperature of the glycol exiting the heat exchanger. The packaged units were manufactured and designed specifically for the engine to be installed. The silencers and the heat recovery system are sized to maintain a minimum temperature of approximately 385° F exhaust gas discharge temperature to minimize the risk of condensation in the exhaust piping.

A separate hydronic loop was designed for the exhaust gas system in each building. A dedicated plate type heat exchanger was installed on the main waste heat circulating line in series with the engine coolant system heat exchangers. The exhaust gas heat recovery system adds heat to the waste heat system to boost the engine jacket water system. The exhaust gas has significant waste heat available which will increase system capacity to allow the waste heat system to meet more of the heating needs of the connected facilities. The primary waste heat recovery system has been sized for up to 4 engines operating with jacket water. The exhaust gas heat recovery systems add as much heat to this flowrate as possible. If the return water from the waste heat system approaches 185° F, the exhaust gas systems shut down to prevent overheating of the engines by reverse heat transfer through the engine jacket water system heat exchangers.

The flow of hydronic solution through the exhaust gas waste heat exchanger is continuous at the engine jacket water system flowrate determined by the number of generators in operation.

The heat recovery silencers have an integral exhaust gas by-pass valve that bypasses the heat recovery silencer when heat recovery is not desired, or when there is a failure of the waste heat system to provide coolant flow through the silencer. The pumps are sequenced so that there is always coolant flow through the silencer if the associated generator is running. This flow will prevent "baking" of the coolant in the silencer should a problem occur. Two variable speed pumps, piped in parallel for primary service and back- up service, was provided to circulate the heat recovery solution through the system. The variable speed function is controlled using differential pressure sensors in the pumped loop. The pumps operate to maintain a set pressure differential of approximately 8 to 10 psi. Flow controls installed adjacent to each of the two-way control valves allow the proper flow through the exhaust gas heat exchangers provided that a 4 psi. minimum pressure differential exists between the supply and return piping. With this system, the pumps automatically ramp up and down as necessary to meet the required flow rate. The design allows for any single heat exchanger to be isolated from the system for maintenance, or emergency purposes. A separate, dry exhaust stack incorporating industrial grade silencers were fitted to attenuate the exhaust when the exhaust is in the bypass position.

The 3516B engines reject 75,296 Btu/min for the 3516's and 55,221 Btu/min for the 3512's of heat to exhaust gases at an 80% load. This value increases to 94,461 Btu/min and 71,315 Btu/min at 100% load. Unlike the jacket water, it is not recommended to extract all the heat from the exhaust gases. If the exhaust gas temperatures are reduced to less than 350° F a potential condensing condition can be created. If the exhaust gases condense then acidic water forms in the exhaust system which can greatly reduce the life expectancy of the exhaust system. Potential increases in stack back pressure can reduce overall engine efficiency and increase long term maintenance costs. Therefore, the exhaust gas temperatures are kept above 380° F after leaving the heat recovery device. To reject the heat using a 15° F temperature rise across the exhaust gas heat exchanger requires 440 GPM for the 3516's and 320 GPM for the 3512's at the exhaust gas heat exchanger manufacturer's recommended selection point.

Due to the peak power loads occurring during the warmest portion of the year, there is the potential that the waste heat system may not have adequate load to absorb all of the heat rejection produced by the engine jacket water and exhaust gas heat recovery systems. Should this occur, the engine jacket water recovery system will become the primary waste heat supplier and the exhaust gas heat recovery system will shut down. If the waste heat system is shut down, or unable to use all of the heat from the engine jacket water system, the radiators will reject all of the heat generated by the engine. Should the waste heat system need additional heat the generator(s) exhaust waste heat exchanger and associated circulation pumps can be brought on line and additional capacity can be added to the system.

It is anticipated that the exhaust gas heat exchanger will see entering coolant temperatures of 185° F and leaving temperatures of 205° F. The jacket water waste heat system heat exchanger will have an anticipated inlet temperature of 165 °F and a leaving temperature of 185° F. It is anticipated that the district wide waste heat system will then see a temperature of 185 to 205° F solution leaving the plant.

The radiator enclosures do not typically require a heating source. The temperature is maintained by heat rejection from the radiators. Return air dampers and exhaust air dampers is provided on the discharge of each radiator to allow for the warm discharge air to either be returned into the room to mix with the colder incoming air, or the warm air will be directed to the exterior if the space is too hot. A goal would be to maintain approximately 50° F in the space. However, with the potential of either generator room operating alone, hydronic unit heaters off of the waste heat system will be provided in each radiator enclosure to maintain minimum temperatures in the space. Portable heaters can be used by the local maintenance personnel to provide heat to the radiator enclosure if 'warm' work is required in the enclosure when the power plant or waste heat system is down.

In the event that the Water Plant experiences catastrophic damage, the waste heat recovery systems includes redundant systems to allow continued operation in each building. Isolation valves and normally closed bypass valves can be exercised to separate the two systems.

1.3.2 Ventilation and Air Systems

Ventilation is provided to the normally occupied spaces in sufficient quantity to meet the ventilation recommendations of the American Society of Heating Refrigeration & Air Conditioning Engineers (ASHRAE) 62 for indoor air quality.

Room A100 is served by a single standard air handling unit and the Switchgear Room is served by a second unit. Both units are designed to mix outside air and return air through dampers modulated by a mixed air controller.
Re-heat coils tempers the air using a hydronic coil, and then provides fan forced air through a ductwork system to the interior spaces within the facility.

All exterior inlets and outlets will have a down turn hood configuration to minimize snow entrainment.

1.3.2.1 Combustion Air Intake

Combustion air needed for the boiler is brought in from outside the building, rather than drawing air from inside the facility. This outside air is brought into the Water Plant through an intake duct that are relocated on the North wall. The air intake is equipped with a motorized louver system that is automatically operated by the boiler controls.

When a boiler is started, the modutrol motor mounted in the corresponding intake opens the louvers if the switch mounted on the wall is in the on position. The louvers close when the boiler is shut off, or if the switch on the wall is manually moved to the *OFF* position. The combustion air intake controls are also connected to the fire alarm system, which automatically closes the louvers whenever a fire is detected within the facility.

1.3.2.2 Exhaust Systems

Several different types of exhaust systems and fans exist in the Water Plant. A double wall flue is used for the boiler. The flues extend into a single vertical chase through the roof where the flue discharges thru an accessory exit cone. Each one of the two generators have their own stack gas exhaust system vented through the roof. Exhaust from each of the generators is fed into an exhaust header attached to a modulating actuator mounted on top of the heat exchanger. The actuator modulates the amount of exhaust sent straight into the heat exchanger then to the silencer, or straight to the silencer bypassing the heat exchanger. After the exhaust passes through the actuator it is sent into a bottom port on the non-heat recovering silencer, then out the top port to the stack.

The Water Plant is also equipped with an exhaust fan that is mounted on the North end of the pipe rack. The fan is ducted through the roof and is used to draw warm air out of the building. It is controlled by a breaker switch mounted in electrical panel “LP-1”. The unit was originally wired such that it had to be on whenever the unit heater was operating. This has been changed so that the exhaust fan is independent of everything other than the fire alarm. If the fan is running and a fire is detected, the fan will automatically shut off. It must be restarted by hand after this occurs. The fan should operate with little attention other than routine maintenance. Use it whenever it is too hot, or stale air and fumes become irritating.

1.3.2.3 Makeup Air / Supply Systems

The two air handlers inside the Water Plant supply fresh air, air circulation, cooling, and heating when necessary to the Room A100 and the new Switchgear Room. The air handler in Room A100 was an existing unit relocated over the seawater surge tank to make room for the new diesel generators to be installed. Both air handlers were designed so the total air volume is greater than the required ventilation rate, and provide a mixed air temperature above 35° F to minimize frosting of the dampers. The total ventilation rate is adjusted as necessary to meet all ventilation rates and any cooling loads.

A typical air handler consists of a mixing box, an hydronic pre-heating coil, an hydronic heating coil, and a fan section. The use of both a pre-heat and heating coil allows single or dual usage depending on the temperature of the incoming air. The air handler was internally isolated for noise control and to simplify the installation. The unit was sized for the thinner air within the facility.

The air handler in the Switchgear room (A103) is dedicated to providing precious cooling and heating in the Switchgear Room only. This precious temperature control not only provides comfort for the operators but protects the electronic equipment.

1.3.2.4 Engine Room Combustion and Ventilation Air System

The engine room combustion and ventilation system is sized to cool the surrounding space with a minimum of three (3) generators operating at full load, and the radiated heat loss of the associated engine coolant and waste heat system piping and equipment. The estimated heat rejection to the atmosphere from both the engine and the generator is approximately 10,650 Btu/min (639,000 Btu/h) per engine. The combustion air requirements for each generator is approximately 5,500 CFM at 100% load. This air is supplied by the ventilation system. In the event of an emergency, the size of the ventilation ductwork alone even without the ventilation fans operating is sufficient to provide required combustion air.

The ventilation system consists of two (2) duct mounted 15,000 CFM propeller ventilation fans (Equip. designator VF-1 and VF-2) with a mixing box designed to provide the required cooling and combustion air, and a motorized damper controlled relief fan (Equip. designator RF-1). The mixing box mixes outside air and interior space air to provide 50° F cooling air (adjustable). In addition to the ventilation fans, relief air fans have been designed to maintain the generator rooms at approximately.05” W.C. positive in relation to the exterior. The use of the relief fans is necessary due to the large amount of ventilation air required. The fans sequence of operation allows the amount of required ventilation to track the number of engines in operation. The ventilation fans also provide combustion air to the diesel generators. The fans are interlocked with the Fire Alarm System to shutdown in the event of a fire and subsequent discharge of the CO_2 system.

The damper controlled relief fan is used to exhaust air to maintain a slightly positive air pressure in the Switchgear Room with respect to the outside air pressure. This prevents cold air from entering the building and relieves excess air brought in by the two ventilation fans. The relief fan works in conjunction with the ventilation fans. If air flow from the ventilation fans increases in order to provide more cooling in the generator room, then RF-1 will automatically increase its air flow to exhaust the extra air and maintain the desired room pressure.

The outside air intake dampers and exhaust air dampers in the generator room are controlled by the fire alarm system to close prior to activation of the CO_2 fire suppression system.

The four (4) paddle fans (PF-1) in the Water Plant provide air circulation in their respective rooms to keep the air from stratifying into thermal layers. The fans are controlled by local variable speed controllers.

1.3.2.5 Remote Radiator Enclosure Ventilation

The new radiator enclosure required inlet air openings and exhaust air outlets to supply the required airflow to the new radiators. The radiators have ductwork extending from the discharge of the radiator to the exterior. Modulating exhaust and return dampers were provided on the discharge to divert the air either to the exterior in the event the enclosure is too warm, or back into the radiator enclosure to prevent over cooling of the space. The outside air inlets are located above the man door, and have dampers mounted at the wall penetrations.

1.3.3 Plumbing Systems

1.3.3.1 Domestic Water Systems

The only water heater in the Water Plant is an wall mounted electric tankless water heater used for hand washing. The water heater is capable of producing continuous hot water to a faucet aerator with an excellent spray pattern.

The water cooler installed in the Water Plant is a self-contained, wall hung electric refrigerated water cooler. This cooler has the capacity to produce 50° F temperature drinking water, based on a 80° F inlet water and 90° F ambient temperature. The non-pressurized tank system is standard. This non-pressurized water tank is located after the bubbler valve, so that the tank is subject to line pressure only when the valve button is pressed. The cooler was manufactured with a waterway system using copper components and completely lead-free materials. These waterways have no lead containing components. All joints are brazed using silver solder only. No lead solder is permitted. A strainer with an easily cleanable removal of water born particulate of 140 microns and larger prior to their entry into the water cooler. The condenser is fan cooled with a copper tube with aluminum fins. The fan motor is permanently lubricated. The cooler was constructed from a one piece stainless steel basin with a smooth deep contoured basin polished to a uniform bright luster. The cabinet is a one piece wrap around design. Properly installed using the materials recommended by the manufacturer eliminates the possibility of metallic tasting water from electrolysis.

Since the personnel will be working on and around batteries for the generators, it was necessary to provide protection to the workers should problems with the batteries occur. The upgrade included the use of a portable eyewash canister. The canister is a 10 gallon water storage tank on a wheeled dolly to allow the personnel to locate it near them while working on the batteries.The unit is located in the Generator Room.

1.3.4 Water Treatment, Storage, and Distribution

1.3.4.1 Sea Water System

Salt water is taken from the ocean and is transported to the Water Plant by an above ground insulated pipe line system. The incoming seawater pipeline passes through two buildings before arriving at the Water Plant. The first Building #179 is located directly above the vertical riser of the intake structure, while the second, Building #124, sits 200 foot downstream. Building #179 houses the top portion of the intake structure, the submerged intake pumps, and the controls for the intake pumps. The intake pumps operate in a lead/lag design to draw the water from the ocean and push it to Building #124 where it is filtered. From Building #124 the seawater flows onto the expansion tanks that replaced the surge tank located in the Water Plant building.

The pipeline distance between the Building #179 and the Water Plant is roughly 3,000 feet. The entire pipeline is insulated and heat taped with two separate heat tape traces. The pipeline is also equipped with an alarm system to alert maintenance personnel of below pipe temperatures which signify heat tape failure.

The submersible pumps are designed for pumping clear, cold water; free of air or gases. Decreased pump performance and life expectancy can occur if the water is not cold, clear or contains air or gasses. The pumps are operated and controlled by a control box located in the same Building. The pumps should never be started unless the pumps are totally submerged. Severe damage may be caused to the pump and motor if they are run dry.

The intake structure for the seawater source is almost entirely hidden by water and/ or dirt. The structure is fabricated from reinforced concrete pipe that rests on the ocean floor, with a vertical riser in the center of the two arms. Water flows towards the riser from the two ends, which are not covered with backfill material. Stainless steel screens cover the two pipe ends to prevent large marine life from entering the structure. The depth of the ocean at the intake structure is approximately 60 feet, The vertical riser protrudes above the grade of the intake quay and is flush with the bottom of the intake building floor. Within the riser sits a section of stainless steel pipe that is approximately 16 feet long and is equipped with a foot valve on the immersed end. The pipe is insulated, heat taped to prevent freezing. The stainless steel pipe has a nominal inside diameter of six (6) inches, while the outside diameter is approximately 12 inches. The stainless steel intake pipe terminates above water with a 90 degree elbow and a six (6) inch flange.

The pipeline run consists of insulated fiber reinforced plastic (FRP) pipe. The pipe is also commonly called "Bandstand" after the manufacturer's brand name. The Bondstrand pipe is nominally six (6) inches in diameter and is covered with polyurethane foam insulation and an aluminum jacket, yielding an outside diameter of approximately 15 inches. The run between Building #179 and Building #124 is approximately 205 feet. The pipe enters Building #124 on the west side and exits on the East, where it continues to the Water Plant.

The pipe is placed above ground on steel supports constructed of 2.5 inch schedule 80 galvanized pipe uprights, with eight (8) inch channel as horizontal members. Support is provided approximately every ten feet with the pipe secured to every cross member by steel straps.

The line was designed and constructed to allow the pipe to be drained completely by opening a valve in the Water Plant and a valve just outside the Building #124, with no water trapped between these two points. Thus, if the need arises, the line can be easily drained from either end, with no need to open valves in the middle. At the present time, there is no means to isolate a section of the saltwater line if a failure occurs.

The pipeline is above ground for the entire route, but passes beneath two roads. The road crossings of the line are accomplished by bridging over the pipe with a box culvert arrangement, The pipeline is constructed entirely of six (6) inch insulated Bondstrand pipe which is heated with two separate traces of heat tape, and monitored for freezing with alarms that are installed for every section of heat tape.

Building #124 contains a filtering system with controls and a compressor. The compressor is used to pressurize and open and close a drain valve connected to the brine line for cleaning and back flushing the filter. The drain valve is opened for a 4 - 6 second interval to clean the filter of pollutants and sand.

Upon reaching the Water Plant, the seawater is stored in the expansion tanks. Use of expansion tanks eliminates the continuous operation of the seawater intake pump(s], provides a working supply of seawater, and prevents the possibility of dead-heading the intake pumps should a clog occur in the Water Plant, which could blow pump seals.

1.3.4.2 Treated Water System

The treated water system at the Water Plant consists of an sea water heat exchanger, expansion tanks in place of the sea water surge tank, a pumping system, a Hydrogen Sulfide Removal System (filter media), an energy recovery turbine, a reverse osmosis system (RO), Calcium Carbonate Tanks, a chemical injection system (Chlorine and Soda Ash), and three (3) fresh water storage tanks along with various pumps and valves throughout the system.

The sea water heat exchanger is used to raise the temperature of the incoming sea water from approximately 28° F to 37° F before it enters the filter media.

Hanging off the system between the heat exchanger and the filter media are new water expansion tanks to take the place of the surge tank. These expansion tanks can supply water to the treatment system for a certain time frame if the sea water supply should stop. During normal input of sea water, these expansion tanks have no function and are invisible to the system. Because the old surge tank is no longer being used, the RO feed water pump was removed.

This line enters the Water Plant in the southeast corner and then runs along the east wall to the seawater expansion tanks. Upon entering the Water Plant, the line wyes, with one branch feeding into a drain line, while the main pipe extends to the tanks. A butterfly valve is located after the wye to block the flow of sea water to the tanks, enabling water to be diverted to the drain, if needed. This allows the sea water line from the Pump House to be flushed after repairs are made, or to run the sea water pumps without filling the sea water surge tank. A second valve, a four inch gate valve labelled is situated in the branch leading to the drain; Valve A500-GB4-1 controls the flow of sea water to the drain and must be closed during normal operation. The sea water intake pump system should be placed in the *hand position* when valve A500-GB4-1 is open. Valve A500-GB4-1 is normally closed, while valve A500-BV6-1 is normally open during operation of the Water Plant facilities.

A motorized butterfly valve, A500-MOV6-1, is located downstream of A500-BV6-1. This valve is controlled by the sea water intake pump relays and opens whenever either of the pumps are activated. This valve keeps the seawater intake line full of water, which prevents a vacuum from being formed.

From the sea water heat exchanger, the water is pumped to the Sulfide Removal System. If the output pressure rises, it indicates that the filters are clogged, and if the pressure falls, it indicates that the pump is not operating well, and is likely worn. The actual operating pressure will vary dependent upon the number of pumps in use, and the amount of water being processed.

The Hydrogen Sulfide Removal System is designed to remove most of the hydrogen sulfide (H_2S), or sulfide ion, that is present in the sea water. The H_2S, if not removed, would cause considerable corrosion of the system, thus creating the need for frequent repair. Sea water in the McMurdo area can run as high as 2.0 ppm, if taken from near the sewer outfall, but contains about 0.2 ppm H_2S when drawn from the present water intake site.

The removal process requires the injection of potassium permanganate into the sea water and further along in the stream, filtering of the water to remove the precipitate that forms. If the pH of the sea water is below 6.5, sodium hydroxide (NaOH) is added in sufficient quantities to raise the pH to the proper level.

The filtering process consists of passing the treated water through a vessel containing manganese zeolite, charcoal, and a bed of sand and gravel. The filters require a backwash system to periodically remove the trapped precipitate which plugs the filters.

Instrumentation is included in the H_2S removal system to monitor the pH, and sulfide ion content of the incoming sea water, and the sulfide content of the treated, or sea water after leaving the filter vessels. This is accomplished by using continuous flow sensors that are mounted in parallel with the sea water feed line to the evaporators. The instrumentation does not control chemical injection rates, nor does it turn equipment on or off, but does display readings so that they can be monitored by the operators.

The twenty five- micron filter prevents courser materials from flowing through it and into the rest of the system. This filter contains a layering of anthracite coal, silica sand, garnet, and gravel (limestone).

Polymer (polyacrylic acid) is injected into the water to prevent precipitation onto the membranes. This polymer is stored in the “Feed Pre-Treatment” Container.

The water then goes through a small blue tank with a five-micron filter. Particulates allowed through this filter are getting smaller. The filter, a polypropylene coil that looks like yarn, are replaceable.

The water is then passed through the accumulator which keeps the water from bouncing as the air-filled bladder within steadies the water.

The filtered sea water is then feed into a high pressure pump designed to significantly increase the water pressure. This high-pressure pump, with five (5) ceramic pistons, boosts the pressure from approximately 40 pounds per square inch (psi) to 700 psi before entering one of the RO units. As part of the upgrade, the third RO unit was relocated to the Power Plant, leaving only two RO units in the Water Plant. The air-filled bladder dampers down the pressure pulsations caused by the piston pump. This is important in order to smooth things out as the water changes pressure.

Right behind the high pressure pump is the energy recovery turbine used to further increase water pressure to 850 psi required by the RO unit to make “drinkable-water” from the cold sea water. The waste flow is reversed in order to turn the energy recovery turbine. The energy recovery turbine uses the discharged brine from the RO unit to increase the supply water pressure before it is sent back to the ocean.

Once in the RO unit, the pressure pushes the water through the membrane filtering out particles and impurities. The brine flow over the membrane is important to both product water quality and quantity. The reverse osmosis valve adjust how much waste brine is going to the energy recovery turbine.

The spiral wound membrane in the RO unit has a spacer, which looks like mesh. This allows seawater to enter, while only fresh water molecules will pass through the "paper-like" membrane. There is also a plastic component which gives fresh water something to ride on as it makes its trip to the center of the membrane. At lower flow rates, concentration of sparingly soluble salts will foul the membrane surface. High brine velocities can also be a source of difficulty. At excessive flows the elements are subjected to severe stress and physical (telescoping, glue-line fracture) will result.

Carbon Dioxide (CO2) is then injected in the water in order to drop the pH level. This enables more calcium to enter the water as it flows through the Calcium Carbonate Tanks. Without the added calcium the treated water would be very corrosive to the plumbing system throughout the Station.

As the water flows over the calcium carbonate rocks in the green "calcium carbonate beds, the water picks up more calcium and raises the pH levels. This process not only raises the pH levels, but adds enough calcium into the water to precipitate out onto the pipelines.

Although the calcium rased the pH, soda ash (stored in the blue "Post Treatment Tank") must be added to bring the pH back up to the desired range in order to balance the water after the calcium was added. Chlorine is added in the final step to fight any bacteria that can get through holes in the RO membrane.

1.3.4.3 Emergency Pump House

A new pump house building was constructed as part of the upgrade to both the Water Plant and Power Plant. The new pump house was located near the exterior tank. Construction of the new pump house was completed using typical insulated roof, wall, and soffit panels used throughout the Station. The pump house contains new circulation pumps (CP-11 & CP-12), booster pump (BP-1 & BP-2), boiler (EB-1), electric heater (EUH-1), electrical panels, power transformer, and controls as required to allow for a stand alone system. Design requirements indicates 1,000 GPM at 277 feet of head system was required.

The new pump house equipment include a skid mounted, variable speed duplex domestic water circulation pump set. The duplex design allows for a primary pump and a secondary pump as a backup. This pump set will provide normal flow to the station. Additionally, a 100 HP booster pump set was installed to meet high flow conditions. Like the circulation pump set, the booster pump set contains a primary and secondary pump. Both pump sets are VFD controlled based on a pressure sensor mounted on the discharge header.

An electric water boiler and associated pumps, valves and controls were installed to provide water heated circulation for the existing external water storage tank. This prevents the incoming and outgoing water lines from freezing.

The electric wall mounted heater cycles on and off to maintain a certain temperature in the pump house. An electric heater was selected over the water type because of the cycling requirement and the fact only fresh water was available.

1.3.5 Fire Protection Suppression Systems

Any existing fire suppression system existing in the Water Plant was removed and equipped with two new independent fire suppression systems. One CO_2 system covers the Day Tank Room, and the Generator Room. The second system provides sprinkler fire suppression for the new Switchgear Room. Both systems are activated by detectors and manual pull stations located in these areas. Additional audio and visual alarms were placed throughout the facility to alert personnel of the impending danger.

The nature of the Water Plant does not warrant a full coverage of water based sprinkler system or a CO_2 fire suppression system. This includes the fact any fire arising in the Water Plant would be associated with the fuel leaks or spills, fuel supply, the generators, or the switchgear. There are certain areas in the Water Plant where the application of water may cause a burning film to spread the fire to previously unaffected portions of the facility. The application of large quantities of water could also adversely affect the electrical equipment and switchgear. This could make putting the plant back on-line time consuming, or even dangerous after the discharge of a standard fire sprinkler system.

Therefore, the fire suppression system for the facility consists of a pre-action dry pipe system providing coverage of the new Switchgear Room and a CO_2 fire suppression system in the new Day Tank and Generator Rooms. The coverage areas not include the interstitial space under the first floor. This area is of noncombustible construction and does not require coverage per National Fire Protection Association (NFPA) 13.

The Fire Detection and Alarm System (FDAS) is a stand-alone system, with appropriate detectors, pull stations and combination horn/strobe units for sounding the evacuation alarm. The FDAS trouble/alarm signals are annunciated to the station via the All-Call system. The combination FDAS Panel interfaces to both fire systems.

No fire detection was installed for the new radiator enclosure or the Pump House.

The FDAS activates audible and/or visual alarms, shuts off equipment such as the exhaust fans, the boiler, any air handlers, relief fans, etc. The FDAS is connected to a radio link transmitter in the Water Plant. The transmitting unit notifies the Fire Department of an alarm condition by a radio link.

The FSDS main panel is equipped with a set of batteries that provide back-up power during power outages. The panel will display a trouble light indicator if the batteries go bad, if a detector fails, or a fault is detected in the wiring or control system. If a fault is detected a quiet alarm will be activated. It can be silenced by using the *trouble silence* located inside the cabinet. An *alarm silence* switch is also located on the panel.

This switch silences the alarm if it has sounded, and prevents the alarm from sounding when placed in the silence position before an alarm condition. The panel will also indicate that an alarm has sounded and has been silenced. The system must be reset at this time though no alarm horn is sounding. The alarm silence and alarm reset switches are again located within the cabinet. The alarm system must be reset before equipment shut off by the alarm can be restarted.

This is a passive system, and should only need to be checked to make sure that the batteries are good and that the trouble lights are off.

Additional information can be found in Appendix Section 4.2.4.7.3 of this manual. This information should be read by all personnel before using this system.

1.3.5.1 Fire Sprinkler System

The pre-action system consists of a dry pipe sprinkler system installed in the new Switchgear Room. The riser for the sprinkler system enters the facility near the existing loading area. The water for the sprinkler system is delivered by a new three inch pipe routed from the existing water plant primary distribution pumps.

The dry pipe valve, or deluge valve, is controlled by the fire alarm system to activate upon the alarming of two separate devices in the same zone. A single device will not allow the operation of the system, nor will the loss of a sprinkler head. The pre-action system prevents accidental discharge of the suppression system due to damage to a head or incidental smoke detection.

Piping is minimum type 'L' copper.

The automatic air maintenance device is an automatic, field-adjustable device of the pressure reducing type. It is used to control the pressure in a dry pipe sprinkler system, pre-action system, or dry pilot line system of a dry pilot actuated deluge or pre-action valve.

The air maintenance device is used in applications where there is a compressed air (or nitrogen) source, which is controlled at a higher pressure than the desired system pressure. Pressure sources include plant air supplies having their own automatic compressor controls, or nitrogen supplies having single stage cylinder mounted pressure regulators.

1.3.5.2 Carbon Dioxide (CO_2) Extinguishing System

A Carbon Dioxide (CO_2) fire suppression system provides fire protection within the Day Tank Room and the Generator Room. The CO_2 system works in conjunction with the fire alarm system, which has detection devices in the protected spaces. The system includes a CO_2 releasing panel.

Two banks each consisting of twelve, 100-pound, CO_2 cylinders provide the extinguishing agent for the Generator Room. Conversely, two banks each consisting of two, 100-pound, CO_2 cylinders provide the extinguishing agent for the Day Tank Room.One bank acts as the primary source with the second bank designed as a reserve. Once a bank has been discharged, the discharge valve and associated fittings must be manually removed from the discharged bank and connected to the full bank. Since the CO_2 cylinders must be located as close as possible to the protected areas without be exposed to a fire in the hazard area they are protecting, the cylinders for the Generator Room are located just outside the Generator Room, and the cylinders protecting the Day Tank Room are located just outside the Day tank Room.

1.3.6 Compressed Air System

Compressed air is used in the Water Plant Facility for general shop air blowdown of the generators exhaust gas waste heat exchangers. Compressed air piping in the space is a Schedule 40 black iron or type 'L' copper to match existing piping preferences at the base.

The existing relocated compressor (relocated to just outside the Generator Room) and compressed air system is adequate for the needs of the Water Plant and for the new generators being installed. However, a new 1,500 gallon air receiver tank was installed in the southwest corner of the Generator Room. The increased capacity is required for the generator exhaust gas heat exchanger soot blower operation.

The air should be will be filtered and regulated at each shop air drop. The air receiver tanks will be maintained @ 125 psig air as required for exhaust gas heat exchanger soot blowdown operation.

General Safety Warnings:

Do not directly inhale compressed air.

Follow precautions on container labels before spraying materials such as paint, insecticide and weed killer.

Wear a respirator and safety glasses when spraying.

Do not over-pressure the receiver tank or similar vessels beyond design limits.

Do not use a receiver tank, or similar vessels, that fail to meet the design requirements of the compressor.

Do not drill into, weld or otherwise alter the receiver tank or similar vessels.

Do not remove, adjust, bypass, change, modify or make substitutions for safety / relief valves, pressure switches or other pressure control related devices.

Do not use air tools or attachments without first determining the maximum pressure recommended for that equipment.

Do not point air nozzles or sprayers toward anyone.

Do not touch the compressor pump, motor or engine or discharge tubing during or shortly after operation. These parts become hot.

Do not operate where flammable or explosive liquids or vapors such gasoline, natural gas and solvents are present.

Do not operate with guards or shields removed, damaged or broken.

Do not remove, paint over or deface decals. Replace any missing decals.

The air compressor was not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

1.3.7 Fuel Oil System

Fuel is delivered to the new 1,000 gallon day tank located inside the facility. The tank is a new double wall fuel storage tank sized to provide two weeks of use between fueling cycles. The interior day tank allow the fuel to have some time to warm-up which results in a more efficient combustion.

The fuel supply line (FOS) feeding the new day tank comes from the existing exterior fuel tanks supplying the Power Plant. The new 2” fuel supply line was routed on the existing utility piping supports behind the Water Plant, and on new piping supports where required. Piping was configured to allow for automatic or manual tank fill. Fuel used is JP-5.

New turbine type (RACOR) filters was packaged with the engines.

Fuel system coolers were installed rejecting heat into the day tank room. The highest level of electrical generation, thus most fuel circulation, will be in the summer time when the fuel is at its warmest point.

Tank levels are monitored by the DDC system to alert personnel of any potential overfilling or low level problems at the day tank.

1.3.8 Engine and Generator Systems

1.3.8.1 Diesel Engine Generators

In its simplest form the engine generator is a diesel engine rotating an armature through a magnetic field to produce power. Back-up Station electrical energy production is provided by two diesel driven generators installed in the new Generator Room in the Water Plant. Both of the engine/generator units are identical and provide base load power production, each with a net prime rating capacity at site conditions of 1825 kW, 2281 kVA and supplying 2400/4160 volts, 3-phase, 4-wire, 60 Hz, wye AC output.

Each engine/generator unit is individually skid mounted, jacket water cooled, and configured to burn JP-5 fuel.

The new engines for the Water Plant were provided with manufacturer's standard air cleaners, manufacturer's Racor fuel filter rack, Racor fuel/water separators, manufacturer's standard oil filters, electronic speed control (mounted in the switchgear) with actuator, electric start, 24 inch long flexible continuous bellows type stainless steel exhaust pipe, heat recovery type exhaust silencer, spring type vibration isolators with earthquake snubbers, starting batteries and battery charger, a remote mounted instrument panel located next to the engine with gauges for jacket water temperature, lubrication oil temperature, lubrication oil pressure, exhaust gas pyrometers, oil filter differential gauge, fuel filter differential gauge, fuel temperature gauge, fuel pressure gauge, silencer differential pressure gauge and air filter gauge (the remote gauges are less susceptible to damage through engine vibration). Automatic safety controls to shut engine down in the event of low lubrication oil level, low lubrication oil pressure, high lubrication oil temperature, low jacket water level, high jacket water temperature, engine overspeed, and engine overcrank was provided.

The alternators on each engine are six (6) lead reconnectable, brushless, two bearing type, bolted directly to the engine housing. The alternator housing is a single cartridge type, re-greasable, ball bearing supports with grease pipes that extend to the exterior of the alternator frame. The rotor is dynamically balanced for up to 25 percent overspeed. The alternator has Class H insulation and a temperature rise of 80° C, over a 40° C ambient. The rotor is form wound, vacuum impregnated, with integral amortisseur windings. The winding pitch is optimized to minimize voltage distortion and harmonics. The voltage regulator is a solid state digital type mounted in the switchgear. The alternators are field resistance matched.

To protect against destructive vibration effects and reduce overall noise generation, each unit is mounted on vibration isolators. The generators are arranged side-by-side in a single row. Spacing between the generators provides a clear aisle between each engine/generator for maintenance access and servicing.

The diesel engines are four-cycle, turbocharged, intercooled and designed for continuous electrical duty. The engines were designed to provide consistent performance and excellent fuel economy with minimum weight. Each engine is equipped with an adjustable electronic speed sensing isochronous governor which includes provisions for adjusting speed while the unit is in operation. The engines are also equipped with protective devices to initiate shutdown. The shutdown devices are direct in action and are independent of the governor. In conjunction with the shutdown devices, each engine contains alarm devices to actuate an alarm on the associated engine control panel.

The attached generators are matched to the performance and output characteristics of the engines. Each generator has optimum winding pitch for minimum total harmonic distortion and maximum efficiency. Each generator was designed with single point access to accessory connections.

Each generator has gauges and indicators to provide engine status and warn the operator of impending trouble. The following gauges and indicators are common on each generator.

The generator engine is equipped with a programmable monitoring system. The Electronic Control Module (ECM) monitors the operating parameters of the engine. The ECM can initiate responses if a specific engine parameter exceeds an acceptable range. The following three (3) possible responses may be available for each parameter:

- WARNING,
- DERATE, and
- SHUTDOWN.

The settings for the parameters are programmed at the factory. If the application requires the settings for the parameters to be reprogrammed, then the parameter must be programmed with an ET service tool. Addition information concerning the monitoring system can be found in the Appendix Section 4.2.3.8.1.1 of this manual.

A redundant control system was installed in the Power Plant enabling complete operation and monitoring of the generators in the Water Plant from the switchgear in the Power Plant.

1.3.8.2 Engine Cooling Systems

The engines are provided with an integral coolant pump driven from the engine. Each pump has the capacity to circulate the required flow of coolant through the system to remove the total heat rejected from the engines.

The jacket water system incorporates waste heat recovery from all available water cooled engine components including: engine jacket water, engine oil cooler, and turbocharger aftercooler.

The jacket water heat rejection loop consists of duplex external circulating pumps, waste heat recovery heat exchangers, remote air cooled radiators expansion provisions, glycol make-up provisions and control valves.

The heat recovery side of the jacket water heat recovery heat exchangers is connected to the Station main heat recovery loop through automatic control valves to allow automatic selection of the operating engine generator unit.

To eliminate the potential for generator damage when the heat recovery system is off-line, or if the waste heat is not being used, remote radiators are used to reject heat from the jacket water. The engines were also designed to automatically shutdown if high coolant temperature is detected.

Grounding of each generator was accomplished by bonding it to the facility structural steel. The structural steel was then connected to the Power Plant grounding grid system where it exits the Power Plant at the front corner of the loading dock.

1.3.8.3 Fuel Oil Cooling System

The fuel oil cooler provides external cooling of the fuel oil used for the generators by routing the fuel oil through high pressure bonded tubes with heat dispensing fins mounted on the tubes. Because of the velocity the fuel oil is moving, friction causes a build-up of heat requiring cooling. Since the primary design of the coolers provided for the Water Plant is air cooling, providing water or water circuit piping is not necessary. The fuel oil cooling system consists of a direct drive air cooler with pressure and temperature gauges.

1.3.8.4 Stack Gas

Engine/generator stack gas combines engine sound attenuation silencers with exhaust gas heat recovery. Heat recovery silencers are located adjacent to each generator. Non-heat recovery silencers are located on the roof above. Stack gas heat recovery takes place using an exhaust gas heat exchanger. These heat exchangers are designed to transfer heat from the hot exhaust gases to the liquid heat transfer fluid.

Engine exhaust heat recovery consists of a hydronic heat recovery silencer, duplex circulating pumps, expansion provisions, glycol make-up provisions and control valves. The engine exhaust heat recovery loop is connected to the Station heat recovery loop in a primary-secondary pumping arrangement to allow off-line isolation.

1.3.8.5 Lubricating Oil System

To increase the engine/generators ability to lubricate the diesel engine cylinders and piston rings and in order to minimize frictional and abrasive wear, deep oil sumps are provided. The increase in nominal capacity effectivity doubles the life of the lubrication oil.

To further enhance service life, a continuous, centrifugal, lube oil purification system is used to process engine/generator lubrication oil.

The system is manifolded to each generator. With this type of system, the lube oil change for each engine can be increased significantly. The lubrication oil filters that are provided standard on the engine/generators also benefit from the lube oil purification system through extended filter replacement intervals.

1.3.9 Control Systems

1.3.9.1 Direct Digital Control Systems

The direct digital control (DDC) system provides automatic temperature control and field monitoring of ancillary control systems using field programmable, microprocessor-based units. The DDC system serves control systems consisting of thermostats, control valves, damper operators, indicating devices, interface equipment, and other accessories required to operate mechanical systems.

The DDC system typically is used in most buildings for the control of the heating and cooling system heat exchangers, the boiler, various pumps, dampers, duct coils, any finned tube radiation heaters, and all of the ventilation systems. The air handler is controlled to provide a minimum supply air temperature and ventilation to the spaces with an overriding room thermostat to override the supply air setpoint-up should either room get too warm or cold. The unit heaters and the one cabinet unit heater all have wall mounted thermostats with guards installed to control the units. Each unit has a control valve to minimize unwanted heat rejection to the spaces.

The DDC system for the Water Plant, the heat recovery systems, and the waste heat system will operate independent of the generator controls. The systems are interconnected for the transfer of data, but the DDC control system does not have any control capability over the switchgear or the generators. The operation of the generators is solely the responsibility of the generator control system and switchgear. The DDC system only monitors the switchgear as required to record engine operation and emergency conditions. This will allow for control and monitoring of the systems from the site, and from off-site if required.

Two separate DDC computers are connected by the LAN system. One is located in the power plant, and the second is located in the water plant. Either computer has the capability of accessing both power plant facilities. The computers are the interface point for the operator to control the engine coolant, HVAC systems, and waste heat systems.

Besides the systems listed above, the DDC system also controls the jacket water coolant system, the jacket water heat recovery system the exhaust gas heat recovery system, and the radiator enclosure ventilation systems.

The DDC system automatically open and close isolation valves to direct the flow of the coolant, and waste heat systems through the generators that are operating.

The DDC system controls the flow of the jacket water through the heat exchanger and radiator by modulating a three-way control valve to maintain a set return temperature to the generator engine. The DDC system varies the fan speed on the radiator as required to reject heat from the coolant system.

The DDC system modulates the dampers on the radiators and outside air intakes in the radiator enclosure to maintain a minimum temperature in the enclosure.

The DDC system monitors and controls the fuel system, including the operation of the fuel coolers, for each generator engine.

The DDC vendor will be required to coordinate with the switchgear provider to coordinate the common alarms and data transfer that will be required between the two systems. An example would be the starting and stopping of an engine is controlled through the switchgear but the DDC system must be informed so the appropriate pumps, valves, radiators, etc can be started.

All the ventilation units and dampers are closed upon activation of the CO_2 fire suppression system. These devices are hardwired to the fire alarm/suppression system. The fire alarm system notifies the DDC system in the event of an alarm.

1.4 ELECTRICAL SYSTEMS

The purpose of the electrical systems to provide energy efficient, adequate, and reliable power, lighting, and signal systems for the facility. The electrical system was designed in accordance with the requirements of the 1999 *National Electrical Code* (NEC)(NFPA 70), the 1997 *Uniform Fire Code*, the 1996 *National Fire Alarm Code* (NFPS 72), the 1996 *Standards for the Installation of Air Conditioning and Ventilating Systems* (NFPA 90A), the 1997 *Life Safety Code* (NFPA 101), and the 1998 *Building Industry Consulting Service International* (BICSI) *Telecommunications Distribution Methods Manual.* All electrical equipment and systems are required to be Year 2000 (Y2K) compliant.

The purpose of the electrical design for the remodel of the McMurdo Water Plant is to provide a partially redundant power plant constructed in the existing Water Plant in case of a catastrophe at the main Power Plant. This was accomplished by reconfiguring the existing 300 kVA pad mounted transformer currently serving the Water Plant to serve as the station service transformer for the Power Plant, installing medium voltage feeders from the generators to the switchgear, installing medium voltage feeders from the switchgear to the pad mounted switches, installing medium voltage feeders from the pad mounted switches to new risers installed on the existing riser poles for the overhead distribution system, installing medium voltage feeders from the medium voltage pad mounted switches to the station service transformer for the power plant, the transformers serving the Water Plant and the transformer serving the load bank, replacing the existing fire alarm system to provide protection for the new spaces added to the Water Plant, installation of a new radio link for the Water Plant fire alarm system, and installation of a CCTV system to allow monitoring of Water Plant generators and switchgear in the Power Plant.

The design of the electrical systems for the new switchgear and engine generators were completed in accordance with the requirements of the *2002 National Electrical Code* (NFPA 70), the *1997 Life Safety Code* (NFPA 401), the *2000 International Building Code* (where NFPA is silent), the *2000 International Fire Code*, the *2002 National Fire Alarm Code* (NFPA 72) the *1999 Standards for the installation of Air Conditioning and Ventilating Systems* (NFPA SOA), and the 2000 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations (NFPA 850). Where there was little to no cost involved, the electrical systems were installed in compliance with the *Americans with Disabilities Act Guidelines* (ADAG). All electrical equipment and systems are Year 2000 (Y2K) compliant.

Power conservation is an important issue at the Station and to the greatest extent possible the electrical systems for the Water Plant were designed to be as energy efficient as possible based on the environment in which they are installed while staying within Station standards for materials and equipment. To this end, energy efficient lighting and low loss transformers have been selected for this facility.

1.4.1 Interior Distribution System

The purpose of the interior distribution system is to provide power, lighting, telecommunications, and fire protection throughout the Water Plant.

All interior receptacles are 20 Ampere devices with nylon bodies rated for industrial use. All exterior receptacles are 20 Ampere, Class A GFCI type. Light switches are 120/277 Volt, 20 Ampere, toggle switches with nylon toggle rated for industrial use. Standard, pressed steel, 4-11/16” square, 2-1/4” deep junction and device boxes with flat steel covers are used in all interior areas 10 feet or more above the floor. Interior devices mounted below 10 feet above the floor were provided with cast aluminum type “FSD” outlet boxes with cast device plates. Exterior devices will be provided with weatherproof, gasketed, cast aluminum boxes with cast aluminum “while in use” type covers.

All branch circuits are installed in a metallic raceway system. In general, all branch circuits will be run exposed. Where branch circuit raceways are installed more than 10 feet above the floor, Electrical Metallic Tubing (EMT) was used. Where branch circuit raceways are installed below 10 feet above the floor, rigid steel or intermediate metal conduit was used. Branch circuit raceways are ¾” minimum and branch circuit conductors are a minimum #12 AWG, copper with type THHN/THWN insulation used indoors, and type XHHW or XHHW-2 insulation used outdoors.

1.4.1.1 Panelboards

Distribution panelboards typically use 3-phase, 4-wire input. Both 277/480-Volt and 120/208-Volt panelboards are used. Panelboards are typically solid neutral, separate ground bus, circuit breaker/branch circuit types equipped with bolt-on circuit breakers.

Panelboards are used throughout both the Water Plant and the Pump House. All panelboards are provided with a ground bus for terminating equipment grounding conductors. Lighting and appliance panelboards, and their associated feeders, have a minimum 25% spare capacity to allow for future load growth. All feeders are installed in rigid metal or intermediate metal conduit, and include an insulated equipment grounding conductor.

1.4.1.2 Motor Control Centers

Motor control centers (MCC) are the primary locations of motor starters for the equipment within the facility. The motor control centers are front accessible and are usually rated at 277/480 Volts, 3-phase, with a short circuit rating of 100,000 Amperes (root-mean-square) symmetrical at 480 volts.

Motor controllers combined with motor-circuit-protection type circuit breakers (in lieu of fused disconnects) are contained in common enclosures. Locking disconnect handles for electrical maintenance safety are also provided.

Half-size, full voltage, non-reversing (FVNR) motor starters are typical for all motor loads not requiring variable frequency drives (VFD) or soft start controllers. For motors rated at or above 5 horsepower, soft-starting motor starters are used unless a FVNR controller is recommended by the manufacturer.

1.4.1.3 Variable Frequency Drives (VFD)

Many electric motor-driven devices operate at full speed even when the loads they are serving are less than their capacity. To match the output of the device to the load, some sort of part load control is in use for the majority of their life.

Many part load control strategies waste energy. The most efficient method of part load control, resulting in minimal wasted energy, is the variable frequency drive (VFD). VFDs accomplish part load control by varying electric motor speed. Energy savings of 50% or more over other part load control strategies are common.

Variable frequency drives are used in the Water Plant to control such devices as the pumps in the hydronic loop, fans on both remote radiators, and the relief fan in the Generator Room.

1.4.1.4 Breaker Switches

A circuit breaker is like a switch that opens (“breaks”) the circuit when it becomes overloaded. Each branch circuit in the Water Plant and in the Pump House is protected by a different breaker switch. The circuit breaker switches are located in the panelboards.

1.4.2 Exterior Distribution System

As part of the upgrade to the Water Plant and to facilitate the addition of the engine generators and switchgear, the existing 300 kVA pad-mounted transformer currently servicing the Water Plant was reconfigured to serve as the Station service transformer for the Power Plant. Install a new 300 kVA pad-mounted transformer to supply power to the Water Plant, installing new pad-mounted medium voltage switches behind the Power Plant, installing new medium voltage feeders from the switchgear to the pad-mounted switches installing medium voltage feeders from the generators to the switchgear, installing medium voltage feeders from the switchgear to the pad mounted switches, installing medium voltage feeders from the pad mounted switches to new risers installed on the existing riser poles for the overhead distribution system, installing medium voltage feeders from the medium voltage pad mounted switches to the station service transformer for the power plant, the transformers serving the Water Plant, and the transformer serving the load bank.

1.4.2.1 Pad-Mounted Medium-Voltage Switches

The six (6) Outdoor Pad-Mounted medium voltage (MV) Switches are located in the MV Switch Yard. These switches enable selective switching of the 4160v power, in association with the Generators Automatic Paralleling Switchgear.

Selectivity allows operation of various Utility feeders from Power Plant (PP) Generators, the Water Plant (WP) Generators, or both.

The Outdoor MV Switches also contain the Utility feeders' over-load and short circuit protection fuses.

1.4.2.2 Transformers

Dry-type transformers were selected because oil-filled transformers may freeze requiring increased maintenance, and raise environmental concerns over potential oil spills. Dry-type transformers are lighter than oil-filled making them less costly to transport and easier to handle.

Outdoor Pad Mounted Transformers (XFR's) were provided to transform the distributed 4160v. 3 Phase, 3 Wire, 60 Hz. Medium Voltage AC power to the equipment service power low voltage (LV) 277/480v and 120/208v, as applicable.

Service distribution transformers are equipped as 'dead front' assemblies, with live bushings in the medium voltage compartment. Load-break elbows connect the incoming medium voltage cables to the dead front bushings.

The transformer Low Voltage (LV) compartment comprises live front LV bus-bar connections to the LV service entry cabling.

1.4.2.3 Load Banks

The existing Load Banks comprise two (2) 500kW, 3 phase, 3 wire, 480v. 60Hz resistive load blocks. The load banks are connected to the existing Load Bank's 1000kVA Transformer T-L.

The purpose of the Load Banks is to provide proportional load to the Generators to ensure stable operation, when required. The Load Banks are also used to enable load testing of individual Generators, or to prevent low load condensate build –up in the exhaust gas system, and to apply stable 'black-start' load, if required.

The connections to the existing load bank were reconfigured to allow any generator to be connected to the load bank. However, due to space limitations in the switchgear rooms, the connections to the load bank were configured such that either half of the switchgear in the Power Plant can be connected to the load banks, or the switchgear in the Water Plant can be connected to the load bank.

In this manner, the Station load can be transferred to from the section of switchgear with the generator to be tested and the switchgear connected to the generator to be tested, can be connected to the load bank allowing each generator individual access to the load banks.

1.4.3 Power Generation & Distribution

1.4.3.1 Medium-Voltage Distribution Switchboards

The Medium Voltage (MV) Distribution Switchboards are contained within the Automatic Paralleling Switchgear.

1.4.3.2 Automatic Paralleling Switchgear / Generator Controllers

The Automatic Paralleling Switchgear comprises two (2) complete metal enclosed Medium Voltage vacuum break circuit breaker switchgear assemblies, as follows:

One, 2 high, 7 panel Switchgear assembly located in the new Switchgear Room in the Water Plant.

The Paralleling Switchgear automatically controls the start-up, synchronizing and controlled Generator power application to the bus-bars to meet the load.

The switchgear was designed so that the generators located in the Water Plant can be completely controlled and monitored from the switchgear in the Power Plant. With the generators and switchgear divided between the Power Plant and Water Plant a major catastrophe at either facility would not leave the Station without power generation capabilities.

The new switchgear is housed in free standing, NEMA 1, gasketed, utility grade, metal clad, medium voltage cabinets with front and rear accessible. The cabinets are rated for 1,200 Amps at 2,400/4,160 Volts, wye. The cabinets contain ANSI grade vacuum circuit breakers, copper phase buses, and a separate 600 Ampere, copper ground bus. The switchgear cabinets are mounted on a 3.5” tall housekeeping pad. The switchgear provides complete engine generator control, protection and monitoring, black start capabilities, automatic paralleling, load add and load shed capabilities. The switchgear will also allow for manual paralleling of generators as a backup to the automatic operation. The switchgear include full data acquisition consisting of power logic monitors, meters and engine controllers connected to the DDC system to allow the Operations personnel to monitor and control the generators and electrical distribution system. Two sets of switchgear were installed, one set was installed in the new Switchgear Room in the Water Plant, and the second set replaced the existing switchgear in the Power Plant.

The switchgear in the Water Plant has generator control sections for the two generators installed in the Water Plant, a master control section, and a medium voltage feeder distribution section. The switchgear in the Power Plant has redundant controls for the generators installed in the Water Plant. The Power Plant switchgear also has remote control and monitoring for the generators installed in the Water Plant.

The new switchgear include a section for each new engine generator with the engine generator protection and control in the top half and a draw out medium voltage generator breaker in the bottom half, medium voltage distribution consisting of three sections with stacked draw out medium voltage feeder breakers with protection and monitoring in each section and a master control section that includes a plant totalizing metering, and the Programmable Logic Controller (PLC) to provide the automatic paralleling, load shed and load add control.

Splitting the bus and distribution in the new switchgear, in conjunction with exterior distribution system upgrades, allows the existing Power Plant to supply the entire Station from either side of the tiebreaker. The tiebreaker would normally be closed but, in the event of a fault in one side of the switchgear, the tie breaker may be opened to allow the other half of the switchgear to continue supplying power to the Station. This would be accomplished by opening the distribution breakers in the faulted side of the switchgear, interconnecting the medium voltage feeders using the new exterior pad mounted switches, and transferring all load to the non-faulted side of the switchgear.

Each engine generator section includes a solid-state, microprocessor controlled, electronic modular engine control panel to automatically start, protect, and monitor the operation of the engine generator set. This control panel provides LED digital read outs for engine oil pressure, coolant temperature, engine RPM, system DC volts, engine running hours, generator AC Volts (three phase L-L and L-N), generator AC Amperes, generator power (kW), generator power (kVA), power factor, generator frequency, and LED indicators for pre-low oil pressure, low oil pressure, pre-high coolant temperature, high coolant temperature, pre-low coolant level, low coolant level, low oil level, high oil temperature, overspeed, overcrank, emergency stop for each generator. The engine control panel will also provide electrically isolated contacts for electronic governor control, electric fuel control, and common shutdown alarm annunciation.

Each engine generator section also include an electronic speed control to control the engine speed, an electronic, solid-state, digital voltage regulator with cross current compensation for reactive load sharing, a Digital Synchronizer and Load Control (DSLC), microprocessor based generator load control to provide dead bus closure, synchronizing, paralleling, loading and unloading for a “bumpless” connection for oncoming and off going generators,

a control module to convert the high speed serial data link to industry standard RS-232C serial data link for connection to the power plant monitoring system, an interface module to provide remote annunciation, a relay driver module to provide additional relay outputs, software to interface the modules to an IBM compatible personal computer, and a synchronizer panel with a rotary synchronoscope and synchronizing lights.

Each engine generator section, except the Water Plant remote control sections, include a generator management relay to provide phase differential, stator ground, ground directional over current, negative sequence over current, high set over current, restrained phase over currents, over and under voltage, over and under frequency, loss of excitation, and reverse power protection of the generator. The relay also provides monitoring of RMS current, negative sequence current, voltage, three phase power and temperature. The relays will be connected to the computer monitoring system using their RS232 port.

Each engine generator section, including the Water Plant remote control sections, include a bank of engine/generator status lights.

The master control sections of each switchgear lineup include meters and controls. The master control section of each lineup of switchgear include a PLC to function as a load demand monitor to sense the proper number and size of sets required to operate to maintain the connected load. The controller has adjustable set points for initiating the addition to and removal from the bus of engine generator sets based on the bus real load.

Each engine generator section, except the Water Plant remote control section, and each distribution breaker in the switchgear include 1,200 Ampere, 4.16 kV, 250 MVA rated, medium voltage draw out circuit breakers to connect the generators to the bus, and to connect the bus to the outside distribution respectively. The feeders are monitored and protected by a microprocessor based, draw out, protective relay to provide phase time over current, phase instantaneous over current, ground time over current, and ground instantaneous over current protection. The relays are connected to the computer monitoring system by their RS232 port. Each feeder section is provided with a digital power meter to display the kV, kW, kVAR and Amperes for the feeder.

Back-up power for the switchgear is provided by new 125 VDC station battery systems. Each new battery charger, and battery bank, are sized to carry the entire 125 VDC load for the breakers and generator controls. The batteries and chargers were installed in two sets, one in the Water Plant and One in the Power Plant to provide redundancy. The station batteries will be used to provide a reliable source of control power for the switchgear.

1.4.4 Lighting

The majority of the lighting in the building is provided by fluorescent fixtures with energy saving T8 lamps and electronic ballasts. Photocell controlled high pressure sodium light fixtures were used on the exterior of the building.

Dock lights are placed at selected loading dock doors. Interior light fixtures are locally switched. Self contained emergency light fixtures were provided throughout the facility to provide emergency egress lighting. LED type exit signs were provided at each exit from the building, and as required, to provide clear direction to the nearest exit.

Lighting levels in each area comply with the Illuminating Engineering Society of North America's recommendations.

Lighting within the facility is typically provided by fluorescent luminaries using T8 lamps. Wherever possible, fluorescent luminaries are equipped with 277-Volt, energy conserving, magnetic ballasts. Due to limitations on the use of T8 fluorescent lighting at temperatures below approximately 60º F, exterior stairways, landings, and decks are provided with incandescent lighting: Fixtures in these areas are typically equipped with vapor-tight globes and cast-metal guards. Incandescent lighting is normally 120-Volt with 130-Volt light bulbs installed to increase bulb life expectancy.

Surface or pendent mounted high pressure sodium lighting will be provided in industrial atmospheres for interior locations. Industrial strip fluorescent lighting is provided in the mechanical room. General purpose lighting shall be 120V. Lighting levels will be designed to meet or exceed Illuminating Engineering Society (IES) recommended levels. Lighting fixture types will be specified as appropriate for the areas of installation that are classified as hazardous, corrosive, or wet locations.

Emergency lighting consists primarily of ballast-channel-mounted, emergency lighting units (back-up ballasts) installed in fluorescent luminaries.

Exit signs within the facility are typically low-energy-consumption, fluorescent type, equipped with lead calcium, back-up batteries. Self-illumination is provided by tritium gas encapsulated within the signs.

Building exterior lighting consists of high pressure sodium fixtures controlled through time clocks and lighting contactors with hand-off-automatic selector switches. Wall pack fixtures provide lighting for the perimeter of the building.

Light fixtures in the Switchgear Room were located so as to not produce glare on the meters in the switchgear.

Incandescent fixtures with clear glass globes and aluminum guards were installed in the remote radiator enclosure.

Night lights are installed to allow adequate illumination to access the spaces without turning on all the light fixtures.

1.4.5 Heat Trace

Heat trace within the facility was provided for vent-thru-roof piping, and waste piping and drains. Typically, all water supply piping are double traced while drain pipes are single traced. Exterior lines such as the lines to and from fresh water tank #4, untreated water lines, brine lines, sea water lines, lines to and from the Pump House, and 3 inch sprinkler lines may have been heat treated. Self-regulating, self-limiting cabling with thermoplastic insulation, parallel conductors, and a nominal output of 3.28 watts per linear foot is utilized.

The control and monitoring unit located in the Power Plant is used for both the Power Plant and the Water Plant. The control and monitoring unit can control up to 80 heat tracing circuits and can monitor up to 1024 temperature inputs with additional devices added. The control and monitoring unit provides relay output to control heat tracing circuits, provides line current monitoring, ground fault monitoring/protection, RTD inputs and line voltage monitoring.

The control and monitoring unit provides temperature/continuity measurements using power line technology (communicates information through the heat tracing bus wires) when used with the transmitters. The remote monitoring module provides 8 temperature inputs. Communication between the control and monitoring unit and the devices installed on the piping is accomplished using a single RS485 cable.

Heat trace is provided with 120-Volt electrical power and supplied via branch circuit distribution panelboards.

1.4.6 Signal Systems

The signal systems for the facility include telephone, computer local area network (LAN), closed circuit television (CCTV) system, and the fire alarm & detection system.

The fire alarm and telecommunications system in the existing Water Plant was modified as necessary to accommodate the remodel work being done to accommodate the new generators, switchgear and relocated RO unit. A new fire alarm system was provided for the new Pump House. A new CCTV system was installed to allow the operators in the Power Plant Control Room or the Water Plant Generator Control Room to maintain visual surveillance of the generators in the Water Plant and/or the Power Plant.

1.4.6.1 Telephone / Local Area Network (LAN)

The telephone system in the Water Plant was designed in accordance with the BISCI category 5e standards. Telephone system wiring was installed on J-hooks to allow for easy removal of the cables for relocating the modules.

The new LAN system in the Water Plant was designed in accordance with the BISCI category 5e standards. LAN system wiring was installed on J-hooks to allow for easy removal of the cables for relocating the modules.

1.4.6.2 Closed Circuit Television (CCTV)

A new closed circuit television (CCTV) system was installed to allow operators in either the Power Plant control room or the Water Plant generator control room to monitor the generators in the Water Plant or the Power Plant. Monitoring of both plants is necessary as the operators may have to be in either control room when generators in both the Power Plant and the Water Plant are operating. This was accomplished by installing color CCTV cameras at vantage points in the generator room and the switchgear room of both buildings with color monitors and switches installed in each control room to allow any or all cameras in the other plant to be viewed.

1.4.6.3 Fire Detection and Alarm Systems

The new fire alarm system uses an addressable class A system compatible with the existing Station fire alarm systems. The fire alarm system is connected to the Communications Center fire alarm to report all trouble and alarm conditions at the Water Plant. The fire alarm system in the facility includes heat detectors in all spaces, manual pull stations at all exterior doors, fire alarm horn / strobes throughout the facility.

The fire alarm system includes triple IR flame sensors and rate compensated heat detectors for each generator, rate compensated heat detectors in the new radiator room, and smoke detectors in the office area and switchgear room. The triple IR detectors are cross zoned with the heat detectors located above the generators to activate the CO_2 extinguishing system protecting the individual generator. The switchgear room was provided with smoke detectors in accordance with NFPA 850. Any activation of the fire alarm system automatically activates the radio link to notify the McMurdo Fire Department of the alarm.

The Pump House was provided with a new single loop fire alarm control panel, initiating devices and notification appliances. The Pump House fire alarm system will report to the Fire Department via the radio link in the Power Plant.

The fire alarm system in the Water Plant is interconnected with the generator and DDC controls so that the fire alarm system will have the capability of shutting off engine generators and turning off ventilation fans upon detection of a fire condition and prior to releasing CO_2 in their associated building (note that the intent is to have the fire alarm system shut the equipment down directly in accordance with NFPA 72 and only send a signal to the DDC system to let it know that the fire alarm system is shutting down the equipment).

Upon first detection of a fire in the generator room (heat or flame detector), the fire alarm system will shutdown supply and exhaust fans, close the intake and exhaust dampers, shutdown the engine/generator whose fire alarm initiating devices have gone into alarm, shut off fuel to the affected generator,

shut the generator air intake valve on the generator where the fire was detected, activate the CO_2 system pre-discharge horn/strobe lights, and send a pre-discharge alarm signal to the radio link panel. Upon confirmation of a fire, (heat and flame sensor both being activated), the fire alarm system shall release CO_2 for the generator where the fire was detected and confirmed and activate the CO_2 system discharge horn/strobes.

In the event of a fire being detected in the Water Plant Switchgear Room, all generators in the Water Plant shall be shutdown, the tie breaker opened, and the pre-action sprinkler system will be activated.

Separate CO_2 extinguishing system strobe tights and horn / strobes alert personnel to CO_2 system predischarge and discharge conditions.

The fire alarm system wiring is installed in a metallic raceway system dedicated to the fire alarm. Interconnecting wiring between modules is made with cannon plugs to allow for quick disconnect and reconnect during module relocation. The cannon plugs will also prevent mis-wiring when modules are reconnected.

2 OPERATIONS

2.0 GENERAL BUILDING OPERATIONS

The original water desalination plant was completed and tested during the 1985-1986 summer season. Once commissioned in 1987, the Water Plant became the sole source of fresh water. The facility is located adjacent to both the power plant and the ocean, and is housed in a steel framed building that is approximately 80 x 60 feet.

The original building housed an 18,000 gallon sea-water surge tank and two 55,000 gallon fresh water storage tanks, spare parts, chemical storage, a steam boiler, and evaporators. Later upgrades added a third 55,000 gallon fresh water tank inside the building, a larger fourth fresh water tank just outside the building, while converting the boiler from steam to water and removing the evaporator and associated plumbing.

Seawater is piped to the building through an insulated pipeline approximately 3,000 feet in length, while waste brine water is returned to the ocean, again through an insulated pipe, which is several hundred feet long. The incoming seawater pipeline passes through two buildings before arriving at the Water Plant. The first building, the Intake House, is located directly above the vertical riser of the intake structure, while the second, the Pump House, sits 200 feet downstream. The Intake Building houses the top portion of the intake structure, as well as an air compressor which supplies an air bubbler system. The original Pump House contained two seawater intake pumps, pump controllers, heat tape circuit panels and a transformer. The seawater intake pumps draw the water from the ocean and push it to the seawater surge tank located in the Water Plant.

The seawater intake pipeline is insulated and heat taped with two separate heat tape traces. The pipeline is also equipped with an alarm system to alert maintenance personnel of low pipe temperatures which signify heat tape failure.

The intake structure is almost entirely hidden by water and or dirt. The structure is fabricated from reinforced concrete pipe that rests on the ocean floor 60 feet below the surface with a vertical riser in the center of the two arms. Stainless steel screens cover the two pipe ends to prevent large marine life from entering the structure.

The present fresh water storage capacity provides a buffer of fresh water, allowing the system to be shut down for maintenance and repairs for a limited time without interrupting water flow to the station. This storage capacity also allows peak water demand to be greater than the distillation process output, as well as providing a source of water for fire fighting purposes.

The fresh water is distributed to the buildings in McMurdo using an above ground insulated piping system, with pressure and flow being maintained by a constant pressure pump unit that is also located within the Water Plant building. The fresh water can be chlorinated if deemed necessary, as a chlorination system is installed.

The use of the 18,000 gallon seawater tank provides a buffer for the system and allows the seawater supply pumps and pipeline to be shut down for several hours at a time, The remaining equipment in the original Water Plant design is used in the process of producing fresh water or is ancillary to equipment needed to support the system.

In summary, the original Water Plant, completed and placed in service in 1987, was capable of producing over 70,000 gallons per day (gpd) of fresh water at times of peak demands, though the system was only designed for a continuous output of 40,000 gpd. The production rate of 70,000 gpd cannot be sustained for more than several days due to excess demands on auxiliary equipment. Seawater is transported to the plant by a pipeline from the intake site, approximately 3,000 foot distant, while the brine, or concentrated waste, is dumped into the ocean directly downhill from the facility. Fresh water is provided to the buildings of McMurdo by a pumping unit, located in the Water Plant, which pressurizes the distribution system.

The concept intent for the newest upgrades is to replace aging water treatment equipment and to provide a redundant power plant system in the Water Plant for use in stand-alone situations. This was accomplished by adding room for two new power generators, cooling radiators for the generators, switchgear, and a fuel oil daytank. The water treatment process was also improved by replacing the seawater surge tank with several expansion tanks and eliminating the reverse osmosis (RO) high pressure pump.

The most recent upgrade also added a new pump house to accommodate additional equipment for the reverse osmosis (RO) unit #3 to operate as a stand alone system.

2.1 ARCHITECTURAL / STRUCTURAL SYSTEMS

2.1.1 Building Systems

2.1.1.1 Foundation

The foundation of the building consists of conventional concrete footings placed on compacted structural fill. From the footings arise anchor bolted steel piers that raise the building approximately 3 feet (914 mm) to reduce heat flow into the ground and allow the wind to scour the underside of the building to minimize snow drifting under and around the building, and prevent the snow from blocking access to under the floor utilities. The floor consists of conventional steel flooring joists with cross bracing. Soffit panels are bolted to this frame, with pre-cast concrete panels anchored into the soffit.

Since the existing foundation in the Water Plant was designed for a 2,000 pound-per-square foot (psf) bearing pressure, a new 4,000 psf precast concrete foundation was constructed under the purposed location for the two diesel engine generators.

Flooring between the generators and the building exterior was modified to accommodate moving the generators in and out of the building.

2.1.1.2 Floor, Wall, and Roof Panels

The floor, wall and roof panels are 41-9/16 inches by 30 foot insulated panels. The panels are metal faced over-lap sidelap 24 gauge steel. Fasteners are located in the major ribs when the panel is used as a roof and in the pan when the panel is used in a wall application. The six (6) inch thick panels are filled with poured in place non CFC polyurethane modified isocyanate foam with a least a 90% closed-cell structure with an “U” value of 0.025 (R-40). The insulated panel interior metal liner acts as a vapor retarder. The wall and roof panels installed on the SSC Building are “Sandblast” in color.

The radiator enclosures are not be kept at the same internal temperature as the existing building, although they will be provided with some heat. Thermal breaks between this structures and the balance of the facility was required to minimize thermal bridging. All exterior materials are factory pre-finished, with no requirements for field painting. Siding is metal sandwich panels, with an interior and exterior metal skin bonded to a foam insulation core. The color, texture and profile of the panels was selected to match or compliment the adjacent existing panel systems. Roofing is similar to the insulated panels at the walls, of unventilated “hot-roof” design, with slopes arranged to protect personnel and overhead door access. New overhead and personnel doors, frames, and hardware is of heavy-duty, insulated construction.

Interior flooring within the radiator enclosure, as well as the rest of the new additions, is steel plating covered with a protective epoxy coating. The existing flooring in the Water Plant is pre-cast concrete slabs covered with a non-slip epoxy coating.

2.1.1.3 Stairs / Landings

Several steel landings and walkways with galvanized steel stair and deck entrance gratings were added as part of the upgrade. The landings consist of steel framing and stairs made of metal gratings covered with an abrasive material with accompanying metal supports. The abrasive material on the landings and stairs protect personnel from slips and falls. Treads and landings are protected from snow accumulation. Handrails were provided for the safety of personnel.

2.1.2 Windows and Doors

2.1.2.1 Windows

The Water Plant and Pump House do not contain any exterior windows. The Water Plant contains two (2) interior windows for the operators to view operation of the diesel engine generators. These viewing windows contain a 21/8” inch thick 2-hour rated glazed panel mounted in 20 gauge cold rolled steel C studs and track.

2.1.2.2 Interior/Exterior Doors

There are a variety of doors within the Water Plant and only one exterior door on the new Pump House. All doors are man-doors except for the two roll-up overhead exterior doors used to move the generators in and out of the facility. Most, but not all, doors incorporate smoke seals and closures. Unless noted otherwise, all doors contain a standard passage doorknob with / without a lock.

Exterior access to the personnel doors will be by a stair, landing, and railing assembly for close snow grooming and module relocation.

The various door types are described in their own sub-sections below:

Type A Doors: Type “A” are hollow metal doors with metal frames. The outside set of doors are thermal break hollow metal. The doorknob must be levered to open the door. (Size for each is 3’0”x 7’0” x 13/4” thick).

Type B Sectional Overhead Door: Type “B” doors are double wide hollow steel doors with a metal frame. These doors are raised and lowered by electric lift mechanisms. (Size for each is 10’0” x 10’0” x 4” thick.)

2.1.2.3 Sound Control Doors

The sound control doors are type “A” interior doors used on the Generator Room to minimize noise. Besides the doors being sound proofed, the frames and jambs are also sound proofed. The doors are also either 60 or 90 minute fire rated.

2.1.2.4 Sectional Overhead Doors

Two sectional overhead doors are used in the Generator Room to facilitate moving the generators in and out of the building. Both doors are made of 13-gauge galvanized steel mounted on steel rails. Each door has either a torsion spring or weight counter-balance to assist in raising and lowering it. The doors are raised and lowered using a 1/2 hp trolley mounted power hoist. The powered hoist is operated by a two (2) button control box. Constant pressure is required on the buttons to lower or raise the door.The two button control box also incorporates an automatic reverse to raise safety feature.

2.1.3 Interior Specialities / Fixtures

2.1.3.1 Fire Extinguishers and Cabinets

Manual handheld and wheeled fire extinguishers are available for putting out small fires before they trigger the sprinkler system. A / B / C fire extinguishers are provided in several locations within the building. The extinguishers are dry-chemical units, rated 1-A: 10-B: C. As such, they are suitable for all three types of common fires.

To properly use a portable fire extinguisher, the operator should stand 8 - 10' away from the fire and follow a 4-step procedure known by the acronym **PASS**:

PULL the safety pin completely out of the extinguisher valve.

AIM the discharge nozzle at the base of the fire.

SQUEEZE the discharge lever to release the extinguishing agent.

SWEEP the discharge from side-to-side across the base of the fire.

WARNING:

Never attempt to extinguish fires with fire extinguishers unless properly trained in the operation of the specific type of fire extinguisher.

Failure to follow this warning can cause serious personal injury, death or major property damage.

Normal operation is to pull the ring, point the extinguisher at the base of the fire (within 12 inches) and CO_2 fire protection system that will operate if the fire gets out of control. All fire extinguishers need to be routinely inspected by safety personnel to verify that the charge is maintenance.

Safety cabinets were provided for type I and type II safety containers up to five (5) gallons throughout the facility. All cabinets have high visibility, tri-lingual labeling, fail safe closing mechanisms, vents, and spill catching shelves.

2.1.3.2 Collateral Equipment

Consult the vendor information contained in Appendix Section 4.2.1.4.2 of this manual for operating procedures.

2.2 CONVEYING SYSTEMS

2.2.1 Monorail Hoist

The monorail hoist is used to simplify the task of moving heavy and/or bulky items around, into, or out of the South Room. The electrically powered, trolley mounted, cable hoist is mounted over reverse osmosis unit # 2. Optional tools can be used with the hoist, such as a pallet lifter, to make moving and lifting tasks easier. Hoist operation is operated using a pendant control system. The hoist is insulated and electrically heated. It is designed to operate at temperatures as low as -20º Fahrenheit (F).

The hoist trolley is motorized and has a maximum rated travel speed of 30 feet-per-minute. The hoist has a maximum lift capacity of 1 Ton, a maximum lift distance of 54', and a travel speed of 14' per minute.

WARNING:

Safe operation of an overhead hoist is the operator's responsibility. Hoist operators should be familiar with the principal parts of the hoist and have a thorough knowledge of hoist control functions and movements. Unqualified personnel should not operate the hoist.

Follow warnings and operating practices from American National (Safety) Standard ASME/ANSI B30.16 which are intended to avoid unsafe hoisting practices which might lead to personal injury or property damage. These recommendations apply to all electric and air powered hoists for vertical lifting service involving material handling of freely suspended unguided loads.

Failure to follow this warning can cause serious personal injury, death or major property damage.

Before Operating Hoist:

1. Do not operate hoist unless you are properly trained, physically fit, and authorized to do so. You must be familiar with all operating controls of the hoist, warnings and instructions on the hoist, the safe hoisting practices listed in the product manual, *ANSI B30.16 Safety Code For Overhead Hoist*, and all pertinent Federal, State, and local regulations before beginning operation.
2. Do not allow unqualified personnel to operate the hoist.
3. Test all controls and limit switches and make sure hoist is well lubricated at the beginning of each shift. Make sure needed lubrication, adjustments, or repairs are made by appointed personnel before operations are begun.

4. Be familiar with the equipment and its proper care. Do not operate hoist if adjustments or repairs are necessary, if any damage or undue wear is known or suspected, or if any warning, operating, or capacity instructions normally attached to the hoist are damaged, obscured or missing. Report these items promptly to the proper person, and also notify the next operator when changing shifts.
5. Do not operate hoist if it is functioning improperly.
6. Do not operate hoist with an out-of-order sign attached until sign has been removed by a properly authorized person.
7. Do not adjust or repair hoist unless qualified for maintenance of hoist.
8. Be sure the power supply is disconnected/locked out/tagged before maintenance and repair procedure is performed.
9. Do not use the wire rope as a ground for welding.
10. Do not touch a welding electrode to the wire rope.

Applying the Load:

11. **NEVER** wrap the wire rope around the load, or allow it to drag under load.
12. Always use slings or other approved devices to attach load.
13. Be sure the sling is properly seated in the saddle of the hook. Do not allow hook latch to support any part of load.
14. Do not apply a load to tip of hook, or in such a way as to cause bending or prying forces on the hook or hook support block.
15. Be sure wire ropes are not kinked or twisted or that multiple part ropes are not twisted about each other.
16. Do not operate hoist if wire rope is not seated properly in the grooves of the drum or sheaves.
17. Do not load hoist with less than two wraps of rope on the drum, unless a lower limit device is provided, in which case, no less than one wrap shall remain on the drum.
18. Center hoist unit over the load before lifting. Avoid side pull.
19. **NEVER** pick up a load beyond the rated capacity appearing on the hoist, except in properly authorized tests.
20. Do not use a load limiting device to measure the maximum load to be lifted. It is a safety device only.

Moving the Load:

21. Do not engage in any activity which will divert your attention while operating hoist.
22. Respond to signals from designated personnel only, except for stop signals.

23. **NEVER** lift a load with the hoist until you and all other personnel are clear of load.
24. Make sure load has proper clearance before moving.
25. Inch the hoist slowly into engagement with a load, but avoid excessive plugging, inching, and quick reversals of load.
26. Do not lift load more than a few inches until it is well balanced in the sling or lifting device.
27. Each time a load approaching rated capacity is handled, check load brake action by raising load just clear of supports and continuing only after you are sure brake is operating properly.
28. Do not transport load over personnel.
29. **NEVER** carry personnel on the hook or the load.

WARNING:

Do not use the hoists or trolleys for passenger elevator applications.

The safety laws for passenger elevators specify construction details that are not incorporated in your hoist.

Failure to follow this warning can cause serious personal injury, death or major property damage.

30. Avoid swinging of load or load hook when traveling the hoist.
31. On trolley mounted hoists, avoid sharp contact between trolleys, or between trolleys and rail stops.
32. Do not use limit devices as a normal means of stopping the hoist. These are emergency devices only.
33. Do not exceed the maximum duty cycle specified by the manufacturer.

Parking:

34. Do not leave load suspended in the air for extended or unattended periods.
35. Keep load block above head level when not in use.

Basic Operations:

Hoisting motion - The hook should be in the intermediate position. Press the "*UP*" button on the pendant. The resultant movement should correspond with the push-button markings. Observe the speed increase in relation to the steps in the controller. Move the hook to a position *near* the upper hook position and slowly inch the hook into the upper limit position. The limit switch should cause the hoisting motion to stop at the upper limit of travel.

If any malfunction of either the hoist brake or the limit switch is suspected, this condition should be reported immediately before proceeding. The hoist limit switch should never be used as an operating control for stopping the load. It is to be considered as an emergency limit switch only.

After the hook has been brought over the load, lower it until the load can be attached to the hook. As the hook approaches the load, reduce the speed so that the lowering can be stopped smoothly and quickly.

If load slings are used to handle the load, the slings should be fully seated in the saddle of the hook. With the hook latch closed, the hook should be started upward slowly until all slack has been taken out of the slings. Then the load should be lifted slowly until it is clear and it has been determined that the load is properly balanced and the slings properly placed. The hoisting speed may then be increased and maintained until the load is clear of all obstructions or if a hitcher gives the signal to stop.

When lowering loads, the lowering speeds should be gradually decreased until the load is near the place where it is to be stopped. If a hitcher is used, it is very important that the operator pay particular attention to the directions of the hitcher. When the operator is signaled to continue lowering, it should be done at the slowest possible speed.

The operator should check the hoist brake by raising the load a short distance and stopping. Check the load for drift. If no drift, lower the load halfway to the floor and stop. Again check for drift. If load drift is noticed in either step, lower the load to the floor and report the situation immediately.

The load limiting clutch is a friction device, and therefore susceptible to overheating and wear. For optimum performance and long life, RELEASE THE PHSUBUTTON IMMEDIATELY WHEN THE CLUTCH SLIPS.

Trolley motion - Repeat the hoist motion procedure with the trolley by pressing the "*LEFT*" or "*RIGHT*" button on the pendant. Observe travel and limits.

Before a load is handled, the hoist should be brought directly over the load that is to be handled. Failure to center the hoist over the load may cause the load to swing upon lifting.

Start the trolley motion slowly and reduce the trolley speed gradually. For very slight trolley movements, follow inching practices.

(These warnings and instructions are general in nature, for specific information on operating your hoist system, see Appendix Section 4.2.2.1 of this manual.)

2.3 MECHANICAL SYSTEMS

Primary mechanical systems in the Water Plant include heating, cooling, ventilation, water treatment & storage, fire protection, a compressed air system, fuel oil system, generator systems, and control systems. The purpose of the mechanical systems mentioned above is to provide energy efficient, adequate, and reliable engine cooling, engine heat recovery, ventilation and heating throughout the Water Plant.

2.3.1 Heating Generation and Recovery Distribution Systems

In the Water Plant, a single heating loop of 40% water / 60% glycol fluid is used as the main internal heating distribution system. This single internal heating loop is connected to and is personally fed from the Station's main heating loop, and from the waste heat systems in the facility. A single boiler, WHB-1, is a converted boiler that supplements the internal heating loop and will only be used when the temperature of the fluid in the internal heating loop cannot meet the setpoint. This interior heating loop then supplies heated fluid moved by the use of pumps to terminal heating units placed throughout the facility. These pumps increase the pressure of the fluid, and pipes distribute this fluid to and from the terminal units (heating and ventilation coils). The terminal units remove heat from the fluid, as required, to heat the space or air. The lower temperature fluid is returned to the internal heating loop system where the cycle is repeated. Since the fluid entering the boiler is already pre-heated by the internal heating loop system, the boiler uses less fuel oil, which in turn reduces station operating expenses. Pre-heating the fluid also prevents "shocking" the boiler.

The second part of the heating distribution system is the use of recovery waste heat. This heat recovery system captures the usable heat from the generators through jacket water cooling and the exhaust systems. The jacket water exchangers capture the heat rejected to the jacket water and distributes it through the internal heating loop described above. If the heated solution cannot be cooled enough by the internal heating loop, before returning to the generators, the solution is routed to remote radiators (RAD-1 and RAD-2), one for each generator, located in a single enclosure outside the facility. Outside air passing the radiators over is used to extract more heat.

Typically the radiator enclosures will not require heating. The temperature will be maintained by heat rejection from the radiators. Return air dampers, and exhaust air dampers, were provided on the discharge of each radiator to allow for the warm discharge air to either be returned into the room to mix with the colder incoming air, or the warm air will be directed to the exterior if the space is too hot. The goal is to maintain the radiator enclosure at approximately 50° F.

However, with the potential of either generator room operating alone, hydronic unit heaters off of the waste heat system will be provided in each radiator enclosure to maintain minimum temperatures in the space. Portable heaters will need to be used by the local maintenance personnel to provide heat to the radiator enclosure if 'warm' work is required in the enclosure when the power plant or waste heat system is down.

The systems are designed to allow the waste heat loop to be operated independently from power generation requirements and building heating requirements. Both are closed hydronic systems, and each use a mixture of 40% water and 60% propylene glycol.

An integral part of the system is the direct digital control (DDC) System. This system is required to provide the integrated control of all the systems used to collect, distribute, and use waste heat. The DDC system provides control and monitoring of the heating generation and distribution system within the building.

2.3.1.1 Auxiliary Fuel-Fired Boiler

In the Water Plant, boiler WHB-1 is used to increase the temperature of the 40% water / 60% glycol fluid if necessary. Pumps are used to increase the pressure of the fluid, then pipes are used to distribute this fluid to and from the terminal units (heating and ventilation coils) located throughout the facility. The terminal units remove heat from the fluid, as required, to heat the space or air. The lower temperature fluid is returned to the boiler where the cycle is repeated. Since the fluid entering the boiler is already pre-heated by the network system, the boiler uses less fuel oil, which in turn reduces station operating expenses. Pre-heating the fluid also prevents "shocking" the boiler.

There are several safety devices associated with the boiler. These include:

A relief valve on each boiler. If the pressure in a boiler exceeds 30 psig, its relief valve will open. The relief valve reduces the pressure in the system by discharging fluid to the glycol make-up tank. If this occurs, the reason for this occurring must be determined and corrected. Possible reasons for the relief valves opening include:

- the fuel burner not shutting off,
- an over pressurization of the water system by the glycol make-up unit,
- a blockage in the piping system, and
- the boiler's inlet and / or outlet valves closed.

A low water cutoff device on each boiler. If the water level in either boiler drops below a predetermined level, the burner is disabled and heat will not be generated. If this occurs, the reason for it occurring must be determined and corrected. Possible reasons for a low water condition include:

- a break in the piping system, and
- a drain valve left in the open position.

If building supply water temperature drops 10° F (adjustable) below setpoint, 170° F (adjustable), for more then 5 minutes (adjustable), the boiler is enabled. The boiler will run based on internal package controls. If the waste heat glycol supply temperature is greater then the Building supply setpoint of 170° F (adjustable) then the boiler is disabled.

When operational, the fuel burner is provided with electricity. The burner has three stages of operation: off, low fire, and high fire. A sensor in the boiler determines the mode of operation. When the sensor indicates that the fluid temperature is below its set point and the burner is off, the burner starts at low fire.

Before low fire begins, the burner's self-contained control system goes through a series of safety checks, which can take approximately one minute. If all of the checkpoints are satisfied, the burner turns on its fan and a fuel / air mixture enters the boiler to provide heat at low fire.

If the burner's controls do not allow it to operate, an alarm is initiated back to the DDC and the control system energizes the second boiler. The source of burner failure needs to be determined and corrected.

The sensor in the boiler maintains control of the burner once it is operating. The sensor alternates the burner between low and high fire as required to maintain the proper fluid temperature. It will also turn the burner off if the temperature becomes too high. At this time, the entire process must be repeated to enable the burner to provide heat.

Operation of the boiler is controlled by the packaged local controls purchased from the manufacturer and are not part of the DDC. These local controls determine the leaving glycol temperature according to their individual set points. These local boiler controls operate the burner which include pre-purge cycles, fuel delivery, ignition, combustion monitoring, shut down and post-purge cycles. The boiler local temperature controls include the normal on / off operating temperature control, redundant temperature high limit shutdown and the low water cut off. The above controls are to be hard wired according to the manufacturers wiring diagrams.

DDC connections to the boiler wiring is limited to monitoring points and one boiler enable relay connected according to the manufacturer approved wiring diagram.

Upon a drop in main heating loop temperature, the DDC system enables the boiler. The DDC system enabling relay is wired in series with the packaged boiler operating control contacts such that DDC can only cause the boiler to fire when the operating control is also in position to cause the burner to fire.

The DDC system shall monitor status of the low water cut-off, high limit shut down, entering water temperature below 140 degrees F, adjustable, glycol pressure below 5psi, adjustable, and no flow to the boiler. An alarm is transmitted by DDC upon detection of any of these five conditions.

To prevent boiler thermal shock, the DDC system modulates the mixing valve to ensure the fluid returning to the boiler does not drop below an adjustable set point, initially set at 140 degrees F sensed immediately down stream of the valve in the mixed glycol stream.

For the purposes of conformity of nomenclature throughout the station DDC systems programming and drawings, the DDC System uses the following abbreviation format for boiler operation:

B2-ENAB	Boiler B-2, enable
B2-STS	Boiler B-2 status
B1-HWST	Boiler B-1, hot water supply temperature
B1-HWRT	Boiler B-1, hot water return temperature
B1-ALARM	Boiler B-1, alarm
CP3-SS	Boiler Circulation Pump CP-3 start stop
CP3-STS	Boiler Circulation Pump CP-3 status
V-BLR3W	Valve, Boiler three way

NOTE:

Heating plants must not be used without forced system circulation, as overheating / failure of cast iron section may occur.

WARNING:

To avoid fire or explosion hazards, do not store anything against modules or allow dirt of debris to accumulate in the area immediately surrounding modules. Keep the heating plant area clear and free from combustible materials, gasoline and other flammable vapors and liquids. Lint, paper or rags must not be allowed to accumulate near burners. Do not place clothing on module castings to dry.

Failure to follow this warning can cause serious personal injury, death or major property damage.

Follow the information below to prevent severe personal injury, death or substantial property damage:

To Place in Operation:

1. Verify the boiler is filled with water.
2. Open burner mounting door and verify rear target wall, floor and burner door insulations are in proper position.
3. Verify burner mounting door is closed tightly and burner wiring harness is connected to junction box.
4. Factory burner adjustment and settings may not be suitable for specific job conditions.
5. Vent air from system. Air in the system can interfere with water circulation and cause improper heat distribution.
6. Check boiler and system piping for leaks.
7. Inspect breeching and venting for proper operation.

(For additional information on the boiler, see Appendix Section 4.2.3.1.1 of this manual.)

2.3.1.2 Terminal Heat Transfer Units

The interior heating loop supplies heated fluid moved by pumps to terminal heating units placed throughout the facility. These pumps increase the pressure of the fluid, and pipes distribute this fluid to and from the terminal units (heating and ventilation coils). The terminal units remove heat from the fluid, as required, to heat the space or air. The lower temperature fluid is returned to the internal heating loop system where the cycle is repeated.

2.3.1.2.1 Unit Heaters

The purpose of the unit heater is to heat the occupied space. These units can quickly heat the space since they contain a coil and forced air fan. These are installed in utilitarian spaces.

The units are suspended in the space from the structure above. The unit heater consists of a heat exchanger, a cabinet, a fan with a direct connected motor, and adjustable air deflectors.

The unit heaters are in the following locations:

DESIGNATION	TYPE	LOCATION
UH-12	Horizontal	Day Tank Room
UH-13	Vertical	Generator Room
UH-14	Vertical	Generator Room
UH-15	Horizontal	Radiator Enclosure

The unit heaters are connected to the heating fluid by glycol heating supply and return pipes. The supply pipes contain an combination isolation valve and a union with a pressure and temperature tap, a two (2) position temperature control valve, and an air vent. The return pipes contain an combination isolation valve and a union with a pressure and temperature tap. A drain valve is located at the bottom of the heater. The isolation valves are to be in the full open except during periods of maintenance on a specific heater. The drain valve is to be closed.

The temperature control valve is preset to automatically regulate the amount of fluid flowing through the heater. There should be no further adjustment on this valve once system balance and GPM is set.

The air vent removes air from the fluid. This is an automatic operation.

The heating fluid flows though the heat exchanger at all times. This helps place a small amount of heat into the space at all times. The wall mounted temperature sensor turns the fan on and off as necessary to maintain the temperature in the space. The set point of the sensor can only be changed through the DDC system and not at the sensor.

Changing the position of the discharge deflectors can change the pattern of airflow. This should be done to achieve optimum comfort by eliminating drafts and placing the hot air at specific locations.

If the space temperature is too low, the following should be checked to determine the reason for the improper operation of the unit heaters:

- confirm the space temperature setting (set point) established within the DDC system,
- verify that there is electricity provided to the motor by checking that the toggle switch (disconnect switch) at the motor is not turned off, or that the circuit breaker in the panelboard is not turned off,
- verify that the inlet and outlet fluid valves are fully open (the heat exchanger [coil] should feel warm),
- verify that there is no air in the fluid system by operating the air vent until all air is removed and fluid flows from the air vent, and
- verify that the temperature control signal is received by the motor.

The hydronic heaters are monitored by the DDC System. The fan and 2-position MOV cycle to maintain the space temperature setpoint by local space thermostats.

(For additional information on the unit heaters, see Appendix Section 4.2.3.1.2.1 of this manual.)

2.3.1.2.2 Cabinet Unit Heaters

The purpose of the cabinet unit heater (CUH-5) is to heat an occupied space, and because the units contain a forced air fan and a coil, they can quickly heat that space. There is one (1) unit floor mounted in the Switchgear Room. Surrounding air is sucked in through the bottom vents, passes through a filter, and heated air is discharged out the top vent. The cabinet unit heaters consist of a heat exchanger (coil), a cabinet, a fan with a direct connected motor, an air filter, and adjustable air deflectors.

WARNING:

Observe all warning and caution notices posted on the equipment.

Do not operate this equipment or apply electrical power without panels in place.

Normal system operation will cause some components and surfaces to become hot and cause burns.

Failure to follow this warning can cause serious personal injury, death or major property damage.

The cabinet unit heaters are connected to the heating fluid by glycol heating supply and return pipes. The supply pipes contain an combination isolation valve and a union with a pressure and temperature tap, a two (2) position temperature control valve, and an air vent. The return pipes contain an combination isolation valve and a union with a pressure and temperature tap. A drain valve is located at the bottom of the heater. The isolation valves are to be in the full open except during periods of maintenance on a specific heater. The drain valve is to be closed.

The non-adjustable flow control valve is preset to automatically regulate the amount of fluid flowing through the heater.

The automatic air vent removes air from the fluid.

The heating fluid flows though the heat exchanger at all times. This places a small amount of heat into the space at all times. The wall mounted temperature sensor turns the fan on and off to maintain the temperature in the surrounding space. The set point of the sensor can only be changed through the DDC system and not at the sensor.

If the surrounding temperature is below the set point, the following should be checked to determine the reason for the improper operation of the cabinet unit heater:

- confirm the space temperature setting (set point) established within the DDC system,
- verify that there is electricity provided to the motor by checking that the toggle switch (disconnect switch) at the motor is not turned off, or that the circuit breaker in the panelboard is not turned off,
- verify that the inlet and outlet fluid valves are fully open (the heat exchanger [coil] should feel warm),
- verify that there is no air in the fluid system by operating the air vent until all air is removed and fluid flows from the air vent,
- verify that the filters are not dirty and restricting air flow, and
- verify that the temperature control signal is received by the motor.

The cabinet heaters are monitored by the DDC System. The fan and 2-position MOV cycle to maintain space temperature setpoint. An alarm is generated for high and low space temperature.

(For additional information on the cabinet unit heaters, see Appendix Section 4.2.3.1.2.2 of this manual.)

2.3.1.3 Heating Coils

Heating coils (HC-1 and HC-2) mounted in air handlers AHU-1 and AHU-2 are used to heat incoming outside air. The heating coils are controlled by the DDC System.

Heating coils (HC-1 and HC-2) are used to temper (raise the temperature of) outside air passing through the Air Handling Units AHU-1 and AHU-2.

Each AHU blends the outside air with “return air” from within the plant to produce “mixed air” used for ventilation. The AHU re-tempers the mixed air. After the mixed air leaves the AHU and enters the ventilation ductwork, the air is considered “discharge air” or “supply air.”

Each branch of the ventilation ductwork has at least one associated temperature sensor which reports to the DDC System for coils HC-1 and HC-2. The DDC uses the temperature sensor output to determine a control valve setting that maintains the desired output air temperature.

WATER PLANT GLYCOL HEATING COILS		
COIL DESIGNATION	**FUNCTION**	**LOCATION**
HC-1	Heating Coil	AHU-1
HC-2	Heating Coil	AHU-2

(For additional information on heating coils, see Appendix Section 4.2.3.1.3 of this manual.)

2.3.1.4 Heat Exchangers

The primary purpose of the heat exchangers used in the Water Plant is to maintain a desirable separation between piping circuits while allowing heat energy to transfer from a relatively hot fluid on one circuit to a cooler fluid in the other. In the SSC building, the waste heat from the heat recovery system enters the building and flows through the heat exchangers.

The Water Plant is supplied with heating glycol water (HGW) from the main waste heat recovery system through Heat Exchanger (HX-7). Two or three way control valves modulate to maintain a preset glycol water supply temperature of (adjustable). As long as heating glycol return temperature is lower than waste heat glycol supply, the glycol circulation pump(s) run continuously. If the waste heat glycol supply temperature is lower than the building heating glycol return temperature, then the control valve closes and the circulation (s) is disabled.

The other two (jacket water waste heat recovery and exhaust gas heat recovery) waste heat systems operate in a similar manner, each containing their own heat exchanger and control valves. Heat exchangers HX-1 and HX-2 are part of the water jacket waste hear recovery system. Heat exchangers EHX-1 and EHX-2 are part of the exhaust gas heat recovery system. These two waste heat recovery systems are them tied together by heat exchanger HX-9. The main waste heat recovery system is tied into both of these two systems through heat exchanger (HX-7). All of the heat exchanges are of the plate and frame design.

Plumbing going to and from each heat exchange contains a flow control valve, a temperature sensor, a pressure gauge, thermometer, flow meter, and isolation valves to take the heat exchanger off-line for maintenance purposes.

(For additional information on heat exchangers, see Appendix Section 4.2.3.1.4 of this manual.)

2.3.1.5 Glycol / Ethylene Pumps

The glycol heating system uses several pumps to distribute the heated glycol solution throughout the facility. Pumps CP-1 and CP-2 are the main pumps used to circulate solution throughout the primary waste heat loop. These pumps are configured in a duplex operation, with CP-1 being the primary pump with CP-2 as a backup.

Circulation pumps CP-3 through CP-8 are the main waste heat circulation pumps. These pumps are used to fill the loop heating system, maintain system pressure, supply heated glycol solution to the dorms, to other buildings, and supply glycol liquid to the boiler. Similar to the main circulation pumps, these pumps are configured in a duplex operation, with one being the primary pump with other as a backup.

The internal water pumps suppled with the generators are used to pump Ethylene through the water jacket system to cool the generators, and supply additional heat to the facility's waste heat recovery system.

(For additional information on the glycol pumps, see Appendix Section 4.2.3.1.5 of this manual.)

2.3.1.6 Waste Heat Recovery System

Part of the heating distribution system throughout the facility is the use of recovery waste heat. This heat recovery system captures the usable heat from the generators through the jacket water cooling and the exhaust systems. This recovered heat is then fed into the main waste heat loop to be used as a heating source throughout the facility and other Station buildings.

Pumps CP-1 and CP-2 are the main pumps used to circulate solution throughout the primary waste heat loop. These pumps are configured in a duplex operation, with CP-1 being the primary pump with CP-2 as a backup.

Circulation pumps CP-3 through CP-8 are the main waste heat circulation pumps. These pumps are used to fill the loop heating system, maintain system pressure, supply heated glycol solution to the dorms, to other buildings, and supply glycol liquid to the boiler. Similar to the main circulation pumps, these pumps are configured in a duplex operation, with one being the primary pump with other as a backup.

(For additional information on the waste heat recovery system, see Appendix Section 4.2.3.1.6 of this manual.)

2.3.1.7 Hydronics Specialities

2.3.1.7.1 Expansion Tanks

The primary purpose of the expansion tank is used to absorb and maintain pressure control in the hydronic heating system caused by the expansion of the fluid. Through the use of a pneumatic cushion (air) it maintains positive minimum pressure throughout the system when it is initially filled.

As the temperature rises in the system, the expansion tank provides an additional space in the system for the expanded volume of water that results. The upper compartment contains pressurized air, while the lower compartment contains the fluid. The air pressure is used to pressurize the hydronic system. This is accomplished as the pneumatic cushion is compressed as system pressure increases, creating additional space for the increased volume of water.

As the system temperature drops, the compressed pneumatic cushion forces water back into the system, maintaining a positive pressure on the system during all temperatures in the system's operating range.

If properly sized, the expansion tank will maintain maximum system pressures within the working pressure limitations of the system equipment and components.

By maintaining a positive pressure on the system throughout the operating temperature range, the expansion tank can constantly vent excess air through the use of automatically operating float type air vents.

The tank is usually connected to the piping system through an air separator. The only concern with the expansion tank is the eventual failure of the diaphragm. The failure of the diaphragm will result in a loss of system pressure. This can be determined by monitoring the inlet pressure on the hydronic pumps.

Several system in the Water Plant use expansion tanks. The main heating system and the heat recovery system contain four (4) expansion tanks (EXP-1 and EXP-4). Two (2) expansion tanks (ETG-1 & ETG-2) are used in the engine coolant system, expansion tanks (ET-SW1 & ET-SW2) are used in the sea water treatment system instead of the surge tank, and expansion tank (ET-2) is used in the exhaust heat recovery loop.

All the tanks mentioned above have similar functions within their respective systems.

(For additional information on expansion tanks, see Appendix Section 4.2.3.1.7.1 of this manual.)

2.3.1.7.2 Air Separators

Air trapped in a hydronic system can hamper circulation, damage pumps, and cause noise objectionable to building occupants.

Air separators create a low velocity vortex where air will separate from the circulating glycol. Air floats to the top of the separator chamber and is removed via an automatic air vent.

Typically, air separators are located on the suction side of the circulation pump at a high point in the immediate system piping. The air separator chamber also provides the make-up water connection for filling the system with glycol.

Automatic air vents are installed at terminal heat transfer units in the hydronic heating loop. Normally installed at a high point in the plumbing loop, these devices contain a chamber to accumulate trapped air.

As air accumulates in the chamber, a float-controlled valve automatically opens, allowing the air to escape. As the air is exhausted, glycol rises in the chamber, closing the valve and preventing liquid discharge.

A tangential flow air separator is used to remove air in the hydronic system and (AS-1) is used to remove air in the exhaust heat recovery system. When heat is added to the system, air is released from the fluid. When new fluid is introduced into the system, air is also introduced into the system. The air separator is placed at the inlet to the pumps, after the point where heat is added to the system and after the point where new fluid is added to the system. The released air is captured by the air separator and removed from the system through an automatic air vent.

(For additional information on the air separator, see Appendix Section 4.2.3.1.7.2 of this manual.)

2.3.1.7.3 Flow Controls

Flow controls are valves, of brass or iron body construction, used to limit liquid flow to within a specific range. The internal mechanism includes a stainless steel spring operating against a perforated piston or regulator cup to control liquid flow within 5% of its rated setting.

These valves are self regulating and require no external power or signal. They are used on hot water piping to unit heaters, duct coils, finned-tube heaters, radiant panels and heating coils to reduce or eliminate the complexities of manual balancing.

They are especially useful in systems with pumps driven by variable speed motors. Variable system flows caused by variable speed pumps can make conventional flow balancing of large systems very complex.

(For additional information on flow control devices, see Appendix Section 4.2.3.1.7.3 of this manual.)

2.3.1.7.4 Valves

Balance valves are used to maintain flow ratios between parallel hydronic circuits sharing the same source circuit and pumps. The balance valves consist of a brass ball valve with ports for measuring differential pressure across the valve seat area.

These valves maintain a specific relationship between pressure difference and flow. By measuring the differential pressure (port-to-port), the flow can be determined from a chart, or read on a companion meter.

Balance valves are located on all parallel piping circuits. Typically they are set, paint-striped, and locked in position (with a screw) by the test and balance contractor. Once set, they will only need changing if the piping circuit is modified to upset the original flow balance.

Balance valves are used throughout the hydronic heating system.

CAUTION:

Balance valves should not be adjusted in the field. The installation contractor has balanced the system. The valves are marked to indicate the final point of balance. Movement of the valve will change the balance of the hydronic system and will affect other parts of the system. These valves should only be adjusted by personnel that understand the effect on all parts of the system.

This section covers safety relief valves used in the hydronic heating system.

Safety relief valves are designed, tested, and rated to open and vent pressure in the event of an over-pressure condition. They are of bronze body construction with teflon seats and stainless steel stems and springs.

They are rated by capacity (in British Thermal Units per hour [btu / hr.] or pounds-of-steam per hour [lb. / hr.]), certified, and labeled for the approved usage by the American Society of Mechanical Engineers (ASME).

Safety relief valves are mounted directly to the vessel protected. The discharge piping size and length is limited according to ASME regulations.

Every closed circuit (or circuit that can be closed by changing valve positions) containing a heating and / or pressure source, is required to have a relief valve for over-pressure protection. Typically, relief valves are used in the hydronic system at the boiler, on heat exchangers, water heaters, main waste heat recovery loop, in the exhaust waste heat recovery system, and in the Jacket Water heat recovery system.

Another type of valve used throughout the various systems in the Water Plant is the ball valve. Ball valves are commonly used where the media in the system needs to be controlled, anything from a trickle to full flow with larger flow rates than other types of valves. Some ball valves are manually operated while others are operated by an actuator.

(For additional information on the valves, see Appendix Section 4.2.3.1.7.4 of this manual.

2.3.1.7.5 Glycol Make-up System

The glycol make-up system is an automatic system used in the hydronic waste heat system (GT-1), in the engine exhaust waste heat recovery system (GT-3), and in the engine jacket heat recovery system (GT-4).

The automatic system consists of a tank, a positive displacement make-up pump, pressure reducing valve, low water cutoff, and controls. The tank contains a fluid mixture of 40% water and 60% glycol. The controls sense a reduction of pressure in the hydronic system. The positive displacement pump operates to add fluid to the system. The pressure-reducing valve regulates the pressure in the hydronic system. Once the pressure is at the proper level, the pump turns off.

Once the system if filled to the correct pressure, ensure that there is an adequate (2/3 full) in the storage tank. The tank will now feed solution automatically to maintain the desired system pressure.

The diverting valve is be used to agitate or mix the solution in the tank. Turn the valve handle so that it is vertical, the pump will start automatically and re-circulate the solution in the tank. When the solution is adequately mixed, turn the valve handle back to the horizontal position. The pump will re-charge the pressure tank and shut off automatically.

The DDC system monitors system pressure and tank water level. Alarms are generated for low system pressure below 5 psi, adjustable and low water condition in the glycol reservoir.

(For additional information on the Glycol make-up system, see Appendix Section 4.2.3.1.7.5 of this manual.)

2.3.1.7.6 Thermometers

Thermometers are installed in various systems with the facility where an accurate temperature reading of the media is required. Most of the thermometers are mounted at a location where it can be read conveniently. Many of the thermometers used have faces or dials that can be rotated for easier display and adjustable pointers. Some of the thermometers used are of the mercury-in-glass design. The maximum temperature range of the fluid should not exceed the maximum temperature rating of the instrument. Temperatures are displayed in fahrenheit, celsius, or both with an accuracy level of +/- 1%.

For applications where the media may be corrosive or contained under pressure, a thermowell was provided to prevent damage to the thermometer and facilitate its removal from the process.

(For additional information on thermometers, see Appendix Section 4.2.3.1.7.6 of this manual.)

2.3.1.8 Suction Diffusers

Pressure drop is the resistance to flow as a liquid moves thru a pipe. It is caused by the viscous shear within the liquid and turbulence along pipe walls. The more the pressure drop the more energy is consumed to overcome it.

The use of a suction diffuser just before a pump assures minimum pressure drop and provides a more uniform flow pattern into the pump.

(For additional information on suction diffusers, see Appendix Section 4.2.3.1.7.9 of this manual.)

2.3.1.9 Water Heaters

The only water heater in the Water Plant is a wall hung single point instantaneous water heater used for hand washing. The heater is specifically designed to be installed under a sink feeding a single faucet. It is designed to take in cold water only and heat it to temperatures suitable for hand washing. The heater incorporates a constant flow device and should only be used with the faucet aerator supplied with this heater.

(For additional information on the water heaters used in the Water Plant, see Appendix Section 4.2.3.1.8 of this manual.)

2.3.1.10 Oil Furnace

The oil furnace in the Water Plant can be used for comfort heating when no other means of heating the facility is available. Since there exists the possibility the furnace is not always used, the following checks should be made prior to using the furnace:

1. Check all oil or gas piping for leaks. In case of a gas leak, have a qualified representative check the installation.
2. Check all sheet metal joints on the ductwork for leakage.
3. Check belt tension on the blower motor drive. Check rotation of the blower by momentarily shorting the fan switch.
4. Set the limit control at 180° F and the fan switch at 140° on - 100° off.
5. Start the burner and check its operation. Oil pressure should be 100 pounds per square inch with the correct nozzle installed. Oil flame appearance should be bright orange and free of smoke. The CO_2 percentage should be between 10 and 11 percent with a number 2 Bacharach smoke or less.

6. Gas flame appearance should have a dark blue base with orange tips extending the length of the firing tube. The CO_2 should be between 8 and 9 percent.

CAUTION:

On all units at full firing rate an over-fire draft of.02" to.05" water column must be maintained. On units equipped with a barometric damper, the damper must be adjusted to maintain this draft. On units equipped with a draft inducer, the discharge damper on the inducer must be adjusted to maintain this draft. (The damper is fully closed at the factory to prevent damage, a good starting point on initial light-off is three-quarters open. After burner air is set, the damper must be re-adjusted to maintain above draft).

7. Check air temperature rise through the unit. Use thermometers on both the intake and discharge and at least three (3) different locations to obtain an average temperature reading. The temperature rise should be approximately 80° F., plus or minus 10%. Adequate air quantities are of vital importance to satisfactory performance and long life of the unit.
8. Allow unit to cycle a number of times on controls to be sure that they are operating correctly. Interrupt fuel supply to the burner to be sure that the safety control functions correctly.
9. Keep the room clean containing the furnace. Do not allow rubbish, boxes or trash to be left around the equipment, especially at or near the air inlet.
10. Conduct the follow-up examination of the unit approximately two or three weeks, after the installation is completed. Repeat all checks noted above.
11. When the burner is fired for the first time, the flame should be observed and if any air adjustment is.necessary, the iris shutter air settings can be made by adjusting the linkage arm to give the proper air for combustion over the full firing range.

(For additional information on the oil furnace, see Appendix Section 4.2.3.1.9 of this manual.)

2.3.2 Ventilation Systems

The ventilation system used in the Water Plant is composed of equipment such as air handlers and fans that provide both incoming fresh cooler air and exhaust unwanted air.

Incoming ventilation air is provided to all occupied spaces to replenish exhausted air, provide combustion air for the boiler, and to provide air for heating and cooling purposes. Usually, as an energy conservation measure, minimum outside air ventilation rates were used for design, or planned for operation. This minimizes the energy required to heat outside air. Ventilation rates provide safe and reasonable quality of indoor air, but are minimized to keep energy use as low as possible.

Air handlers and intake fans provide fresh incoming air for heating, cooling, and ventilation.

Exhaust fans eliminate air from the facility because of pollution, heat, or to maintain a positive pressure level within a confined space.

Variable-air-volume systems and fans with variable-speed drives serve spaces where air requirements are subject to change.

The DDC System monitors the status of the intake fans and the exhaust fans. DDC increases outside air intake as exhaust fans are turned on and decreases intake when the fans are turned off.

Two (2) ventilation systems exist in the Water Plant comprised of motorized dampers, heat coils HC-1 and HC-2, mixing box, and air handler units AHU-1 and AHU-2.

2.3.2.1 Air Handling Unit

The air handling units (AHUs) provide cooling and fresh air to building spaces. Typically, an AHU is built-up of air-tight sections, and contains an air preheating coil, a mixing box with dampers, air filters, a heating coil, and a fan. Access doors are provided on both sides of the sections for service. The fan is fitted with a differential pressure switch piped from the suction side to the discharge side to sense fan operation.

Fans are variable speed. They are set either to maintain a specific down-stream static pressure in the duct, or for a schedule of 100% (full speed) in the summer and 75% otherwise. In applications where the fan is set to maintain duct static pressure, Variable Air Volume (VAV) boxes are typically used to control the air volume flowing through individual branches of the ductwork.

As air passes through the ventilation system, it undergoes a series of processes that prepare it to meet the heating, cooling and ventilation load of the conditioned space. After each process, the terminology used to describe the air changes:

Outside Air as its name implies, is air that is being drawn into the system directly, from outside of the building.

Return Air is air that is drawn back into the ventilation system after circulating through the conditioned space.

Mixed Air is a combination of outside and return air, as it leaves the mixing box.

Supply Air is mixed air that has passed through the fan (and possibly through a cooling, heating and/or reheating coil, whether or not it is cooled or heated) and is ready for delivery to the conditioned space.

The Water Plant contains two (2) such air handlers, one located in the Switchgear Room and the other is located above where the seawater surge tank was located. Both air handlers contain heating coils designed to pre-heat the incoming outside air. Since these heating coils use liquid like the unit heaters, they are fed from the glycol heating loop.

Both air handlers contain an averaging temperature sensor and two modulated dampers. One modulated damper controls the incoming outside air and the other controls the amount of pre-heated air from the facility back into the AHU. A mixed air controller modulates these two dampers based on input back from the averaging temperature sensor.

Operation of the air handlers is under DDC control. The air handlers can be manually started, stopped, or set to run continuously. The outside air damper is closed when the air handler is off to prevent the flow of incoming cold air. A mixed air controller modulates both the outside air and return air dampers to maintain the setpoint discharge air temperature.

The setpoint discharge air temperature is adjustable from 50 degrees F to 75 degrees F using the room temperature transmitter. Areas with re-heat coils maintain room temperature by modulating their respective 3-way valves.

CAUTION:

The use of untreated or improperly treated water in unit coils may cause scaling, erosion, corrosion, algae, slime or other equipment damage. Consult a qualified water treatment specialist to determine if water treatment is required. The manufacturer assumes no responsibility for equipment damage caused by untreated or improperly treated water.

Whenever the operating conditions of the fan are to be changed, (speed, pressure, temperature, etc.) The manufacturer must be consulted to determine whether or not the unit can be operated safely at the new conditions.

Failure to follow these instructions can result in minor or moderate injury.

The DDC alarms if the supply air fan should fail to operate after initiated.

The AHU may stop operating due to any of the following conditions:

- lose of power,
- low temperature in the duct system,
- smoke in the duct system,
- a signal from the fire alarm system,
- a broken belt that connects the fan and the motor, or
- fan/motor failure.

A more detailed explanation of operation for the air handlers can be found in Appendix Section 4.2.3.2.1 of this manual.

2.3.2.2 Ventilation Fans

Three (3) such ventilation fans are in the Water Plant, two are located in the engine room and one is located near the boiler. The engine room combustion and ventilation system is sized to cool the surrounding space with a minimum of three (3) generators operating at full load, and the radiated heat loss of the associated engine coolant and waste heat system piping and equipment. The estimated heat rejection to the atmosphere from both the engine and the generator is approximately 10,650 Btu/min (639,000 Btu/h) per engine. The combustion air requirements for each generator is approximately 5,500 CFM at 100% load. This air is supplied by the ventilation system. In the event of an emergency, the size of the ventilation ductwork alone even without the ventilation fans operating is sufficient to provide required combustion air.

The ventilation system consists of two (2) duct mounted 15,000 CFM propeller ventilation fans (Equip. designator VF-1 and VF-2) with a mixing box designed to provide the required cooling and combustion air, and a motorized damper controlled relief fan (Equip. designator RF-1). The mixing box mixes outside air and interior space air to provide 50° F cooling air (adjustable). In addition to the ventilation fans, relief air fans have been designed to maintain the generator rooms at approximately.05” W.C. positive in relation to the exterior. The use of the relief fans is necessary due to the large amount of ventilation air required. The fans sequence of operation allows the amount of required ventilation to track the number of engines in operation. The ventilation fans also provide combustion air to the diesel generators.

The third ventilation fan located near the boiler is used to provide combustion air for the boiler. Combustion air needed for the boiler is brought in from outside the building, rather than drawing air from inside the facility. This outside air is brought into the Water Plant through an intake duct that are relocated on the North wall. The air intake is equipped with a motorized louver system that is automatically operated by the boiler controls.

When a boiler is started, the modutrol motor mounted in the corresponding intake opens the louvers if the switch mounted on the wall is in the on position. The louvers close when the boiler is shut off, or if the switch on the wall is manually moved to the *OFF* position. The combustion air intake controls are also connected to the fire alarm system, which automatically closes the louvers whenever a fire is detected within the facility.

The outside air intake dampers on all three ventilation fans are controlled by the fire alarm system to close prior to activation of the CO_2 fire suppression system. The fans are interlocked with the Fire Alarm System to shutdown in the event of a fire and subsequent discharge of the CO_2 system.

(For additional information on ventilation fans installed in the Water Plant, see Appendix Section 4.2.3.2.2 of this manual.)

2.3.2.3 Paddle Fans

The four (4) paddle fans (PF-1) in the Water Plant provide air circulation in their respective rooms to keep the air from stratifying into thermal layers.

The fans are controlled by local wall mounted variable speed controllers. The controller provides adjustable speed operation at any point between minimum and maximum fan speeds.

To turn the controller *ON*, turn the knob clockwise until a click is heard. To reduce fan speed, continue rotating the knob clockwise to the desired speed setting.

(For additional information on paddle fans installed in the Water Plant, see Appendix Section 4.2.3.2.3 of this manual.)

2.3.2.4 Exhaust Fans

Four (4) such exhaust fans are used in the Water Plant, two are located in the radiator enclosure, one is mounted on the North end of the pipe rack, and one in the generator room. The damper controlled relief fan in the generator room is used to exhaust air to maintain a slightly positive air pressure in the generator room with respect to the outside air pressure. This prevents cold air from entering the building and relieves excess air brought in by the two ventilation fans. The relief fan works in conjunction with the ventilation fans. If air flow from the ventilation fans increases in order to provide more cooling in the generator room, then RF-1 will automatically increase its air flow to exhaust the extra air and maintain the desired room pressure.

The two exhaust fans in the radiator enclosure are provided to automatically exhaust air to the outside if the temperature of the enclosure reaches a pre-determined set point.

The Water Plant is also equipped with an exhaust fan that is mounted on the North end of the pipe rack. The fan is ducted through the roof and is used to draw warm air out of the building. It is controlled by a breaker switch mounted in electrical panel "LP-1". The unit was originally wired such that it had to be on whenever the unit heater was operating. This has been changed so that the exhaust fan is independent of everything other than the fire alarm. If the fan is running and a fire is detected, the fan will automatically shut off. It must be restarted by hand after this occurs. The fan should operate with little attention other than routine maintenance. Use it whenever it is too hot, or stale air and fumes become irritating.

NOTE:

This exhaust fan will not restart automatically after a fire alarm has occurred and the alarm has been reset. The fan must be restarted by turning the control switch *off* and then back *on*.

WARNING:

If the exhaust fan is left running overnight when the unit heaters are off and no equipment is operating to generate heat, freezing of equipment and pipes may occur. The fan will draw much of the warm air out of the building. Do not leave the exhaust fan running overnight unless regular rounds are made.

The exhaust dampers on all four exhaust fans are controlled by the fire alarm system to close prior to activation of the CO_2 fire suppression system. The fans are interlocked with the Fire Alarm System to shutdown in the event of a fire and subsequent discharge of the CO_2 system.

(Refer to Appendix Section 4.2.3.2.4 of this manual for additional information regarding exhaust Fans.)

2.3.2.5 Weather Hoods

The outside weather hoods are used to vent air out of the building or allow air to enter the building without allowing the weather to enter the building.

Care should be taken to ensure that the screens on the outlets to the hoods do not get plugged.

2.3.2.6 Air Outlets and Inlets

Supply diffusers control air volume, direction, and velocity to optimize comfort, appearance and noise level where conditioning air enters various rooms.

Grilles and Registers provide security, optimize appearance, and control noise.

(For additional information on air outlets and inlets installed in the Water Plant, see Appendix Section 4.2.3.2.6 of this manual.)

2.3.2.7 Air Cleaning Devices

The interior of the Water Plant is maintained at a slightly positive pressure only to limit infiltration of cold air. This slightly positive pressure is possible by keeping the damper on the air handling units at 20% open and the fan running continuously pulling in outside air. As a result, virtually all air entering the facility passes through the air handling units. Consequently, the primary air cleaning device is the filter box inside the air handling units. The filters used in the them are typically 25 to 30 percent dust spot efficient, 2” nominal thickness, modular, replaceable, pleated media units.

Filter gauges are mounted on the outside of the filter housing. The clean filter pressure drop is 0.15 inch water gauge at 260 feet per minute face velocity. Filters should be replaced when this pressure drop reaches 0.57 inch water gauge.

(For additional information on air cleaning devices installed in the Water Plant, see Appendix Section 4.2.3.2.7 of this manual.)

2.3.2.8 Dampers

Dampers are devices used in air systems to regulate the amount of air (cfm-cubic feet per minute) that flows through a duct system. There different types of dampers. There are dampers at the face of registers and diffusers, manual dampers at various points in the duct system, backdraft dampers, fire / smoke, relief dampers, balancing dampers, and so on. The damper may be manually operated as most balancing dampers are, motorized if the air conditions in the space change, or stationary as most pass-through wall dampers are.

Fire / smoke dampers remain open under normal conditions and close upon an alarm indication from the fire alarm system.*Fire / smoke dampers* are installed at critical points in the HVAC ducting system at JSOC. The damper is normally 100% open. The purpose of the damper is to stop the flow of air in the ducting whenever there is a fire. There are two different methods used to control these dampers:

1. A fire link (feasible link) is installed in the duct. The link is connected to the damper. If the temperature at the link (within the duct) is approximately 165° F, the link will melt and allow the damper to close. This stops the flow of air past this point. Access panels are usually installed near the fire damper to allow access to replace the feasible link should it melt.

2. A second device is installed to sense smoke in the duct at the damper. If smoke is detected in the duct and near the damper, a mechanism closes the damper.

Backdraft dampers are counter-balanced to open and allow air flow in one direction but close if the air flow reverses. The counter-balance is adjustable and can be set to open at a specific positive pressure.

The wall-mounted return damper is motorized to open when the ventilation fan is energized. It remains closed at all other times.

The balancing damper is used to balance and regulate air flow through the HVAC ducting system to maintain a certain setpoint of air flow.

Motorized dampers are located at all the exhaust fans, the intake air ducts, and in the air handler. These dampers are spring loaded, normally closed, and open once the fan is turned on.

During an emergency situation, such as fire, all the fans are shut down and the dampers return to their normally closed state.

The balancing damper are used to manually regulate the return air to the air handler based on the amount of incoming air.

(For additional information on dampers installed in the Water Plant, see Appendix Section 4.2.3.2.8 of this manual.)

2.3.2.9 Thermometers

Thermometers are installed in various systems with the facility where an accurate temperature reading of the media is required. Most of the thermometers are mounted at a location where it can be read conveniently. Many of the thermometers used have faces or dials that can be rotated for easier display and adjustable pointers. Some of the thermometers used are of the mercury-in-glass design. The maximum temperature range of the fluid should not exceed the maximum temperature rating of the instrument. Temperatures are displayed in fahrenheit, celsius, or both with an accuracy level of +/- 1%.

For applications where the media may be corrosive or contained under pressure, a thermowell was provided to prevent damage to the thermometer and facilitate its removal from the process.

(For additional information on therometers, see Appendix Section 4.2.3.2.9 of this manual.)

2.3.3 Plumbing

2.3.3.1 Plumbing Fixtures

2.3.3.1.1 Emergency Eyewash

All emergency eyewashes should be tested weekly. A testing tag is attached to each unit and is used to record the date of the test and the initials of the tester. If there is no floor drain available for proper testing of the shower, a container should be used.

Eyewashes should be connected to the main potable water supply, and a loose-key lock-shield type stop or shut-off valve is recommended to allow proper maintenance of the unit. Valve must be labeled to prevent unauthorized shut-off.

When installations are outside and temperatures drop below 32° F, freeze-proof units are recommended. Precautions should also be taken to protect the user under frigid conditions. It shall be the responsibility of each specifying authority to determine the delivered water temperature that will be required in an area, not only to provide the flow of water as required, but also to maintain it at a temperature that will be safe for the user. Delivered water temperature should not be at extremes that might be expected to discourage the unit's effective use under emergency conditions. A comfortable range is 15° C - 35° C (60° F - 95° F). In circumstances where chemical reaction is accelerated by water temperature, a medical advisor should be consulted for the optimum temperature for each application.

If eye protection fails, continuous washing with plain water for 15 minutes should be administered, or serious damage to the eyes may occur.

An eyewash should be connected with piping no smaller than the 3/4” IPS. All eye and eye/face wash units should be attached to a drain by a code-approved method to facilitate ease of testing.

Dynamic water pressure at the eyewash should be no less than 30 pounds-per-square-inch (psi) or more than 90 psi during operation.

More than one eyewash is recommended in areas where multiple eye injuries could occur simultaneously.

To insure adequate operation of the units, all persons should be instructed in the proper use of the eyewash. Affected areas should be rinsed at the scene of the accident for at least 15 minutes, and a doctor or industrial nurse should be contacted immediately.

(For additional information on the emergency eyewash device installed in the Water Plant, see Appendix Section 4.2.3.3.1.1 of this manual.)

2.3.3.1.2 Water Cooler

The water cooler installed in the Water Plant is a self-contained, wall hung electric refrigerated water cooler. This cooler has the capacity to produce 50° F temperature drinking water, based on a 80° F inlet water and 90° F ambient temperature. The non-pressurized tank system is standard. This non-pressurized water tank is located after the bubbler valve, so that the tank is subject to line pressure only when the valve button is pressed. The cooler was manufactured with a waterway system using copper components and completely lead-free materials. These waterways have no lead containing components. All joints are brazed using silver solder only. No lead solder is permitted. A strainer with an easily cleanable removal of water born particulate of 140 microns and larger prior to their entry into the water cooler. The condenser is fan cooled with a copper tube with aluminum fins. The fan motor is permanently lubricated. The cooler was constructed from a one piece stainless steel basin with a smooth deep contoured basin polished to a uniform bright luster. The cabinet is a one piece wrap around design. Properly installed using the materials recommended by the manufacturer eliminates the possibility of metallic tasting water from electrolysis.

Stream height is factory set at 35 psi. If the supply pressure varies greatly, adjustments can be made to compensate for the variations in pressure.

(For additional information on the water cooler installed in the Water Plant, see Appendix Section 4.2.3.3.1.2 of this manual.)

2.3.4 Water Treatment, Storage, and Distribution

It is highly recommended all personnel read and understand the materials provided by the manufacturers of the various equipment in the water treatment system before operating the system. It is important to have an experienced person familiar with the operation of the equipment present the first few times it is used. It is not a difficult task to undertake as long as one is familiar with the facilities and equipment. If all functions correctly, the procedure is easy to accomplish. It is not the intent of this section to detail the exact procedure involved, but rather to offer a high level overview of some of the systems involved in treating the water since procedures do change.

2.3.4.1 Chemical Solution/Injection Systems and Pump Assemblies

Two such systems exists in the water treatment process and are included in this section. The first one is the Hydrogen Sulfide Removal System and the second one is the Chlorination Injection System.

The Hydrogen Sulfide Removal System is designed to remove most of the hydrogen sulfide (H_2S), or sulfide ion, that is present in the sea water. The H_2S, if not removed, would cause considerable corrosion of the system, thus creating the need for frequent repair. Sea water in the McMurdo area can run as high as 2.0 ppm, if taken from near the sewer outfall, but contains about 0.2 ppm H_2S when drawn from the present water intake site.

The removal process requires the injection of potassium permanganate into the sea water and further along in the stream, filtering of the water to remove the precipitate that forms. If the pH of the sea water is below 6.5, sodium hydroxide (NaOH) is added in sufficient quantities to raise the pH to the proper level.

The filtering process consists of passing the treated water through a vessel containing manganese zeolite, charcoal, and a bed of sand and gravel. The filters require a backwash system to periodically remove the trapped precipitate which plugs the filters.

Instrumentation is included in the H_2S removal system to monitor the pH, and sulfide ion content of the incoming sea water, and the sulfide content of the treated, or sea water after leaving the filter vessels. This is accomplished by using continuous flow sensors that are mounted in parallel with the sea water feed line to the evaporators. The instrumentation does not control chemical injection rates, nor does it turn equipment on or off, but does display readings so that they can be monitored by the operators.

The water Chlorination and Soda Ash Injection System immediately follows the Calcium Carbonate Tanks. The Chlorination and Soda Ash Injection System is used to inject Chlorine into the fresh water system to provide a means to restrict the growth of bacteria in the potable water. The system installed in the Water Plant uses a dry chemical, Calcium Hypochlorite, that is mixed with water in a small tank to form a chlorine solution. This solution is then injected into the fresh water before it enters the storage tanks. The chlorination system is also equipped with a residual analyzer that indicates the amount of chlorine in the water after treatment.

The chlorine residual level must be above a certain value to achieve adequate treatment results. This is carried out by a duplex chemical injection unit. The chemical injection system has two 55 gallon tanks in which the Calcium Hypochlorite solution is mixed and held. Each tank is equipped with an agitator to aid in the mixing of the chemicals, and is connected to the intake manifold of the pumps.

The rate of chemical injection by the pumps is manually adjustable to rates from 0 to 3.8 gallons per hour. The amount of solution needed per hour is dependent on the amount of fresh water being produced and the strength of the mixture being introduced. The chlorine solution is injected into the fresh water downstream of the water post treatment system.

A chlorine residual analyzer is used to measure the chlorine residual in the fresh water after the chlorine is added. The analyzer samples the water continuously, and gives a visual readout of the chlorine level on a large indicator supplied with the system. The analyzer is mounted on the same skid as the chemical injection pumps.

(For additional information on the chemical solution tanks installed in the Water Plant, see Appendix Section 4.2.3.4.1 of this manual.)

2.3.4.2 Calcium Carbonate Bed Tanks

The three water post treatment tanks are the core of the post treatment system. It is in these tanks that the pH of the fresh water is raised by passing the water through Calcium Carbonate granules. The three tanks are made of a fiber reinforced plastic and are located directly behind the Panalarm board. Each tank is equipped with a water softening unit which is used only as a combined inlet/outlet manifold. Though the unit has a timer and a multitude of valves, its sole purpose is to provide an input and output connection on the tank top. Neither the timer, nor the valves are used. The entering water is channeled to the bottom of the tank through a piece of plastic pipe attached to the head, and is then forced up through the media to the outlet. The water is then drawn off the top of the tank and is pumped to the fresh water storage tanks.

Each tank is partially filled with sand which acts as a diffuser, upon which the $CaCO_3$ sits. A layer of gravel covers the calcium carbonate to prevent it from rising from the bed and flowing into the piping system, A gate valve is placed on both the inlet and outlet line of each unit, valves A526-GV2-1,-2,-3, and B528-GV2-1,-2,and -3, to allow each tank to be isolated. In addition, each inlet line has a 35 gallon per-minute flow nozzle in place, which distributes the flow amongst the tanks being used. The flow nozzle prevents too much flow through a single unit. If the flow through one tank is above 35 gpm, the water may not remain in contact with the media for the time required to raise the pH sufficiently.

NOTE:

The following valve configuration should be used during normal operation:

VALVES A8526-GV2-1. -2. -3 NORMALLY OPEN

VALVES B8528-GV2-1. -2. -3 NORMALLY OPEN

The life of the $CaCO_3$ is dependent upon the amount of water that is passed through the treatment tanks. The units should cause no maintenance problems and will need little attention.

(For additional information on the Calcium Carbonate tanks installed in the Water Plant, see Appendix Section 4.2.3.4.2 of this manual.)

2.3.4.3 Thermometers and Gauges

Thermometers and gauges are installed in the water treatment system where an accurate temperature reading of the media is required. Most of the thermometers and gauges are mounted at a location where it can be read conveniently. Many of the thermometers and gauges used have faces or dials that can be rotated for easier display and adjustable pointers. Some of the thermometers used are of the mercury-in-glass design. The maximum temperature range of the fluid should not exceed the maximum temperature rating of the instrument. Temperatures are displayed in fahrenheit, celsius, or both with an accuracy level of +/- 1%.

For applications where the media may be corrosive or contained under pressure, a thermowell was provided to prevent damage to the thermometer or gauge. Use of the thermowell also facilitates removal of the thermometer or gauge from the process.

2.3.4.4 Fresh Water Storage Tanks

The Water Plant Facility is equipped with three (3) internal and one (1) external 55,000 gallon fresh water storage tanks. This storage capacity provides a buffer of fresh water, allowing the system to be shut down for short periods for maintenance without interrupting water flow to McMurdo. This storage also allows peak water demand to be greater than the distillation process output, as well as providing a source of water for fire fighting purposes.

The tanks are constructed of steel and sit on concrete blocks laying below the floor level of the Water Plant. Each tank has an overflow and drainage system, as well as an outlet to the fresh water distribution pumps. The tanks have gate valves B528-GV11/2-1 and B528-GV11/2-2 on the inlet line. These valves are used to prevent fresh water just produced from flowing into the tank.

If neither valve is open, flooding of the system will occur. These valves are accessed by climbing the ladder to the top of the tanks. The outlets on the tanks are supplied with four (4) inch gate valves, C567-GV4-1 and C567-GV4-2. The tank from which water is to be drawn must have this gate valve open. If both valves are open the water level will equalize between the two tanks, and water will be drawn from both tanks.

NOTE:

The following valve configuration should be used during normal operation:

VALVE C567-GV4-1	**NORMALLY OPEN**
VALVE C567-GV4-2	**NORMALLY OPEN**
VALVE C528-GV11/2-1	**NORMALLY OPEN**
VALVE C528-GV11/2-2	**NORMALLY OPEN**

(For additional information on the fresh water storage tanks installed in the Water Plant, see Appendix Section 4.2.3.4.4 of this manual.)

2.3.4.5 Sea Water Heat Exchangers

The sea water heat exchangers are used to raise the temperature of the incoming sea water from approximately 28° F to 37° F before it enters the filter media.

The sea water heat exchangers operate under continuously changing demands. Loads may repeatedly vary from 0% to 100% of maximum rated flow throughout the day; however, the system will operate at low demand most of the time.

The temperature controller in the control panel operates on domestic hot water (DHW) supply temperature and domestic hot water usage using feedback and fee forward compensation principles.

The PID constants are rapidly changing to adapt to load changes in the process by using the state-of-the-art Adaptive Fuzzy Tuning control. The actual DHW supply temperature is maintained to within +/- 4° F of the set point. The temperature controller clips any overshoots or undershoots in the DHW supply temperature that might exceed the above-mentioned band. Moreover, the temperature controller corrects for the hunting of the 3-way control valve should that happen during low demand.

At full load, the 3-way control valve has the boiler port fully open. At lower demand load the control valve starts modulating to mix boiler hot water with return warm water from heat exchanger. This assists in meeting the demand and maintaining the DHW set point. At all times the flow through the primary side of the heal exchanger is constant.

The DHW supply is maintained at a present temperature ranging from 110° F to 140° F at the outlet of the heat exchange. At low demand periods (nighttime), the DHW set point temperature is automatically reset to lower temperatures to reduce heat loss from recirculating piping, thus conserving energy consumption. The minimum temperature setting shall be 110° F. Return boiler temperature is maintained above 40° F. Should the temperature drop below that limit, an alarm message appears on the control panel's display.

A high limit temperature switch on the DHW side, set at 20° F above temperature controller set point, when activated cuts off the source of heat by closing the boiler port of the 3-way control valve. This will prevent scalding water from reaching the fixtures. Again, an alarm message is indicated on the control panel's display should the DHW supply attain scalding levels.

(For additional information on the sea water heat exchangers installed in the Water Plant, see Appendix Section 4.2.3.4.6 of this manual.)

2.3.4.6 Sea Water (Intake) Pumps

Salt water is taken from the ocean and is transported to the Water Plant by an above ground insulated pipe line system. The incoming seawater pipeline passes through two buildings before arriving at the Water Plant. The first building, the Intake House Building #179, is located directly above the vertical riser of the intake structure, while the second, Building #124, sits 200 foot downstream. Building #179 houses the top portion of the intake structure, the intake pumps, and the controls for the intake pumps. The intake pumps operate in a lead/lag design to draw the water from the ocean and push it to Building #124 where is filtered. From Building #124 the seawater flows onto the expansion tanks that replaced the surge tank located in the Water Plant building. The pipeline distance between the Building #179 and the Water Plant is roughly 3,000 feet.

The submersible pumps are designed for pumping clear, cold water; free of air or gases. Decreased pump performance and life expectancy can occur if the water is not cold, clear or contains air or gasses.

The pumps are operated and controlled by a control box.

CAUTION:

The pumps should never be started unless the pumps are totally submerged. Severe damage may be caused to the pump and motor if they are run dry.

(For additional information on the sea water intake pumps installed in the Water Plant, see Appendix Section 4.2.3.4.7 of this manual.)

2.3.4.7 Fresh Water Piping System

After the fresh water leaves the output of the distribution pump system, the water enters the potable water supply piping. This piping transports water not only to the town distribution network, but also to many places in the Water Plant. Within the Water Plant fresh water is delivered to the chemical solution tanks, the injection chlorination system, the sea feed heat exchanger, the emergency eyewash, and to line P534 which supplies make up condensate to the boiler feed water system.

The chemical solution tanks and the chlorination system use the fresh water for preparing the proper chemical mixes, while the connection to the condensate receiver is to initially supply water to the system, and to add make up water during operation of the facilities. The potable water connection to line P534 is for use during start up of the facility and allows water to be added to the boiler feed water tank.

This water is distributed through the plant by two separate piping systems, E571 and D570. This portion of the system can be isolated from the Station's distribution network using valve D570- BV2-1 located in the pipe rack at the junction of the pump riser and the main pipe run.

Immediately downstream is a pressure reducer which limits the water pressure in the plant to 40 PSI. This branch of D570 then runs the length of the building where valve D570-BV2-2 is located, just before the pipe exits through the wall. This pipe continues on to the Power Plant and ties into the building plumbing system. Two branches are present on this pipe run through the Water Plant; one supplies water to the eyewash system through valve D570-B1-2, while the other supplies water to line E571 through valve D570-81-1. Line E571 supplies potable water to all equipment located within the water plant. In addition, line E571 connects with line P534 allowing the filling of the boiler. This is accomplished using valve E571-GV1-2 located on the cross connection between the lines. This valve should remain closed during all normal operations. Water can be supplied to the boiler during operations using this connection.

WARNING:

Valves D570-BV2-1. D570-B1-1. and E571-GV1-1 must be open during plant operations. If any of these valves are closed. Rapid shutdown of equipment will occur. This situation will possibly cause damage to several pieces of machinery and loss of water producing capabilities.

Water is distributed to the Station through an insulated, above ground piping system. The piping system is connected to the Water Plant distribution pumps through a six inch pipe line that exits the building through the southeast corner. Two gate valves, D570-GV6-1 and D570-GV4-1, in addition to the two butterfly valves mounted on the pump unit, are incorporated into the piping system. Valve D570-GV6-1 is located just before the pipe exits the building and is used to isolate the Water Plant from the distribution network. This valve must be open to pump water out of the Water Plant and to the Station, or to let town water, supplied from a different source, flow into the Water Plant. The flow of water into the Water Plant may be of use if renovations or repairs are made and water must be supplied from the plant on Observation Hill. The second valve, D570-GV4-1, is located on a branch line of the distribution pipe as it runs along the south wall and is used to divert water into the drain line that returns to the ocean. This is for use if the system must be flushed or drained and the water is not of potable quality. It also allows water from the distribution network in town to be drained without having to run it out onto the ground. This valve, D570-GV4-1, must be closed at all times other than flushing or draining of the water lines.

The distribution system to town contains one single line which is located in the pipe rack and along the south wall.

CAUTION:

Valve D570-GV6-1 must be open for fresh water to be pumped out of or to flow into the water plant. Failure to have this valve open may cause shutdown of equipment in the water plant due to lack of water.

WARNING:

Valve D570-GV4-1 must be closed at all times other than when the potable water line is being flushed or drained. Failure to keep this valve closed will result in a tremendous loss of potable water.

2.3.4.8 Fresh Water Distribution Pumps

The fresh water distribution pumps are used to distribute water to equipment in the Water Plant, and to supply water to all of McMurdo. The system is comprised of two constant pressure pumps and a control unit.

The power to the motors and control panel is supplied by a 400 amp module located in the Motor Control Center. This circuit breaker must be *ON* for the system to operate.

The pump system installed in the water plant is a duplex package. The pumps are designed to maintain a constant pressure within the McMurdo water distribution network since it is not gravity fed. A variable speed Hydro constant drive and centrifugal pump is coupled to each of the two 50 horsepower motors. One pump motor operates continuously, with the output pressure and volume of the pump controlled by the Hydro constant drive. If the pump controls are in the *AUTO* position, the second motor-pump combination will start if the system pressure falls below a preset level for a length of time. The continuously running pump is termed the lead pump, while the second pump is the lag. The lead/lag pumps are alternated automatically every 24 hours by a timer located within the control panel, if the controls are in the *AUTO* position.

The controls consist of a main power switch, two 3-position switches for the pumps, an indicator light, a test button for valves one and two, a low suction shutdown indicator light, a thermal cutout light, and a silence/reset button.

The 3-position switches for Pump #1 and #2 have an *OFF, HAND*, and *AUTO* position. Under normal operations the switches should be placed in the *AUTO* mode. This allows the pump control panel to alternate the pumps and to bring the second unit on-line when needed. The *HAND* position of the switch turns the pump on regardless, bypassing the controller. This switch position is used when the controller is not operable, or when the controller is not supplying the desired commands.

The second set of controls consist of a pilot light and test pushbutton for each of the two pump units. The pilot lights are labelled “valve #1” and “valve #2”, while the push buttons are labelled “test #1” and “test #2”. The lights indicate whether the solenoid valves, allowing circulation of water through the pumps at times of low demand, is energized. The valve is energized and allowing circulation when the pilot light is lit. The test buttons are used to verify operation of the solenoid valves.

NOTE:

The pilot lights and therefore the solenoid valves, should not be lit under normal operating conditions unless the stored water is hot.

The purpose of the above system is to prevent overheating of the water in the pump when there is no water being delivered through the distribution network. The pump impeller spins at low speed when there is no demand for water heating the water in the pump casing. If no water is delivered for an extended period, the water in the pump casing can become very hot, causing damage to the pump unit. A temperature sensor located in the casing causes the solenoid valve to energize, or open, when the water temperature rises too high. This allows water to flow out of the casing and back into the input line, cooling the pump. Unless the water in the storage tanks is quite warm, this valve will remained closed. If the pilot light is energized, verify the pump output valves are open and that water can flow to the Station.

The low suction shutdown pilot light indicates a low water level condition in the fresh water tanks. The pump(s) will automatically be stopped if a low water condition exists in the fresh water tanks. This alarm and stoppage of the pumps can be bypassed using the switches located on the side of the control panel. There is a switch for each of the tanks. The low water level shutdown pilot is controlled by the level sensing system installed in each of the tanks. This system is an integral part of the Panalarm network.

The final pilot light on the control panel is the thermal cutout. This light indicates that a high temperature has been detected in either the Hydro constant drive or pump casing. If a high temperature is detected, the pump affected will be automatically shut down and cannot be restarted until the condition is cleared.

The final control on the panel is the silence/reset button. The use of this feature is straight forward. It silences the alarm horn when a fault condition occurs, and resets the controller after an alarm condition is cleared.

Additional controls are located within the panel itself. These include start and stop pressures for the lag pump, minimum run period times, and the pump start delay times. These are programmable sequencing controls that are set once at the time of installation. This portion of the control system needs no adjustment unless sufficient water is not being delivered during peak usage periods. These controls should also be adjusted if the pump output pressures are changed more than 5 psi.

The Hydro constant drive portion of the distribution system is responsible for maintaining a constant pressure in the Station's water piping. The Hydro constant drive is a variable speed transmission, whose output RPM is controlled by water pressure in the piping network.

The Hydro constant drive has two controls that must be set during initial startup and at intervals during operation. The first of these controls is the pressure adjustment knob located on the top of the drive unit.

This controls the pump output pressure. Clockwise rotation increases the pressure, and conversely, anti-clockwise decreases it. Once set, this knob should need little attention other than a routine glance at the water pressure in the distribution piping. If the pressure is not correct, adjust this control to obtain the desired setting.

The second control located on the unit regulates the temperature of the oil that is used in the drive. The oil acts as the coupling agent between the input and output sides of the drive. At times of low water demand the rotational energy of the drive motor is converted to heat.

The Hydro constant Drive is equipped with a heat exchanger to maintain an oil temperature of 140° F, or below. A manually adjusted thermostat is used to control the flow of cooling water to the exchanger. This thermostat must be adjusted during initial start up of the system. The temperature of the oil should be routinely monitored and the control adjusted as needed.

WARNING:

The oil temperature of the hydro constant drive must be below 150° F. Rapid deterioration of the oil and excessive wear of the unit will occur if oil temperature is allowed to exceed this limit.

The pump and motor portions of the water distribution system have no controls, and therefore require only routine inspection and maintenance. The pump and motor should be checked frequently for excessive heat, vibration, and wear. Before starting a pump, make certain that water can flow to the unit, and after starting, water can flow into the distribution piping.

WARNING:

The distribution pump system cannot be used if the water level in the source tank is below the intake line. There are no foot valves inside the tanks and the pumps are not self-priming. The pumps will continue to operate if the water level falls below the intake height during operation. If it appears that the water level will fall below the intake height, do not shut down the pump in operation unless absolutely necessary.

(For additional information on the fresh water pumps installed in the Water Plant, see Appendix Section 4.2.3.4.8 of this manual.)

2.3.4.9 Sea Water Expansion Tanks

Hanging off the system between the heat exchanger and the filter media are new water expansion tanks to take the place of the surge tank. These expansion tanks can supply water to the treatment system for a certain time frame if the sea water supply should stop. During normal input of sea water, these expansion tanks have no function and are invisible to the system. Because the old surge tank is no longer being used, the RO feed water pump was removed.

The expansion tanks contain a replaceable type pre-charged hydro-pneumatic tank for commercial and industrial well and water system. The tanks are designed to deliver water under pressure between pump cycles to provide sufficient flow to meet demands of the Water Plant.

The primary purpose of the expansion tank is used to absorb and maintain pressure control in the water system caused by the expansion of the fluid. Through the use of a pneumatic cushion (air) it maintains positive minimum pressure throughout the system when it is initially filled. Use of expansion tanks eliminates the continuous operation of the seawater intake pump(s), provides a working supply of seawater, and prevents the possibility of dead-heading the intake pumps should a clog occur in the Water Plant, which could blow pump seals.

If pressure rises in the system, the expansion tank provides an additional space in the system for the expanded volume of water that results. The upper compartment contains pressurized air, while the lower compartment contains the fluid. The air pressure is used to pressurize the hydronic system. This is accomplished as the pneumatic cushion is compressed as system pressure increases, creating additional space for the increased volume of water. As the system pressure drops, the compressed pneumatic cushion forces water back into the system, maintaining a positive pressure on the system during all pressure variations in the system's operating range. If properly sized, the expansion tank will maintain maximum system pressures within the working pressure limitations of the system equipment and components.

(For additional information on the sea water expansion tanks installed in the Water Plant, see Appendix Section 4.2.3.4.9 of this manual.)

2.3.4.10 Reverse Osmosis (RO) Units / Media Tanks

The reverse osmosis system is used to filter out impurities in the water as it is pushed through a membrane at a very high pressure. The water flow through the membrane is significantly affected by the water temperature. At any given pressure, this flow increases with increasing water temperatures and decreases at lower temperatures. Although the system design is based on expected product water temperature of 77° F, the actual water temperature at the Plant is between 28 - 34 ° F depending on the seawater heat exchangers.

It is recommended that the system not be operated at maximum pressures if temperatures are significantly higher than 85° F for any length of time.

The operating pressure has a direct effect on product water quality and quantity. Both factors will increase as the system pressure increases (within design limits). The system must be operated at the lowest pressure required to achieve the designed product water flow rate. Always adjust the system pressure to the product flow. Booster pumps (one for each RO Unit) increase system flow and pressure to approximately 75 gallons per minute at 1000 psi. A turbocharger is used to recovery energy from the high pressure brine flow flow and transfer this energy to the seawater feed stream going into the membranes.

The brine flow over the membrane is very important to both product water quality and quantity. The brine flow through an element should be maintained as given in the its design data sheet. At lower flows, concentration of sparingly soluble salts will foul the membrane surface. High brine velocities can also be a source of difficulty. At excessive flows the elements are subjected to severe stress and physical (telescoping, glue-line fracture, etc.), will result. The total system has been designed with these factors in mind, and should be controlled as specified in the operating procedures.

The electrical conductivity of the product water is measured by the conductivity meter that is located at the front of the electrical panel. The meter is equipped with an adjustable high point setting that allows the poor quality water to be dumped to waste. This meter displays the salinity of the water in micro-ohm's / cm.

The flow meters, located on the hydraulic control panel, monitor the flow rate of the product and concentrate streams. Reduced feed water temperature, membrane fouling, etc., will cause a decrease in product flow. An adjustment of the pressure control valve towards the closed position will result in higher operating pressure; and increase the product flow.

The water pressure to which the membrane elements within the pressure vessels are exposed is normally described as the R/O operating pressure. Pressure gauges are mounted on the hydraulic panel for precise measurement of the operating conditions.

Frequent reading and recording of each of these measurements is highly important for evaluating system performance and in determining corrective measures that may be required.

The media tank assembly consists of a tank with a threaded head (cap) on top. This head has two (2) ports on each side, which are plumbed to two (2) 3-way valves. There is a small engraved "I" and "O" above the ports on the top of the head. To remove the head from the tank, the two valves nuts must be unscrewed at the valves. The head may now be unscrewed from the tank.

Upon removal of the head, a PVC tube will be found inserted into the center hole. This tube will have to be pulled out of the head, capped off with tape to prevent any media to fall inside and plugging the distributor on the bottom of the tube.

This PVC tube should be placed into the tank during the loading of the media and held into position, so that the top end is flush with the top of the tank and that it is in the center of the opening. After the media has been loaded, the tape should be removed from the PVC tube. This procedure will enable the replacement of the head to the tank.

The media load in the media tank consists of bags, and or boxes, or pre-measured ingredients such as gravel, sand, garnet, and carbon or anthracite.

Once in the RO unit, the pressure pushes the water through the membrane filtering out particles and impurities. The brine flow over the membrane is important to both product water quality and quantity. The reverse osmosis valve adjust how much waste brine is going to the energy recovery turbine.

The spiral wound membrane in the RO unit has a spacer, which looks like mesh. This allows seawater to enter, while only fresh water molecules will pass through the “paper-like” membrane. There is also a plastic component which gives fresh water something to ride on as it makes its trip to the center of the membrane. At lower flow rates, concentration of sparingly soluble salts will foul the membrane surface. High brine velocities can also be a source of difficulty. At excessive flows the elements are subjected to severe stress and physical (telescoping, glue-line fracture) will result.

Flow indicators located on the fresh water output side and on the waste side of the turbocharge provide visual indication in gallons-per-minute. The indicators convert an AC transducer signal from a flosensor into a fixed-width positive pulses. Although rate measurements are usually displayed in gallons-per-minute or liters-per-minute, the indicator can be calibrated to measure virtually any volumetric unit from milliliters to acre-feet.

A microprocessor based controller is used to control and monitor a range of parameters, both analog and digital, of the system. Electrodes positioned at various points in the system provide input signals to the controller. The controller than energizes relays in response.

(Refer to Appendix Section 4.2.3.4.10 of this manual for detailed operating procedures).

2.3.4.11 Metering

2.3.4.11.1 pH Monitor and Recorder

The Hydrogen Sulfide Removal System is equipped with a pH monitor that is used to indicate the pH of the sea water after it leaves the sea water feed pumps. The unit consists of a flow through probe that is mounted in parallel with the water flow, and a control and display module. The pH probe is mounted on the pump stand between the sea water feed pumps, while the display module is located on a panel just to the west of the pump stand.

The pH probe consists of an electrode assembly and a flaw chamber through which the sea water passes. The electrode assembly contains a reference junction and a pH sensing electrode which contact the sea water flowing by electrical signal is generated and is sent from the electrode assembly to the display module, where the signal is conditioned. After conditioning, the signal is displayed on an analog scale and if above or below the alarm set points, triggers an alarm on the panel alarm.

The set points are easily adjusted using the two (2) knobs provided on the front of the display module. The pH system was also wired to automatically turn the NaOH chemical feed pump on when the pH level of the sea water dropped below the set point. This feature is not really needed and can be ignored by turning the selector switch to the *off* position.

The pH sensing system needs periodic calibration to maintain the accuracy of the meter. This calibration is achieved by placing the probe in a solution of known pH and adjusting the meter.

NOTE:

The pH of the sea water is of little importance case under must circumstances, the pH meter and accompanying NaOH feed system can be ignored during normal operating conditions. An occasional check of the sea water should be made to verify that the pH is within limits.

The sulfide ion measuring systems are used to monitor the sulfide content of the sea water as it leaves the sea water feed pumps and after passage through the sulfide removal process. The reason for the use of the monitors is so that the operator can change chemical dosage as the sulfide content of the incoming water changes, and is able to detect problems with the system if the sulfide content, after treatment is too high.

The probes are of a flow through design with a portion of the sea water flow diverted through each sensor. The output of the sensors is processed and displayed on two separate monitors mounted at the end of the sea water feed pump stand. The post H_2S removal process sensor system is used to trigger the panel alarm if the sulfide ion content of the sea water is above the set point. This set point should be at a level of 0.1 PPM or below, and can easily be adjusted if need be.

It was found that the sensors tend to drift with time, and therefore need to be adjusted regularly, to be of real use. The proper dosage rate of $KMnO_4$ is easily monitored by taking samples of the sea water as it leaves the filter and at the bed sampling point. The water should have a slight pink color at the bed sample point and be clear at the filter outlet. If any color shows at the outlet, the chemical injection pump should be turned off for an hour and then restarted at a lower injection rate. This method is less refined than using the instrumentation, but is much simpler than trying to mix standard solutions needed to calibrate the electronic sensors.

(For additional information on the pH monitor and recorder used in the Water Plant, see Appendix Section 4.2.3.4.11.1 of this manual.)

2.3.4.11.2 Flow Meter

A flow meter is mounted in the output line of the filter backwash pumps to monitor the flow rate to the filters. The flow meter is battery powered with a long-life lithium battery. The unit displays independently calibrated flowrate and totalizer values. The display shows the flow rate in large numerals and a totalizer value in smaller numerals. Any one of three (3) different totalizers can be selected as the standard display.

The flow rate should be adjusted to approximately 190 gallons-per-minute (gpm) for each filter. This adjustment is best done by using the valves located at the filters themselves, but the valves on the pump output lines can be used. Each pump can produce a flow of 185 gpm, which is sufficient flow to backwash a filter, so no adjustment of valves is normally needed.

(For additional information on the flow meters used in the Water Plant, see Appendix Section 4.2.3.4.11.2 of this manual.)

2.3.4.12 Filter / Compressor

Building #124 contains a self-cleaning screen type water filtration system, electronic flushing controls, and a compressor.

The filtration system consists of a tank body with a first stage mesh screen and a second stage fine screen, a 2" flushing valve and an electronic controller. Pressurized water enters the filter inlet and travels through a 1/8” perforated stainless steel coarse screen where large particles are pre-filtered. The water then passes through a fine stainless steel screen where small contaminants (down to 10 microns) are filtered out. The clean water then exits the outlet.

When the fine screen becomes contaminated, a pressure differential is sensed causing the automatic controller to open the flushing valve. When the flushing valve opens, the pressure is reduced causing the clean water to reverse flow through the filter element pushing contaminants off the screen, through the nozzles, through the water motor and out the flush valve. The water passing through the angular holes in the motor creates a torsional rotation of the nozzles, thus vacuuming the entire inside diameter of the filter element. When the screen is clean, the unit automatically returns to the full filtering mode. The entire cleaning cycle takes approximately four (4) to six (6) seconds and uses 10 to 12 gallons of water. it should be noted that even during the back flush cycle, the filtration process continues uninterrupted.

The electronic flushing control panel is used to set and control how often flushing takes place, duration of the flush, provides power to all filter solenoids, controls the alarm circuits, provides an LCD screen to display backwash and controller status, and manual controls.

An alarm output is activated whenever the controller initiates three or more consecutive back washes by pressure differential signal in less than two (2) minutes. This alarm has both a visible light and an electrical output capable of activating a relay which can, in turn, operate a lamp or a bell. The alarm is resettable with the pushbutton on the controller’s panel.

The compressor is used to pressurize and open/close the 3-way flushing valve connected to the brine line for cleaning and back flushing the filter.

(For additional information on the filter and compressor installed in the Water Plant, see Appendix Section 4.2.3.4.12 of this manual.)

2.3.4.13 Emergency Pump House

The primary purpose of the emergency pump house is to circulate water to and from the exterior fresh water tank, and to sense a pressure drop in the normal fresh water distribution system and activate additional pumps to boost the delivery pressure.

The emergency pump house contains a duplex set of lead/lag pumps intended to circulate water from the exterior tank, through a boiler to heat the water, and then back to the tank. The pump house also contains another set of duplex set of lead/lag booster pumps intended to activate when a higher pressure is needed for emergency situations such as extreme high water pressure for fire purposes.

The pumps in the emergency pump house are in a parallel configuration with the existing normal fresh water distribution system, but is intended to become the main distribution pumps in the future.

2.3.4.13.1 Electric Boiler

The purpose of the electric boiler (EB-1) in the Pump House was provided to heat the water stored in the fresh water tank #4 located outside of the Water Plant.

Water is pumped from the top of the tank by circulation pumps CP-11 and CP-12, through a network of valves to the boiler. The water is heated and returned back to the tank. A thermometer was included in the piping network for visual inspection of the water temperature.

High and low pressure switches were installed to prevent the heating elements from energizing during a pressure drop in the system to protect the elements, or if pressure in the tank exceeds a safe limit and the relief valve should malfunction. The elements cannot energize if pressure is below 30 psi. or exceeds 160 psi. The switches are wired to the control circuit.

The boiler also has a electronic low water cutoff mechanism. This device consists of a probe in the tank which acts as a switch, closed when submerged in water and open when the water level is below the probe, preventing heating elements from energizing.

(For additional information on the boiler installed in the Pump House, see Appendix Section 4.2.3.4.13.1 of this manual.)

2.3.4.13.2 Electric Unit Heater

The electric comfort heater installed in the Pump House was provided to warm the interior of the pump house. The heater is operated manually by the use of a local thermostat.

The heater is equipped with an automatic reset over temperature cutout which de-energizes the heater in the event of an over temperature condition. The cutout will reset itself after the heater temperature returns to normal.

The motor is protected by an automatic reset thermal overload protector built into the motor.

The heater incorporates an automatic fan delay circuit. When the thermostat calls for heat, fan action is delayed for approximately 30 seconds until the heater element is warm. When the desired temperature setpoint has been reached, the fan continues to run until the heater element is cool. This prevents circulation of cold air and allows removal of residual heat from the heater element for maximum heat usage.

(For additional information on the unit heater installed in the Pump House, see Appendix Section 4.2.3.4.13.2 of this manual.)

2.3.4.13.3 Packaged Booster Pump System

The pump house contains new variable speed booster pumps (BP-1 & BP-2). The booster pump set was installed to meet high flow conditions. BP-1 is designed to deliver 150 gallons-per-minute and BP-2 is designed to deliver 1000 gallons-per-minute. Like the circulation pump set, the booster pump set contains a primary and secondary pump. The booster pumps are VFD controlled based on a pressure sensor mounted on the discharge header.

The controller for the pumps is a microprocessor based combination pump logic controller and variable frequency drive dedicated controller for variable volume pumping systems.

The controller consists of a single enclosure containing a microprocessor, an operator interface with four (4) line display and membrane key pad, and a 24 VDC power supply for the pressure sensors. The controller is capable of controlling up to two (2) additional drives for a total of three (3) pumps in parallel.

DANGER:

When in S*leep Mode*, the motor may restart at any time without warning.

When in *Start Delay* Mode, the motor may restart at any time without warning.

When in *Run Request* Mode, the motor may restart at any time without warning.

When in Jog *Request* Mode, the motor may restart at any time without warning.

When in *Freeze Request* Mode, the motor may restart at any time without warning.

WARNING:

Motor will start when *HAND START* is activated.

The controller can start at anytime with a start signal through the digital inputs. Digital inputs have higher priority than control keys *HAND START* and *AUTO START.*

Ensure all safety instructions in the manufacturer's manual, as well as all local safety requirements, have been satisfied prior to applying power to the unit.

CAUTION:

Initialization using parameter 620, *Operating Mode*, will reset drive to default parameters. Any special applications programming performed at the factory during start-up or thereafter, will be lost.

The differential pressure sensor is a completely self-contained two wire unit that takes accurate pressure readings and transmits a proportional 4 to 20mA DC signal back to the controller.

(For additional information on the booster pump system installed in the Pump House, see Appendix Section 4.2.3.4.13.3 of this manual.)

2.3.4.13.4 Circulation Pumps

The pump house contains new circulation pumps (CP-11 & CP-12), and controls as required to allow for a stand alone system. Design requirements indicates 1,000 GPM at 277 feet of head system was required.

The new circulation pumps are a skid mounted, variable speed duplex domestic water circulation pump set used to circulate fresh water to and from the exterior tank. The duplex design allows for a primary pump and a secondary pump as a backup. The circulation pumps are VFD controlled based on a pressure sensor mounted on the discharge header.

PRIMING

The circulation pumps are not self-priming, and must be completely primed (filled with liquid) before starting.

If the pumps are operated with a positive suction head, prime by opening the suction valve and allow liquid to enter the pump casing. Open the air vent at the top of the upper pump casing and the top of each suction dome, and make sure all air is forced from the pump by liquid before closing.

IMPORTANT: Rotate the shaft by hand while priming and venting to free entrapped air from the impeller passageways.

If the pumps have suction lift, priming must be accomplished by other methods. The use of foot valves, ejectors or vacuum pumps, or by manual filling of the pump casing and suction line with liquid are possible methods suggested for this purpose.

CAUTION:

Never run the pumps dry in the hope that they will prime themselves! Serious damage to the shaft seals, pump wear rings and shaft sleeves will result.

Perform the Pre-Start check list.

WARNING:

In the interest of operator safety, the unit must not be operated above the nameplate conditions. Such operation could result in unit failure causing injury to operating personnel. Consult the instruction book for proper operation and maintenance of the pump and its supporting components.

Check motor rotation before operating.

CAUTION:

Never check driver rotation unless the pump and driver couplings are disconnected and physically separated.

Failure to follow this instruction can result in serious damage to pump and driver if rotation is wrong.

Starting The Pump:

WARNING:

The pump must not be operated without an approved coupling guard in place.

Failure to observe this warning could result in injury to operating personnel.

1. Install coupling guard on flexible coupled units.
2. Fully open valve (if any) in suction line, and close valve in discharge line.
3. If applicable, turn on any external source of cooling or lubricating fluid to the shaft seals.
4. Start the motor (pump).
5. Immediately after the pump reaches full operating speed slowly crack open the discharge valve and open bleed valves at system high points. Do not open discharge valve completely until the system is full of liquid, purged of air, and checked for leaks.
6. After filling the system, fully open the discharge valve and close any system bleed valves. If the pump is fitted with pressure gauges, open gauge cocks and record pressure reading for future reference. Verify that the pump is performing in accordance with the parameters specified on the performance curve.
7. Check and record voltage, amperage per phase and kilowatts, if a watt meter is available.

Pump Shutdown:

1. The following shutdown procedures will apply in most normal shutdowns for the circulation pumps. If the pumps will be in operative for an extended length of time, follow storage procedures.
2. Always close the discharge valve before stopping the pumps and close the valve slowly to prevent hydraulic shock.
3. Cut and lock off power to the motor.

Short Duration Shutdown:

For short or frequent shutdown periods under freezing conditions, keep fluid moving within the pump casing and insulate or heat the pump exterior to prevent freezing.

Extended Period Shutdown:

For long shutdowns or to isolate the pump for maintenance, close the suction and discharge valves. If no suction valve is used and the pump has positive suction head, drain all liquid from the suction line to terminate liquid flow into the pump suction nozzle. If applicable, turn off any external source of cooling or lubricating fluid to the shaft seals. Remove plugs in pump drain and vent taps, as required, and drain all liquid from the pump casing. Remove packing, if applicable.

If freezing conditions will exist during long shut down periods, after draining the pump, blow out all liquid in passages and pockets with compressed air. Freezing of pump liquid can also be prevented by filling the pump with antifreeze solution.

Rotate the shaft by hand monthly to coat bearings with lubricant and retard oxidation and corrosion.

(For additional information on the circulation pumps installed in the Pump House, see Appendix Section 4.2.3.4.13.4 of this manual.)

2.3.4.14 Mixers

The chemical injection system has two (2) 55 gallon tanks in which the Calcium Hypochlorite solution is mixed and held. Each tank is equipped with an electrically powered agitator to aid in the mixing of the chemicals, and is connected to the intake manifold of the pumps. Before the system is started, make sure enough solution is mixed and available in the tanks selected to supply the injection pumps. Start the agitator motor so that the solution is well mixed. The agitator motor is equipped with a timer that will shutdown the motor automatically.

CAUTION:

Before energizing the motor for the first time, or after an extended shut down, it is advisable to check insulation resistance, power supply and mechanical freedom of the motor. If the motor has been stored in a damp location, dry it out thoroughly before operating.

Before measuring insulation resistance, the machine must be at a standstill and all windings to be tested must be electrically connected to the frame and to ground for a time sufficient to remove all residual electrostatic charge.

Failure to observe these precautions may result in injury to personnel.

Steps Prior to Initial Start-up or Start-up After a Long Idle Prior

1. Check insulation as indicated in caution above.
2. If the insulation resistance is lower than this value, it may be wet and it is advisable to eliminate the moisture. Dry the stator in an air-circulating oven with the air surrounding the part at 95° C to 115° C until the stator has been above 9O° C for at least four (4) hours, then the air temperature may be raised to l35° C to 155° C. Continue to heat until the insulation resistance is constant for a one-half hour period.
3. Enclose the motor with canvas or similar covering, leaving a hole at the top for moisture to escape. Insert heating units, or lamps, and leave than on until the insulation resistance is constant for a one-half hour period. Be careful not to get heating units so close to the winding that they cause localized damage or combustion of the canvas or other covering.
4. With the rotor locked and using approximately 10% of rated voltage, pass a current through the stator windings. Increase the current gradually until the temperature reaches 90° C. Do not exceed this temperature. Maintain a temperature of 90° C until the insulation resistance becomes constant for a one-half hour period.
5. Check bearing oil reservoirs to be sure they have been filled to the proper level with fresh oil and that grease lubricated bearings are properly greased.
6. When ever possible, examine the interior of the machine for loose objects or debris which may have accumulated and remove any foreign material.
7. If possible, turn the rotor by hand to be sure it rotates freely.
8. Check all connections with the connection diagram. Check all accessible factory-made connections for tightness to make sure none has become loose during shipment.

9. If possible, leave the motor uncoupled for initial operation so motor vibration, noise, current and bearings can be checked uncoupled before they are masked by the pump. To run a VHS motor uncoupled, it is recommended the pump head-shaft be removed. If this cannot be done, remove the upper half-coupling and be sure the pump shaft is well centered in the motor shaft so it will not rub. IF THIS IS DONE, ROTATE THE MOTOR BY HAND TO BE SIJRE THERE IS NO INTERFERENCE BETWEEN SHAFTS. Do not try to run the motor uncoupled by just removing the gib key.
10. When the driven machine is likely to be damaged by the wrong direction of rotation, it is imperative to uncouple the motor from its load during the initial start and make certain it rotates in the correct direction. If it is necessary to change rotation, interchange any two line leads. For multispeed motors, check each speed independently. On VHS motors do this before installing the pump head-shaft and upper half-coupling. Some motors are designed for unidirectional rotation. Rotation of these motors must be in accordance with the rotation indicated on the nameplate(s) furnished with the equipment.

Initial Start:

1. After inspecting the machine carefully as outlined above, make the initial start by following the regular sequence of starting operations in the control instructions.
2. Run the motor uncoupled initially, if possible, checking for abnormal noise, vibration or high bearing temperatures and for current and voltage balance. Then check motor operation under load for an initial period of at least one (1) hour to observe whether any unusual noise or hot spots develop.
3. In the event of excessive vibration or usual noise, remove all power and disconnect the machine from the load and check the mounting and alignment.
4. Space heaters (if supplied) should be de-energized during motor operation.
5. Check line voltage on all three phases to be sure it is balanced and within 10% of motor rated voltage with motor drawing load current.
6. Check the operating current against the nameplate value. Do not exceed the value of nameplate amperes X service factor (if any) under steady continuous load. Also check to be sure that current in all three lines is balanced.

Jogging and Repeat Starts:

CAUTION:

Repeated starts and/or jogs of induction motors greatly reduce the life of the winding insulation. The heat produced by each acceleration or jog is much more than that dissipated by the motor at full load. If it is necessary to repeatedly start or jog the motor, it is advisable to check the temperature of the motor often.

Failure to observe these precautions may result in injury to personnel.

Check motor heating but do not depend on your hand to determine the temperature. Use the temperature detectors furnished with the motor if there are any, or use a thermometer. If there is any doubt about the safe operating temperature, take the temperature of the part in question and confer with the manufacturer, including all nameplate information.

Overheating of the motor may be caused by improper ventilation, excessive ambient temperature, dirty conditions, excessive current due to overload, unbalanced AC voltage or (if a variable speed controller is used) harmonics in power supplied to the motor.

(Detailed start-up and operation instructions for the mixers can be found in Appendix Section 4.2.3.4.14 of this manual.)

2.3.4.15 Chlorine Analyzer

The chlorine analyzer is used to measure the chlorine residual in the fresh water after the chlorine is added. The analyzer samples the water continuously, and gives a visual readout of the chlorine level on a large indicator supplied with the system. The analyzer is mounted on the same skid as the chemical injection pumps. The water sample is then discarded into a floor drain near the injection system.

(Detailed start-up and operation instructions for the analyzer can be found in Appendix Section 4.2.3.4.15 of this manual.)

2.3.5 Fire Protection System

The Water Plant is equipped with two new independent fire suppression systems. One CO_2 system covers the Day Tank Room, and the Generator Room. The second system provides sprinkler fire suppression for the new Switchgear Room. Both systems are activated by detectors and manual pull stations located in these areas. Additional audio and visual alarms were placed throughout the facility to alert personnel of the impending danger.

The nature of the Water Plant does not warrant a full coverage of water based sprinkler system or a CO_2 fire suppression system. This includes the fact any fire arising in the Water Plant would be associated with the fuel leaks or spills, fuel supply, the generators, or the switchgear. There are certain areas in the Water Plant where the application of water may cause a burning film to spread the fire to previously unaffected portions of the facility. The application of large quantities of water could also adversely affect the electrical equipment and switchgear. This could make putting the plant back on-line time consuming, or even dangerous after the discharge of a standard fire sprinkler system.

Therefore, the fire suppression system for the facility consists of a pre-action dry pipe system providing coverage of the new Switchgear Room and a CO_2 fire suppression system in the new Day Tank and Generator Rooms.

The new emergency pump house is monitored by a manual pull station located at the exit, a heat detector, and a visual alert horn and strobe light.

2.3.5.1 Carbon Dioxide Extinguishing System

WARNING:

All personnel must be instructed to evacuate the area at the first alarm.

After a CO_2 discharge, all personnel must stay out of the affected area until it has been properly ventilated, unless they are equipped with a Self-Contained Breathing Apparatus (SCBA).

CO_2 is colorless, odorless, and tasteless. It is an asphyxiant. A space that has been flooded with CO_2 does not contain enough oxygen to sustain human life. Failure to follow these instructions could result in severe injury or death.

The system installed was designed to protect only the Mechanical Room and not the remainder of the facility.

The Carbon Dioxide (CO_2) fire extinguishing system consists of a releasing panel, activation devices, compressed gas storage cylinders, cylinder manifolds, valves, piping, controls and discharge nozzles.

DANGER:

ASPHYXIATION HAZARD: All personnel must be instructed to evacuate the area at the first alarm.

After a CO_2 discharge, all personnel must stay out of the building until it has been properly ventilated, unless they are equipped with a Self-Contained Breathing Apparatus (SCBA).

CO_2 is colorless, odorless, and tasteless. It is an asphyxiant. A space that has been flooded with CO_2 does not contain enough oxygen to sustain human life.

The suppression system can be activated either automatically or manually. For automatic activation, indications from at least two automatic sensors (fire / smoke detectors) are required. Pull stations are provided for manual operation.

To extinguish a fire, the system discharges CO_2 by opening automatic discharge valves on the selected cylinder bank. A 30-second, pre-discharge alarm signal alerts occupants to evacuate the facility.

Emergency manual release (without pre-discharge alarm) is also provided at the storage cylinders. If manual release is initiated, pressure switches in the CO_2 piping generate a signal to the Fire Detection and Alarm System (FDAS) to indicate that discharge has occurred.

The CO_2 releasing panel provides a one-person, “walk test” feature, which allows the service person to enable a group of devices for walk test, then proceed through the installation activating the specified devices.

The system will respond to each activation with a short burst of the programmed signal circuit. The related signal circuit will only be pulsed if it has been configured for the walk test feature when defining it in the panel’s configuration software.

The walk test feature can be deactivated in two ways; the service person can deactivate it through the user menus or the walk test function will time out after 10 minutes of non-activation. This ensures system response if the service person is called away for an extended period of time.

NOTE:

When the walk test is active, the panel will annunciate a trouble condition.

To extinguish a fire, the system discharges CO_2 by opening automatic valves on the pressurized storage cylinders. A 30-second, pre-discharge alarm signal alerts occupants to evacuate the facility. Emergency manual release (without pre-discharge alarm) is also provided at the storage cylinders.

General Systems Operation:

Automatic Operation

When a system is operated automatically by the electric or pneumatic detection system, proceed as follows:

1. All personnel must evacuate the hazard area promptly. Close all doors.
2. Call or radio the fire department immediately to report and verify system activation.
3. If the system is provided with a reserve cylinder(s), see the section Main and Reserve Systems.

Manual Operation

Electric Systems

Operate electric systems as follows:

1. Proceed to the manual electric station for the hazard.
2. Operate the manual electric station.
3. Immediately evacuate all personnel from the hazard area. Close all doors.

WARNING:

If the time delay fails to operate, operate manual control head lever installed on the time delay to immediately discharge system.

4. Call or radio the fire department immediately to report and verify system activation.
5. If the system is provided with reserve cylinder(s), see the section Main and Reserve Systems.

Systems Equipped with Remote Pneumatic Actuator

1. Proceed to remote pneumatic station for appropriate hazard.
2. Operate the control head mounted on the nitrogen actuation cylinder.
3. Move the ball valve installed in the actuation piping downstream of the nitrogen cylinder to the OPEN position.
4. Immediately evacuate all personnel from the hazard area. Close all doors.

WARNING:

If the time delay fails to operate, operate manual control head lever installed on the time delay to immediately discharge system.

5. Call or radio the fire department immediately to report and verify system activation.
6. If the system is provided with reserve cylinder(s), see the section on Main and Reserve Systems.

Local Manual Operation - All Systems

CAUTION:

This manual control is not part of the normal system actuation mode and should only be used in a last resort, emergency condition.

1. Proceed to the cylinder(s) for the hazard.
2. Remove the locking pin from the cylinder control head.
3. Rotate lever up - in a counter-clockwise direction.
4. Proceed to hazard area directional valve is one is installed. Remove the locking pin from the valve control head. Rotate lever clockwise.
5. Immediately evacuate the hazard area. Close all doors.
6. Call or radio the fire department immediately to report and verify system activation.

Main and Reserve Systems:

WARNING:

The following procedures can be applied only when the reserve system has not been previously discharged.

After operating the system, place the reserve system in standby mode as follows:

1. Reset all pressure operated trips, discharge indicators, and pressure operated switches.
2. If the system uses directional valves, reset control head on valve.
3. If installed, reset pneumatic transmitter on directional valve.

WARNING:

When pneumatic main / reserve transfer switch, is installed, wait approximately 15 minutes before moving lever to the "RESERVE" position. This allows any remaining pressure in the lines to vent to atmosphere.

Failure to do this may accidentally discharge the reserve system when the transfer switch is moved.

Proceed to the main / reserve transfer switch. Move switch lever to the **RESERVE** position.

(Detailed start-up and operation instructions for the Carbon Dioxide System can be found in Appendix Section 4.2.3.5.1 of this manual.)

2.3.5.1.1 Storage Cylinders

)Two banks (primary and reserve) each consisting of twelve, 100-pound, CO_2 cylinders provide the extinguishing agent for the Generator Room. Conversely, two banks each consisting of two, 100-pound, CO_2 cylinders provide the extinguishing agent for the Day Tank Room. Since the CO_2 cylinders must be located as close as possible to the protected areas without be exposed to a fire in the hazard area they are protecting, the cylinders for the Generator Room are located just outside the Generator Room, and the cylinders protecting the Day Tank Room are located just outside the Day tank Room.

The remaining reserve cylinders are not connected to the discharge manifold that is piped to the discharge nozzles. These reserve cylinders must be manually connected to the discharge manifold. The cylinder that is connected to the discharge manifold will discharge completely once activated.

DANGER:

ASPHYXIATION HAZARD: All personnel must be instructed to evacuate the area at the first alarm.

After a CO_2 discharge, all personnel must stay out of the building until it has been properly ventilated, unless they are equipped with a Self-Contained Breathing Apparatus (SCBA).

CO_2 is colorless, odorless, and tasteless. It is an asphyxiant. A space that has been flooded with CO_2 does not contain enough oxygen to sustain human life.

To extinguish a fire, the system discharges CO_2 by opening automatic valves on the pressurized storage cylinders. A 30-second, pre-discharge alarm signal alerts occupants to evacuate the facility. Emergency manual release (without pre-discharge alarm) is also provided at the storage cylinders.

(Additional information regarding the CO_2 storage cylinders is contained in Appendix Section 4.2.3.5.1.2 of this manual.)

WARNING:

Insure that all personnel have evacuated the facility before actuating the manual CO_2 release valve(s) located at the cylinder bank. In a restricted space, CO_2 displaces the oxygen required to sustain human life.

Actuating the manual CO_2 release valve at the cylinder bank discharges CO_2 into the protected space immediately and without warning. Direct skin contact with super-cooled CO_2 gas can cause immediate and severe tissue damage due to frostbite. Failure to follow these instructions could result in severe injury or death.

2.3.5.1.2 Initiating Devices

Electric, manual-pull stations are located just inside all exterior doors and other locations within the plant.

The control lever on each pull station is double acting with a “push-in” tab and a “pull-down” lever that locks in position after releasing a spring-loaded contact switch. When the lever is pulled, the contact switch sends an electric signal to the CO_2 releasing panel. When the releasing panel receives a signal from a pull station, a distinct, 30-second, CO_2 pre-discharge alarm sounds. After a 30-second delay, the CO_2 is released into the protected area.

WARNING:

Ensure that all personnel have evacuated the facility before actuating the emergency (mechanical) manual stations or the CO_2 release lever(s) located at the cylinder bank.

Actuating the emergency (mechanical) manual station(s), or the manual CO_2 release lever(s) at the cylinder bank, discharges CO_2 into the protected space immediately and without warning.

In a restricted space, CO_2 displaces the oxygen required to sustain human life. Direct skin contact with super-cooled CO_2 gas can cause immediate and severe tissue damage due to frostbite. Failure to follow these instructions could result in severe injury or death.

A steel cable physically connects the pull-station to a mechanical discharge valve on the first CO_2 cylinder of the related CO_2 cylinder bank. Pulling a mechanical manual station discharges the CO_2 gas immediately, without the benefit of the 30-second, pre-discharge alarm.

Emergency manual controls are also provided in the CO_2 storage room. The controls in the CO_2 storage room consist of a manual release lever (equipped with a locking pin) on the cylinder control head(s).

CAUTION:

The cylinder-mounted manual release lever is not part of the normal system actuation mode and should only be used in a last resort, emergency situation.

To effect emergency manual release of the CO_2:

- Remove the locking pin from the cylinder control head.
- Rotate the local manual release lever to the “released” or “open” position.
- Exit the area immediately.

2.3.5.1.3 Discharge Nozzles

Discharge nozzles control the rate of discharge and distribute CO_2 extinguishing agent uniformly throughout the protected area. Their sizing and location have been calculated to produce the best possible CO_2 dispersion pattern. If a discharge nozzle requires replacement, it must be replaced with an identical unit.

(For additional information regarding the Discharge Nozzles, refer to Appendix Section 4.2.3.5.1.3 of this manual.)

2.3.5.1.4 Zone Valves / Control Heads

The rack of CO_2 cylinders has a cylinder control valve that provides both automatic and manual operation and includes an integral safety valve. Check valves are used at the connection to the header pipe to prevent back flow.

The CO_2 fire suppression system has two distinct zones, the Generator Room and the Day Tank Room.

(Additional information regarding the Zone Valves and Control Heads is contained in Appendix Section 4.2.3.5.1.4 of this manual.)

2.3.5.2 Fire Sprinkler System

The building is protected by a single zone pre-action fire sprinkler systems. The system is interconnected to the Fire Alarm Control Panel. The sprinkler heads are interconnected by piping to the main water supply source, all the fresh water tanks. The piping system contains compressed air. In case of a fire, indicated by loss of air pressure opening a sprinkler head, and a fire detector, water is allowed to enter the piping system. The water is discharged through the opened sprinkler heads in the space containing the fire. At the same time audible alarms are provided.

Type “L” copper piping is concealed in some rooms and exposed in other rooms. The piping interconnects the sprinklers in each room with the pre-action deluge valve and the water supply through a set of valves and auxiliary equipment. The valves in the system are to remain open at all times. Only drain valves are to remain closed. Attempting to close a valve will activate an alarm. The piping between the water supply and the deluge valve contains water. The piping downstream of the deluge valve contains compressed air.

The operation of the system is automatic. Care should be taken to drain the water collected in the piping system to avoid frozen pipes. The water will accumulate as a result of the water vapor in the compressed air condensing within the piping system. Drain valves are provided at low points.

The pre-action covers the new Switchgear Room. The riser for the sprinkler system enters the facility near the existing loading area. The water for the sprinkler system is delivered by a new three inch pipe routed from the existing water plant primary distribution pumps.

2.3.5.2.1 Sprinklers

There may be three (3) types of sprinkler heads in the building; standard spray pendent (SSP), standard spray upright (SSU), and standard spray sidewall (SSW). Each head contains a device (glass bulb) that senses heat from a fire. The device opens the head and initially the air in the piping system is released to the room. Once the fire alarm system's detector, in the same room, indicates a fire, water is allowed to flow in the piping system. The water will flow through the head(s) that have opened. The sprinklers installed produce a semi-spherical, or fan shaped (SSW), water discharge pattern that is predominately directed downward and outward from the deflector. However, a portion of the spray is also directed towards the ceiling or backwall (SSW).

(Additional information for the fire sprinklers used in the Water Plant can be found in Appendix Section 4.2.3.5.2.2 of this manual.)

2.3.5.2.2 Fire Sprinkler Air Compressor

The purpose of the fire sprinkler air compressor is to keep the piping between the deluge valve and the sprinkler heads charged with compressed air at a pressure of twelve (12) pounds-per-square-inch (psig) nominal in the Fire Protection System.

DANGER:

This compressor is not equipped and should NOT be used "as is" to supply breathing quality air.

WARNING:

Motors, electrical equipment and controls can cause electrical arcs that will ignite a flammable gas or vapor. Never operate or repair in or near a flammable gas or vapor. Never store flammable liquids or gases near the compressor.

Do not operate this compressor if damaged during shipping, handling, or use. Damage may result in bursting and cause injury or property damage.

If the compressor is exposed to freezing temperatures, a Dry Air PAC should be used.

Do not attempt to change the safety relief valve setting.

NOTE:

Single-phase motors include internal thermal overload protection, which has an automatic reset device.

Accumulation of condensed water in a system causes corrosion of components and reduces system capacity.

Operation of the compressor is automatic.The by-pass valve on the air maintenance device is opened to fast fill the system during the initial pressurization. Once the required system pressure has been reached, the by-pass valve closes and the air supply control valve opens to place the compressor in automatic operation.

If a slight air leak should occur in the system, the pressure regulator will automatically maintain system pressure at the preset level. The 1/8” (3.2 mm) orifice in the restrictor check valve limits the flow of air from the pressure regulator into the system to a value which is significantly less than that which will be exhausted by the operation of a 5.6 K-factor sprinkler less than 60 seconds per code. In the event the pressure regulator cannot maintain the preset pressure setting, a supervisory alarm will be indicated in the fire alarm system and DDC system. The alarms could be from a failure of the compressor, a broken pipe, a leak in the piping system, or failure of a link in a sprinkler head. The pressure can also be monitored by the pressure gauge attached to the piping system at the deluge valve. Corrective action must be taken immediately in the event of an indication of reduced pressure in the piping system.

The fire sprinkler air compressor is vertically mounted on the riser near the backflow preventer. The compressor is an oil lubricated reciprocating type. The compressor is a two-stage machine consisting of one first-stage cylinder with a larger bore size, and a second-stage cylinder with a smaller bore size. The basic principle of operation of a two-stage compressor is as follows:

On the suction stroke of the first-stage piston, air at atmospheric pressure enters the cylinder through the inlet filter, and then enters the inlet valves located in the airhead. On the compression stroke of the first-stage piston, the air is compressed intermediate pressure and discharged through the discharge valves into common manifold.

From the manifold the air passes through the intercooler tubes, where the heat of first-stage compression is removed by the action of the fan passing cool air over the intercooler tubes. On the suction stroke of the second stage piston, this cooled air enters the second-stage cylinder through the inlet valve.

The compression stroke of the second-stage piston compresses the air into the final discharge pressure and forces it out through the discharge valve into the receiver or system. If cooling of the discharge air is required, an air-cooled after cooler should be installed between the compressor discharge and the receiver or system.

The compressor is capable of pressurizing the system to 40 psi. in 30 minutes per (NFPA 13).

(Additional information for the fire system compressor used in the Water Plant can be found in Appendix Section 4.2.3.5.2.3 of this manual.)

2.3.5.2.3 Air Maintenance Device

The By-Pass Valve used on the air maintenance device is opened to fast fill the system during the initial pressurization. Once the required system pressure has been reached, the By-Pass Valve is closed and the air supply control valve is left open to place the D-2 in automatic operation.

If there is a slight leak in the system, the pressure regulator will automatically maintain system pressure at the preset level. The 118 inch (3.2 mm) orifice in the restrictor check valve limits the flow of air from the pressure regulator into the system to a value which is significantly less than that which will be exhausted by the operation of a 5.6 K-Factor sprinkler.

(Additional information for the fire system air maintenance device can be found in Appendix Section 4.2.3.5.2.4 of this manual.)

2.3.5.2.4 Backflow Preventer

The backflow preventer consists of two independently opening, spring loaded check valves. The pressure drop across the first check valve is approximately 1.0 pound per square inch with no flow. The pressure drop across the second check valve is also 1.0 pound per square inch with no flow. A complete assembly includes two shut-off valves and four test cocks.

All low flow demands up to a minimum of three (3) gallons per minute are to pass only through the bypass assembly. All flows above three (3) gallons per minute will pass through both the bypass and mainline valve without accurate meter registration.

In normal operation, the backflow preventer valve assembly prevents water (which may contain contaminants) from flowing back into the supply water system if the supply system should loose pressure.

(Additional information for the fire system back flow preventer can be found in Appendix Section 4.2.3.5.2.5 of this manual.)

2.3.5.2.5 Pre-Action Valve and Trim

The pre-action valve separates the portion of the system that contains water from the side of the system that contains compressed air. The fire alarm system controls the valve. When the valve is set for service the differential chamber is pressurized through the differential chamber supply connection. The deluge valve is a differential type valve which depends on the water pressure in the differential chamber to hold the clapper latch arm set and the valve closes against the water supply pressure.

The pre-action valve has a nominal trip ratio of 5 to 1, i.e., the valve operates when pressure in the differential chamber is reduced by approximately one-fifth of the water supply pressure.

Opening of an actuation device, for example, the release solenoid or manual control station, will release water from the differential chamber faster than it can be replenished through the 3/32 inch (2.4 mm) diameter orifice of the restrictor assembly. A rapid pressure drop then results in the differential chamber, and the pressure between the differential chamber and waterway is eliminated. The water supply pressure then forces the clapper latch arm open, permitting a flow of water to the system piping. Water flowing into the system also flows to the water flow pressure alarm switch, which actuates the system water flow alarm signal.

When the main control valve is closed to stop water flow into the system, the clapper assembly is prevented from resetting by the clapper latch until the valve is reset.

NOTE:
The pre-action valve will not automatically reset after an operation. It must be manually reset and it should be restored to service as soon as possible. Any impairment to the system must be promptly reported in order to maintain the integrity of the system.

(Additional information for the fire system pre-action valve and trim device can be found in Appendix Section 4.2.3.5.2.6 of this manual.)

2.3.5.2.6 OS&Y Valve

Two Outside Screw and Yoke Valves are used in the sprinkler fire system. One is mounted before the first check valve on the backflow preventer, and the second one is mounted after the second check valve.

The first OS&Y valve functions as an inlet shut-off valve and the second OS&Y valve functions as an outlet shut-off valve. Both valves are capable of a bubble tight seal at all pressures up to its full rated pressure of 250 pounds per square inch.

(Additional information for the fire system OS&Y valve can be found in Appendix Section 4.2.3.5.2.7 of this manual.)

2.3.5.2.7 Deluge Valve

The heart of the sprinkler control system is the Deluge Valve. A deluge valve contains a pivoting “clapper” type gate. When the valve is actuated, water pressure on the supply side pushes the clapper aside, providing full, unrestricted flow almost instantly.

The deluge valve contains a push-rod arid lever triggering mechanism that holds the clapper closed under normal conditions. The push-rod extends into a push-rod chamber.

Water from the supply side of the deluge valve enters the push-rod chamber through a restricted orifice and balances the force of the water pressure on the supply side of the clapper valve; this keeps the valve closed.

When the valve activates, the push-rod chamber is vented to the atmosphere through an outlet that is considerably larger than the restricted orifice. Since the pressure cannot be replenished through the restriction as fast as it is vented through the outlet, the chamber pressure falls instantaneously. When the push-rod chamber pressure reaches about one-half the supply pressure, the upward force on the clapper is greater than downward force on the lever and thc clapper opens.

The term “trim” refers to the method and equipment used to vent the push-rod chamber and actuate the deluge valve.

An electrically actuated solenoid releasing valve connected to the outlet of the deluge valve push-rod chamber, vents the chamber (opening the valve) only when it receives an actuation signal from its associated Pre- Action System.

A Hydraulic Manual Emergency Station provides a back-up means of triggering the deluge valve if the electrically activated solenoid releasing valve fails to operate. The Hydraulic Manual Emergency Station consists of an aluminum nameplate, mechanically attached to a ball valve.

One end of the ball valve is installed between the push-rod chamber outlet and the electrically activated solenoid releasing valve. The other end of the ball valve is vented to the atmosphere. Opening the ball valve vents the push-rod chamber which, in turn, allows the deluge valve to open.

A nylon cable tie, inserted through the ball valve handle, prevents inadvertent activation of the manual emergency station, but allows forceful operation of the valve in an emergency.

NOTE:

The deluge valve will not automatically reset after an operation. It must be manually reset and it should be restored to service as soon as possible. Any impairment to the system must be promptly reported in order to maintain the integrity of the system.

(Additional information for the fire system deluge valve can be found in Appendix Section 4.2.3.5.2.8 of this manual.)

2.3.6 Compressed Air System

Compressed air is used in the Water Plant Facility for general shop air blowdown of the generators exhaust gas waste heat exchangers. Compressed air piping in the space is a Schedule 40 black iron or type ‘L’ copper to match existing piping preferences at the base.

The existing relocated compressor (relocated to just outside the Generator Room) and compressed air system is adequate for the needs of the Water Plant and for the new generators being installed. However, a new 1,500 gallon air receiver tank was installed in the southwest corner of the Generator Room. The increased capacity is required for the generator exhaust gas heat exchanger soot blower operation.

The air should be will be filtered and regulated at each shop air drop. The air receiver tanks will be maintained @ 125 psig air as required for exhaust gas heat exchanger soot blowdown operation.

2.3.6.1 Air Compressor

A two-stage air compressor with a single receiver tank is used to provide air throughout the building. The compressed air is distributed to the end points by a Schedule 40 black iron or type 'L' copper piping system. Outlets for portable equipment contain filters, pressure regulators, automatic lubricators, quick disconnect couplings, and drain valves.

DANGER:

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. Air compressors are not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

The air compressor is mounted on a horizontal tank. The compressor is an oil lubricated reciprocating type. The compressor is a two-stage machine consisting of one first-stage cylinder with a larger bore size, and a second-stage cylinder with a smaller bore size. The basic principle of operation of a two-stage compressor is as follows:

On the suction stroke of the first-stage piston, air at atmospheric pressure enters the cylinder through the inlet filter, and then enters the inlet valves located in the airhead. On the compression stroke of the first-stage piston, the air is compressed intermediate pressure and discharged through the discharge valves into common manifold.

From the manifold the air passes through the intercooler tubes, where the heat of first-stage compression is removed by the action of the fan passing cool air over the intercooler tubes. On the suction stroke of the second stage piston, this cooled air enters the second-stage cylinder through the inlet valve.

The compression stroke of the second-stage piston compresses the air into the final discharge pressure and forces it out through the discharge valve into the receiver or system. If cooling of the discharge air is required, an air-cooled after cooler should be installed between the compressor discharge and the receiver or system.

WARNING:

Do not operate compressor in wet conditions. Store indoors.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically.

HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

HIGH PRESSURE AIR. Bypassing, modifying or removing safety relief valves can cause serious injury or death. Do not bypass, modify or remove safety relief valves. Do not direct air stream at body.

Rusted tanks can cause explosion and severe injury or death. Drain tank daily or after each use. Drain valve located at bottom of tank.

CAUTION:

Do not over-pressurize the receiver tank or similar vessels beyond design limits.

Do not use a receiver tank or similar vessels that fail to meet the design requirements of the compressor.

Do not remove, adjust, bypass, change, modify, or make substitutions for safety / relief valves, pressure switches, or other pressure control related devices.

Do not use air tools, or attachments, without first determining the maximum pressure recommended for that equipment.

Do not touch the compressor pump, motor, engine, or discharge tubing during or shortly after operation. These parts become hot.

Wear eye protection when operating or servicing compressor.

Do not operate where flammable explosive liquids or vapors such as gasoline, natural gas and solvents are present.

Do not operate with the guards or shields removed, damaged, or broken.

Do not remove, paint over or deface decals. Replace any missing or damaged decals.

Not adhering to these safety rules will or can cause minor injury or property damage.

Normal Start-up:

1. Close the manual service valve.
2. Release any remaining tank pressure by slowly opening the manual drain valve.

3. Attach hoses and accessories.
4. Close the manual drain valve and apply power to the compressor. If the pressure switch is equipped with an *ON/AUTO-OFF* lever, flip the switch to the *ON/AUTO* position. If the unit is equipped with a control panel *ON/OFF* switch, move the switch to the *ON* position
5. The unit will now start.

CAUTION:

Unusual noise or vibration indicates a problem. Do not continue to operate until you identify and correct the source of the problem.

NOTE:

Ensure the direction of rotation is correct per the arrow on the motor. If the rotation is incorrect on three-phase units, interchange any two of the three leads.

Normal Shut-down

1. Set the pressure switch lever to the *OFF* position.
2. Close the service valve fully.
3. Remove hoses and accessories.
4. Slowly open the service valve to bleed air pressure down to 20 psig.
5. Slowly open the manual drain valve at the bottom of the tank to drain all condensate (water).
6. Close the drain valve and the service valve for the next use.

(Additional information regarding the compressor is contained in Appendix Section 4.2.3.6.1 of this manual.)

2.3.6.2 Air Receiver

The air / filter regulator combination was designed to be compact and easy to use and maintain.

The regulator is designed to provide quick response and accurate pressure regulation over a wide range of applications. The two gauge ports allow for more versatility in mounting and usage of the unit. Three spring options allow for spring changes, instead of entire regulator changes.

The heavy duty filter portion extends the life of air-operated equipment while reducing maintenance costs. The filter efficiently removes solid particles from compressed air lines - making them the perfect choice for large flow applications.

(For additional information regarding the air receiver refer to Appendix Section 4.2.3.6.2 of this manual.)

2.3.6.3 Air Outlet Accessories

The pipe connecting the air receiver (compressed air tank) to the main air supply line that runs throughout the building contains an isolation valve, a pressure gauge with isolation cock, and quick disconnects.

The isolation valve serves to isolate the compressor from the rest of the system should it stop operating or requires maintenance. The pressure gauge displays the outlet pressure.

The air receiver also has a pressure relief valve and a tank drain. The relief valve and drain were located and installed so that they cannot be readily rendered inoperative. The safely valve is a direct spring-loaded type. The drain is used to dispose of the water vapor extracted from the air by the separator.

The compressed air outlets (air drops) from the main air line contain an isolation valve, a filter regulator, a drip leg blow down, and a heavy duty female quick disconnect coupling.

Two (2) inch line was used for all drops. From this point typically an air hose is attached between the air drop and the intended receiving device or tool. To connect, plug the male inlet connector attached to the tool into the female quick disconnect coupler on the air hose. To connect or disconnect the, pull the sleeve on the quick disconnect coupler back (away from the outlet) while pulling on the male inlet connector. This disconnects the device or tool and automatically stops the flow of air.

(Additional information for the air outlet accessories used in the Water Plant can be found in Appendix Section 4.2.3.6.3 of this manual.)

2.3.7 Fuel Oil System

The new 1000 gallon fuel oil day tank (DT-3) is located inside the new Day Tank Enclosure added to the Water Plant. The day tank is gravity filled from the main 25,000 gallon tank located up on the hill. A two (2) inch fuel oil supply (FOS) line is routed from the day tank to the four (4) inch main line running along side the Water Plant. The DDC system monitors tank levels to alert personnel of any potential overfilling or low level problems. Piping was configured to allow for automatic or manual tank fill. Fuel used is JP-5.

All fuel piping is installed above-grade which makes it available for continual visual inspection for any leaks or discharges. All piping is welded or flanged, with the exception threaded connections are allowed inside mechanical rooms. Fuel is delivered to the point-of-use (boiler and the generators) by 1/2" piping and valves designated as Fuel Oil Supply (FOS), and a 3/4" return line designated as Fuel Oil Return (FOR).

The fuel oil system normally consist of the following major components:

- Fuel tank,
- Day tank,
- Strainers/Filters,
- Fuel Meter,
- Deaerator, and
- Piping and valves.

A single basket strainer was designed into the system to remove dirt and other unwanted debris from the fuel oil before it goes into the day tank. Isolation valves are installed on both sides of the strainer so the strainer can be taken out of service to clean the basket.

2.3.7.1 Fuel Flowmeter

The fuel meter added to the FOS line going into the day tank is used to record and track the amount of fuel supplied to the tank. The meter is a highly accurate, positive displacement meter which uses electronic output registration. The meter uses precision matched oval gears for exact liquid measurement with very little pressure drop across the meter.

WARNING:

Do not operate this instrument in excess of the specifications listed in the manufacturer's manual. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

The meter accurately measures liquid flow by using a slight pressure differential to rotate a pair of oval gears. The meshed gears seal the inlet from the outlet flow, developing the pressure differential. All of the driving torque resulting from the differential pressure is applied to the first gear. The second gear has zero driving torque since equal areas of gear surface is on opposite sides of the axis of rotation are exposed to the higher inlet pressure. As the gears begin to rotate, the torque applied to the first gear decreases but the second gear now has driving torque due to the increased area exposed to the high pressure. This alternate driving action provides a smooth rotation of almost constant torque without dead spots.

The process continues until the last gear is reached. Because of the amount of slippage between the oval gears and the measuring chamber wall is minimal, the meter is essentially unaffected by the viscosity and lubricity of the liquids.

The power pulse sensor is designed to detect the movement of the rotors in the flowmeter and generate a pulse train with a frequency proportional to rotor speed. To achieve this function, a sensor pick-off assembly is mounted in close proximity to the turning rotors. The sensor picks up signals produced by the magnets embedded within the rotors and transmits these signals and their variations to the generator.

The output shaft is rotated in direct [proportion to the oval gears by means of a powerful magnetic coupling. The output shaft drives a gear train that provides meter registration in engineering units of gallons, liters, pounds, etc.

After the meter has been installed, slowly allow the liquid to flow in the bypass section. This will clear the line of any foreign particles.

Normal Start-up Procedure:

1. Apply power to the preamp (if supplied).
2. SLOWLY open the inlet valve.
3. SLOWLY open the outlet valve.
4. Completely close the bypass valve.
5. Make sure that temperature, pressure, and flow rate are within the recommended specifications.

On high temperature service above 150° F, special start-up procedures are required to prevent permanent damage to flowmeter components:

1. Open the inlet valves just slightly admitting the liquid to flow around the flowmeter to stabilize the meter with the temperature.
2. With the flowmeter rotors operating normally, gradually open the outlet valve in small increments until the valve is fully open.

The following equation may be used to determine the approximate flowmeter warm-up time:

$$\text{Warm-up Time (Hrs.)} = \frac{\text{Nom.Conn.Size x (Oper. Temp. °F - 150)}}{100}$$

Periodic inspections should be made during flowmeter operations. The following points should be checked and the flowmeter shut down if any discrepancy is found:

- Make certain that temperature, pressure, and flow rate are within specifications.
- Check for abnormal noises.
- Pressure differential should remain constant.
- Electronic output should remain relatively stable for a given flow rate.
- Check the strainer screen and clean as necessary.

(Additional information for the fuel system flow meter used in the Water Plant can be found in Appendix Section 4.2.3.7.1 of this manual.)

2.3.7.2 Day Tanks / Gauges

The new 1,000 gallon fuel oil day tank (DT-3) is located inside the new Day Tank Enclosure added to the Water Plant. The day tank is gravity filled from the main 25,000 gallon tank located up on the hill.

A two (2) inch fuel oil supply (FOS) line is routed from the day tank to the four (4) inch main line running along side the Water Plant. The DDC system monitors tank levels to alert personnel of any potential overfilling or low level problems. Piping was configured to allow for automatic or manual tank fill. Fuel used is JP-5.

The following ports, vents, and gauges were designed into the tank by the manufacturer:

- (2) 4 inch Inlets,
- (2) 6 inch E-Vents,
- (2) 3 inch Fittings,
- (2) 2 inch Fuel Gauges,
- (1) 2 inch Return,
- (1) 2 inch Monitor, and
- (1) 1 inch Bottom Drain.

The fuel level gauge is for measuring the fuel level in the tank. The gauge mounts on top of the tank and is activated by a float connected to a cable. Readout is on a 12 hour clock face. The gauge can be rotated 360° for easy reading.

(Additional information for the fuel system day tank installed in the Water Plant can be found in Appendix Section 4.2.3.7.2 of this manual.)

2.3.7.3 Fuel Oil Filters / Strainers

In-line fuel oil filters and strainers may be located before the boiler and the furnace in the FOS line to remove particulates from the fuel supply. Constant flow is maintained through the fuel filters. Filter fouling may cause improper fuel flow to the boiler and furnace causing pressure drop and insufficient burner operation.

A single basket strainer was designed into the system on the FOS line to remove dirt and other unwanted debris from the fuel oil before it goes into the day tank. Isolation valves are installed on both sides of the strainer so the strainer can be taken out of service to clean the basket.

The strainer has a special yoke screw and swinging yoke for quick cleaning without the use of a wrench or other tools. The basket is usually large with an area at least six (6) times the cross section of the pipe.

Straining is accomplished by directing the fuel oil through sized openings in the basket. The strainer is designed to with stand the rated pressure of the fuel piping system.

The following steps are used to start-up and operate the strainer:

1. Open the top air vent (if so equipped) slowly to expel air from the strainer.
2. Slowly introduce fuel oil to be strained by opening the outlet valve first, followed by opening the inlet valve.

CAUTION:

Start system GRADUALLY. This eliminates sudden shock to the strainer and other equipment in the line.

3. Close the top air vent when all air has been expelled and fuel oil begins to flow.

(Additional information for the fuel system filters and strainers used in the Water Plant can be found in Appendix Section 4.2.3.7.3 of this manual.)

2.3.8 Engine and Generator Systems

The purpose of the engine and generator systems is to provide a redundant power plant within the Water Plant. This will ensure continuous power available to McMurdo Station in case of a catastrophe failure of the Power Plant.

2.3.8.1 Diesel Engines and Accessories

2.3.8.1.1 Diesel Engine

Back-up Station electrical energy production is provided by two diesel driven generators installed in the new Generator Room in the Water Plant. Both of the generator engine units are identical and provide base load power production, each with a net prime rating capacity at site conditions of 1825 kW, 2281 kVA and supplying 2400/4160 volts, 3-phase, 4-wire, 60 Hz, wye AC output.

Each generator engine unit is individually skid mounted, jacket water cooled, and configured to burn JP-5 fuel.

Because the operation of the generator engine is involved and can change depending on the circumstances, it is not the intention of this section to list all of the indicators, meters, or control switches, just the main ones with the highest priority. The manufacturer recommends any operator reads and becomes familiar with the manufacturer's manuals contained in Sections 4.2.3.8.1.1 and 4.2.3.8.1.5 of this manual. This manual contains exact procedures for starting, operation, stopping, and emergency stopping the generator engine.

The generator engine is equipped with a programmable monitoring system. The Electronic Control Module (ECM) monitors the operating parameters of the engine, The ECM can initiate responses if a specific engine parameter exceeds an acceptable range. Three possible responses may be available for each parameter: "WARNING","DERATE", and "SHUTDOWN*. Some of the responses are not available for some of the parameters. An ET service tool is used to perform the following activities:

- Select the available responses.
- Program the level for monitoring
- Program delay times for each response.

The settings for the parameters are programmed at the factory. If the application requires the settings for the parameters to be reprogrammed, then the parameter must be programmed with an ET service tool

The screens of the ET service tool provide guidance for the programming. The following options can be programmed: “ON/OFF. “WARNING”, “DERATE”, and “SHUTDOWN”. The screens of the ET service tool also provide guidance for changing set points.

The monitoring system is enabled after the engine is started. When the engine rpm exceeds 56 rprn below low idle, the ECM begins checking parameters. The ECM monitors the parameters in order to determine if the parameters exceed the set points.

The ECM will log the event if any response is made by the monitoring system. A parameter may be programmed “OFF: the ECM will log the event it the setpoint for the parameter is exceeded.

Any failure of a sensor will result in disabling the corresponding portion of the monitoring system. The failure of a sensor will cause an “ACTIVE” diagnostic code for the sensor.

All of the derating is cumulative. A derating of five percent followed by a derating of two percent results in a total derating of seven percent. If the conditions that cause the derating are not corrected, the derating will continue. The process will continue until the engine is at low idle with no load.

For more specific information concerning the ECM, reference Section 4.2.3.8.1.1 of this manual.

The electronic modular control panel II+ (EMCP II+) is located above the generator distribution housing. The control panel consists of the following components: a main panel with indicators, meters, and control switches. This control panel may be equipped with optional modules in order to match specific needs and requirements.

The engine control switch (ECS) determines the status of the control panel. In the *AUTOMATIC* position (3 o'clock), the engine will start automatically whenever a remote initiating contact is closed. The engine will shutdown after the initiating contact opens and after a programmable cool down period has elapsed. The cool down period can be programmed to give a 0 to 30 minute cool down period before the engine shuts down.

In the *MANUAL START* position (6 o'clock), the engine will start and run as long as the ECS switch remains in this position.

In the *STOP* position (9 o'clock), the fuel solenoid shuts the engine down after a programmable cool down time period has elapsed.

In the *OFF/RESET* position (12 o'clock), the fault lights are reset and the engine shuts down immediately.

The left side of the control panel contains the generator set control + (GSC+). The GSC+ is the main component of the system. The GSC+ displays the following information: generator output, generator set functions, fault conditions, and key engine parameters. The GSC+ accepts information from the following sources: operator, speed sensor, engine oil pressure sensor, water temperature sensor; and optional remote sources.

This information is used to determine the following parameters: the “on/off” state of the engine air, the 'on/off” state of the diesel fuel, and the “on/off state of tine starter.

In the very basic operating conditions, the GSC+ receives a signal to run the generator set. The GSC+ turns on the engine's fuel and starter. When the engine speed reaches the crank termination speed, the starter is disengaged. When the GSC+ receives a signal to stop the engine, the GSC+ shuts the fuel off.

The functions of the GSC+ are listed below:

- The GSC+ controls the normal starting and stopping of the engine.
- The GSC+ shows engine conditions and generator output information on two displays.
- The displays also show fault codes and GSC+ programming information.
- The GSC+ monitors the system for faults, if a fault occurs, the GSC+ performs a controlled fault shutdown or the GSC+ provides a fault alarm annunciation, The GSC+ uses indicators and displays in order to describe the fault.

Proper operation is a key factor in attaining the maximum service life and economy for the engine. While operating the generator engine, the operator should keep the following in mind:

- To avoid overheating of the engine and accelerated wear of the engine components, stop the engine using standard operating procedures.
- Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. DO NOT use the Emergency Stop Button for normal engine stopping After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.
- On the initial start-up of a new engine, or an engine that has been serviced, make provisions to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

- Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.
- Noticeable changes in gauge readings can indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings.
- Configuration parameters concern various engine features. Some parameters can affect the performance of the engine. Most of the parameters may be programmed with an Electronic Technician (ET) service tool. Some of the parameters require a password in order to be programmed.
- Observe the gauges frequently while the engine is operating. Record the data from the gauges in a log regularly. Compare the data to the specifications for normal engine operation. Comparing the data over time will help to detect changes in engine performance.
- Investigate any significant change in the gauge readings. Monitor the engine operation arid take action when discrepancies are found.
- Check the gauges and the generator frequently while the engine is operating under a load. The engine can be operated for extended periods of time at full load.
- Extended operation at low idle or at reduced load may cause increased oil consumption and carbon buildup in the cylinders. Carbon buildup results in a loss of power and/or poor performance.
- When possible, apply a full load at least on an hourly basis. This will burn excess carbon from the cylinders.
- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbochargers are operating correctly so that the proper air to fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Ensure that the belts are properly adjusted. The belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the generator is in good working order.

- Cold engines consume excess fuel. Use heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures

2.3.8.1.2 Engine Pre-Heat System

The engine pre-heat system is used to keep the engine coolant at a desired operating temperature range when the engines are not in use. Two tubular shaped circulation heaters with electric heating elements are used for each engine to keep the coolant temperature at a level so the engines could be operated at full capacity. This not only prevents freezing, but enables bring the engines on-line without a pre-heat cycle required.

(Additional information for the engine pre-heat system used in the Water Plant can be found in Appendix Section 4.2.3.8.1.3 of this manual.)

2.3.8.1.3 Engine Protective Devices

This section contains some general information about the function of some of the typical engine protective devices. Alarms and shutoffs are electronically controlled. The operation of all alarms and shutoffs use components which are actuated by a sensing unit.

The alarms and shutoffs are set at critical operating temperatures, pressures, or speeds in order to protect the engine from damage. The alarms function in order to warn the operator when an abnormal operating condition occurs, The shutoffs function in order to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the equipment.

The action alarm provides the operator with an audible indication of abnormal engine operation. Action alarms visually display on the a main display module. The alarm silence switch will silence the action alarm for five minutes. The alarm will sound again if the condition has not been corrected. The switchgear panels also have warning lights and a rotating beacon for alarms. Engines are also shut down by fire protection heat sensors located near the engines.

If an engine protective device shuts off the engine, always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

The following table contains the common alarms and their factory programed trip-point values or condition. Additional programmed alarms can be added.

Low Engine System Voltage	Below 20 VDC
Engine Overspeed	1.18 times synchronous speed
Overcrank	Crank cycle timed out
Not in AUTO	Engine Control Switch
Low Oil Pressure @ Turbocharger	Limit Varies with RPM
Low Engine Oil Pressure	Limit Varies with RPM
High Coolant Temperature	Above 102° C (215 °F)
Low Coolant Temperature	Below 80° C (176 °F)
Low Coolant Level	Level sensor is tripped
Low Fuel Level	Level sensor is tripped

Become familiar with the following information:

- Types of the alarm and shutoff controls,
- Locations of the alarm and shutoff controls,
- Conditions which cause each control to function, and
- Resetting procedure that is required before starting the engine.

For information about the specific alarms and shutoffs for the engine and the generator, refer to Section 4.2.3.8.1.1 of this manual.

2.3.8.2 Cooling Systems

Diesel engines require cooling of cylinder heads, cylinder walls, turbo charger bearings, pistons, and piston rings through the oil intercooler and engine water jacket. High temperatures can cause damaging metal distortion and breakdown of materials and lubricants.

Diesel engine cooling is accomplished by circulating jacket water (glycol) through the external jacket water heat rejection loop. This loop consists of duplex electric motor driven circulation pumps, waste heat recovery heat exchangers, remote air cooled radiators, fluid expansion provisions, glycol make-up provisions, and interconnecting piping and control valves.

2.3.8.2.1 Jacket Water

Jacket water is a mixture of 60% antifreeze (glycol) and 40% water for freeze protection. When the engine/generator is operating, controls are set to maintain the temperature of water entering the jacket at approximately 198°F. The maximum allowable exiting jacket water temperature, for safe engine operation, is 210°F. This temperature range is maintained at these levels by the use of two (2) heat exchangers HX-1 and HX-2. The heat exchangers pull heat from the water jacket system and feed it into the main waste heating loop. Excess heat not used by the main waste heating system is directed to the two radiators.

When the engine/generator is not operating, the Pre-heat System maintains jacket water temperature at a suitable operating level.

Coolant flows to jacket water pump through an elbow that connects to the radiator or heat exchanger. Part of the coolant is sent to the aftercooler while most of the coolant is sent through engine oil cooler.

NOTE:

There is one opening on the pump outlet so that a remote pump can be connected to the system The remote pump can be used if there is a failure of the pump on the engine.

The coolant that is sent to the aftercooler goes through the aftercooler core. The coolant then goes through an elbow. The coolant goes into a passage in the block. The passage is at the rear of the block.

The coolant that is sent to the engine oil cooler goes through the engine oil cooler. The coolant flows into the water jacket of the block at the right rear cylinder. The cooler coolant is mixed with the hotter coolant.

The mixture goes to both sides of the block through distribution manifolds. The distribution manifolds are connected to the water jacket of all the cylinders. The main distribution manifold is located just above the main bearing oil gallery

The coolant flows upward through the water jackets. The coolant flows around the cylinder liners from the bottom to the top. Near the top of the cylinder liners, the water jacket is made smaller. This is the area that has the hottest temperature. This smaller area causes the coolant to flow faster for better liner cooling. Coolant from the top of the liners flows into the cylinder head which sends the coolant around the parts that have the hottest temperature.

Coolant flows to the top of the cylinder head (one at each cylinder). The coolant flows out of the cylinder head through an elbow into water manifold. Coolant then flows through the manifold to the temperature regulator housing (thermostat).

The regulator housing has an upper flow section and a lower flow section. The regulator housing uses four (4) temperature regulators. The sensing bulbs of the four temperature regulators are in the coolant in the lower section of the housing. Before the regulators open, cold coolant is sent through the bypass line back to the inlet of the water pump. As the temperature of the coolant increases, the regulators start to open. When the regulators open the coolant flow in the bypass line is then restricted. Coolant is then sent through the outlets and circulated through the remote radiator.

(Additional information for the engine jacket water cooling system used in the Water Plant can be found in Appendix Section 4.2.3.8.1.1 of this manual.)

2.3.8.2.1.1 Remote Radiators

Remote radiators (RAD-1 and RAD-2) are located within the new radiator enclosure located out side the Water Plant. The enclosure is normally kept at approximately 50° F to maximize heat transfer efficiency. Air dampers mounted on inlet and exhaust air openings at the discharge side of each radiator allow for controlled air recirculation. The warm discharge is either returned into the room to mix with the colder incoming air, or the warm air is directed to the exterior if the space is too hot.

Remote radiators are used for engine/generator cooling any time the heat recovery system is off-line, or the waste heat is not being used for any reason.

When engine/generator exiting jacket water temperatures exceed 198°F and the control valves remain at full open, the remote radiator fans start. The DDC System modulates the dampers to maintain a minimum temperature within the radiator enclosure. The DDC System also controls the speed of the remote radiator fans in order to keep jacket water (glycol) temperatures at safe levels before returning to the engines.

(Additional information for the remote radiators used in the Water Plant can be found in Appendix Section 4.2.3.8.2.1 of this manual.)

2.3.8.3 Stack Gas

Exhaust gas from engine generators is routed either to heat recovery silencers or non-heat recovery silencers by exhaust bypass valves. The exhaust bypass valve consists of two butterfly valves in a tee section linked together to one operator controlled by the DDC System. When glycol heat recovery exiting temperatures exceed 230° F, or anytime the heat recovery system is offline, exhaust gas bypasses heat recovery silencers and is directed to the non-heat recovery silencers.

Heat recovery silencers designated EHX-1 and EHX-2 are used to pull heat from the exhaust system and direct it to the main waste heating loop. Glycol fluid is circulated through the heat exchangers by circulation pumps CP-13 and CP-14. Non-heat recovery silencers located above the building roof, are used to silence and exhaust burned gases from the engines.

2.3.8.3.1 Non-Heat Recovery Silencers

Besides providing a bypass for the heat recovery silencers, non-heat recovery silencers (ES-1) provide containment and noise reduction. Under full load, the diesel exhaust can exceed 1000° F. When waste water temperatures approach 230° F exiting the heat recovery silencers, the exhaust bypass valve diverts exhaust flow to these silencers.

(Additional information for the engine non-heat silencers used in the Water Plant can be found in Appendix Section 4.2.3.8.3.2 of this manual.)

2.3.8.3.2 Heat Recovery Silencers

Exhaust heat recovery silencers remove heat from the hot exhaust gas directly to the glycol of the Main Distribution Loop. The silencers are essentially a static type heat exchanger of single-pass U-tube construction. The exchangers are equipped with an exhaust bypass to divert the waste heat through the fin tubing or bypass a portion away from the exchanger or modulate.

The hot gas passes through the outer shell and the glycol through the inside of the U-tube piping. Tubes have.75” tall fins welded to the outside diameter to enhance the gas side heat transfer. High temperature exhaust heats the fins and U-tube piping on the outside, causing the cooler glycol/water mixture pumped through the inside to get hot. Tube bundles are removable for access to the inside and outside of the tubes.

NOTE:

If liquid is introduced into a hot exchanger, sever damage can result and will void any manufacturer’s warranty.

Once the exchangers are brought on line, it is recommended to note and record the liquid inlet and outlet temperatures, the exhaust gas inlet and outlet temperatures, and if applicable - the pressure gauge reading, for future reference while the exchanger is in a like new condition. This will allow a good comparison later on to determine a potential fouling condition which would require immediate corrective action.

The exchangers were designed to a have minimum friction loss at maximum firing loads with the damper assembly in the normal operating position. If too much Btu/hr recovery is being achieved, or if the final exhaust temperatures are too low, or if the desired water temperature is not reached, adjust the exhaust bypass damper to attain the desired objective. Refer to the optional liquid temperature control or stack corrosion control assemblies for performance data.

It is recommended to inspect the exchanger's heating surface if the performance (liquid temperatures leaving and Btu/hr. recovery) begins to decrease. A good practice of maintenance is to keep a performance schedule starting when the silencer is installed to compare with any future changes.

A simple method of determining whether the exchangers are performing properly is to monitor the exit temperatures on the liquid and gas sides while in the new condition to establish a base of comparable data. If the exhaust temperature leaving the exchanger is higher than normal and the liquid exit temperature is lower than normal, then either the heat transfer surface is fouled or the inside of the tubing is scaled. This requires cleaning as soon as possible during a convenient shut-down period.

If the exchanger's liquid inlet and outlet temperatures are approaching being equal as compared to the original data, this may be a pump problem and/or a scale accumulation occurrence in the finned tubing. It is also possible that the fin coils are severely fouled.

To prevent severely fouling of the fin coils, a Sootblower Assembly was included with the exchanger. Operation of the sootblower is controlled by a fully programmable timed controller.

Sootblowers are best suited for combustion sources where the sulfur content is high and/or combustion is poor. More specifically, the sootblower is applied where combustion can foul to the degree where it is not cost effective to manually open inspection doors and physically clean the exchanger with other means. Typically units with multiple cores, with proper fin spacing, that have exhaust from diesel, No. 2 fuel oils - No. 6 oil should include a sootblower assembly.

A single row design or a maximum of three coils (square pitch design), in conjunction with the proper sootblower will ensure the best possible solution to achieve a nearly soot free exchanger.

Sootblowers can definitely minimize the need for manual cleaning. It is the owner's responsibility to maintain a good maintenance program to assure that the engine and exchangers are working to their originally designed output at peak efficiency. For fuel oil type atmospheres, regular periodic manual inspection and cleaning of the heat exchanger surface is mandatory to insure maximum efficiency and equipment longevity.

The Sootblower Assembly surrounds the outside of the heat transfer core area. When operated, the particulate is blown off into the exhaust gas stream. The internal bypass damper must be in the 'normal operating' position during blowdown. A routine blowdown schedule should be established at time intervals consistent with the soot loading characteristics of the fuel being burned. For example, on an engine burning diesel or No. 2 fuel oil, a daily blowdown may be all that is required. Interval time or the length of time between sootblowing cycles (off/interval) ranging from 1-24 hours is factory set: No. 2 fuel oil & diesel at 8 hours and No. 4 or 6 fuel oil set at 4 hours. The total duration for a sootblowing cycle ranges from 30 – 60 seconds before resetting for the next sootblowing cycle.

All Sootblowers are designed to use high pressure air at 50 psig minimum -100 psig maximum (consistent pressures at 100 psig will clean the exchangers more efficiently).

If compressed air is the only means available, an accumulator tank should be selected and properly sized to allow for a slow filling time between blow downs. A slow filling time can result in a minimum sized air compressor dedicated to filling the tank during the interval time periods.

The Sootblower Assembly contains ring nozzle assemblies for inward blowing and utilizes special flood-jet type nozzles for achieving maximum velocity and a concentrated spray pattern. The ring nozzle assembly is attached to a manifold and powered up and down (vertical installation) or side to side (horizontal installation) by a Pneumatic Drive Cylinder. When the internal bypass opens, the exhaust flow then changes from the normal gas flow to bypass gas flow direction, enabling a unique 'cross flow cleaning' to take place. This type of cleaning occurs because the ring nozzle assembly encompassing the heat transfer surfaces, blows transverse to the finned tube row(s) while the flue gases blow longitudinal to the row. The actual cleaning occurs as a result of an effective sootblower design penetrating one to a maximum of three rows, (depending on the model number). The sootblowing sequence can operate at any load condition.

Sootblowing Operating Sequence:

1. Upon the start of the sootblowing cycle, the Pneumatic Drive Cylinder is activated and begins to extend, by an adjustable Duration/ Interval Timer.
2. At the same time, both the Damper Actuator Control, and Control Valve are also activated.
3. Damper Actuator Control diverts the majority of exhaust gas flow out through center of the economizer.
4. The Control Valve opens and allows steam or air to begin the cleaning action.
5. As the Pneumatic Drive Cylinder's plunger begins to move the manifold and ring nozzle assembly, steam or air passes out the nozzles and the cleaning action begins to takes place.
6. When the Pneumatic Drive Cylinder reaches the full stroke, its solenoid is de-energized by the Duration/Interval Timer and begins to retract to the original position.
7. The Delay Timer keeps the bypass in the maximum bypass position and steam valve open until the cylinder returns to its normal operating position.
8. The Damper Actuator control returns to the normal heat recovery operating position and the Control Valve closes.
9. Upon completion of the sootblowing cycle, the Duration Timer resets for the next period.

NOTE:

Sootblowing intervals are dependent on periodic inspections of the finned tubing and the efficiency of the combustion source. It is recommended to establish a base performance while the economizer is in a clean state running state with inlet and outlet temperatures and flow conditions. When performance begins to diminish as compared to established recorded load levels, the blowdown intervals should be adjusted closer together so the sootblowing occurs more often. Also an adjustment should be made to the combustion source for improved efficiency which would reduce the production of soot.

(Additional information for the engine heat recovery silencers used in the Water Plant can be found in Appendix Section 4.2.3.8.3.3 of this manual.)

2.3.8.3.3 Diverter Control Dampers

The diverter control damper is located inside the exhaust bypass assemble mounted on top of the exhaust heat recovery silencer. The purpose of the diverter damper is to divert the waste heat through the fin tubing or bypass a portion away from the exchanger or modulate according to performance requirements. The normal operating position of the diverter is where all the exhaust is being diverted into the exchanger.

The diverter controlled damper receives a signal from the temperature controller and modulates the damper to bypass the flow of exhaust, to maintain a desired liquid outlet temperature (or minimum outlet exhaust temperature leaving the exchanger). During the sootblowing cycle, the damper moves to the full bypass position. This allows the full flow of exhaust to help draw the soot out the exchanger until the end of the sootblowing cycle.

The Electric Steam Valve Assembly is energized to open (5 seconds) during sootblowing operation allowing 50 psi (minimum) to 100 psi (maximum) air to pass through a flexible stainless steel hose, through a manifold, then through the ring nozzle assembly and finally passing out through the flood jet nozzles and energized again to close after the sootblowing cycle is complete.

The Temperature Indicating Controller receives a signal from the thermocouple sensing either the liquid temperature leaving or the exhaust temperature leaving the economizer and controls the Modulating Electric Damper Assembly.

(Additional information for the engine diverter control dampers used in the Water Plant can be found in Appendix Section 4.2.3.8.3.4 of this manual.

2.3.8.4 Lubricating Oil System

A standard configuration engine generator set typically requires oil changes every 500 hours. One standard oil change for the engine generator requires 61.5 to 106 gallons of oil depending on the factory installed oil filter system. The primary purpose for the Lubricating Oil System is to use less oil by extending the required time between oil changes. The diesel engines for the Water Plant have larger oil sump capacities of 106 gallons and will continuously reprocess the lubricating oil to extend its life to 8000 hours between oil changes. Oil is pumped and reprocessed, one diesel engine at a time, to limit cross contamination. Each engine has its own supply pipe and a common return to and from the engine lubrication oil reprocessing skid. Lubricating oil is manually sampled and tested for metal content every 250 hours of operation.

2.3.8.4.1 Engine Oil Filters

Duplex oil filters are supplied as part of the diesel engine. Filter elements should be changed at every regular oil change or before the filter gauge indicates 15 psi.

(Additional information for the engine oil filters used in the Water Plant can be found in Appendix Section 4.2.3.8.4.1 of this manual.)

2.3.8.5 Engine Fuel Oil System

Fuel is delivered to the new 1,000 gallon day tank located inside the facility. The tank is a new double wall fuel storage tank sized to provide two weeks of use between fueling cycles. The day tank is gravity filled from an outside main storage tank by opening and closing feed valves. The interior day tank allow the fuel to have some time to warm-up which results in a more efficient combustion.

From the day tank fuel is delivered to three points of use, the engine generators, the boiler, and the standby furnace.

The DDC System monitors and controls fuel levels in the day tank including the operator of the fuel oil coolers.

The fuel delivery system to the engine is a conventional design for engines that use fuel injectors. The fuel delivery system uses a fuel transfer pump to deliver fuel from the day tank to the electronic fuel injectors. The transfer pump is a fixed displacement gear pump.

The fuel flows from the fuel transfer pump through the cored passages of the Electronic Control Module (ECM). This cools the module. The fuel then flows through a fuel filter before entering the fuel supply manifold. A fuel priming pump is located on the fuel filter base in order to fill the system. The system must be primed after the filter changes. The system must be primed after draining the fuel supply and return manifolds, when the fuel injectors are replaced.

The fuel flows continuously from the fuel supply manifold through the fuel injectors. The fuel flows when either the supply or the fill port in the injector is not closed by the injector body assembly plunger. The fuel that is not injected into the cylinder is returned to the day tank through the fuel return manifold. Since this returned fuel has been heated from the engine, fuel oil coolers were installed in the Day Tank Room to cool the returning fuel.

A pressure regulating valve is at the end of the fuel return manifold. The pressure regulating valve controls the entire fuel system pressure. This provides proper filling of the fuel injectors.

The electronically controlled, mechanically actuated, fuel injector system provides total electronic control of injection timing. The injection timing is varied in order to optimize the engine's performance.

The timing ring is part of the rear gear group. A signal is generated by the engine speed limiting sensor. This information is for detection of crankshaft position and for engine speed. Other information and this data allows the ECM to correctly send a signal to the injector solenoids. The fuel injector's solenoid is energized in order to begin fuel injection. The fuel injector's solenoid is de-energized in order to end fuel injection.

2.3.8.5.1 Fuel Oil Filters

Duplex oil filters are supplied with 2020 series 2-micron (brown) filter elements. The double filter manifold has shut off valves for filter element replacement. Filter gauge typically reads 3.7 psi clean and 15 psi maximum for a dirty filter. The lower bowl collects water and heavy particles separated by the integral turbine centrifuge.

(Additional information for the engine fuel filters used in the Water Plant can be found in Appendix Section 4.2.3.8.5.1 of this manual.)

2.3.8.5.2 Fuel Oil Coolers

Fuel oil coolers were installed in the Day Tank Room to cool the circulating fuel oil coming back from the engine generators. The returning fuel oil is heated as it is circulated through the engine generators. The fuel is routed through the coolers prior to be dumped back into the Day Tank. Reducing fuel temperatures also improves its fuel energy at the engine generators. The oil coolers used are of a high pressure round tube and fin construction. Heat from the direct drive fan is injected into the Day Tank Room.

The coolers have isolation valves on both the FOS and FOR lines provided to take the cooler out of service if needed. The fans on the fuel oil coolers are under DDC control.

(Additional information for the engine fuel coolers used in the Water Plant can be found in Appendix Section 4.2.3.8.5.2 of this manual.)

2.3.8.5.3 Fuel Oil Shut-Off Valves

Both the FOS and FOR lines to and from the engine generators have a normally closed, spring loaded, fuel shut-off valves. These vales are specialized fusible link assemblies for fail safe situations where high temperature heat from fire results in a main valve springing closed when a fusible link breaks. This restricts the flow of flammable liquids or gasses, reducing the spread of fire or explosion.

The valves are designed so that the valve can function as a manually operated unit even while the fusible link is still armed.

The valves are tied to a CO_2 release mechanism designed to release CO_2 in case of a fire in the Generator Room.

(Additional information for the engine fuel shut-off valves used in the Water Plant can be found in Appendix Section 4.2.3.8.5.3 of this manual.)

2.3.8.6 Generator

The generator units may be operated as single units or as parallel units. Multiple units are started the same as single units, but the stopping procedure is different. Units can be paralleled with units under load.

The following steps are suggested by the manufacturer as the starting and stopping procedures for single unit operation. These steps should only be used after the "initial start-up" conditions have been completed and the units tested:

Single Unit Starting:

1. Before the initial start-up, the operator should perform the megohm meter test on the main stator winding.
2. Make all preliminary engine starting checks.
3. Be sure that the main circuit breaker or the line circuit breaker is open.
4. Start the engine. Allow the engine to warm up.
5. Adjust to the full load engine speed
6. Close the main circuit breaker.
7. Apply the load. Do not try to apply the full load.
8. Apply the load in increments in order to maintain system frequency at a constant level.
9. Readjust the governor for rated frequency

Single Unit Stopping:

1. Remove the load in increments.
2. Open the circuit breaker.
3. Allow the engine to run for five minutes in order to cool.
4. Stop the engine.

Multiple Unit Stopping:

1. Check the load. The load must be less than the rated capacity of the remaining units.
2. Be sure that the neutral of one of the remaining units is grounded.

3. Remove the load from the outgoing unit. The amperage may never go to zero due to circulating currents.
4. Open the circuit breaker.
5. Allow the engine to cool for five minutes.
6. Stop the engine.

Use the following steps to parallel units after their initial start-up:

Units may be paralleled at no load or paralleled with units under load. After the initial start-up conditions are satisfied, verify for the following requirements

- One of the governors can be an isochronous governor. Electronic load sharing governors are an exception.
- Generators must have voltage droop compensation or cross current compensation.

1. Start the unit which will be paralleled.
2. Turn the synchronizer lights on.
3. After the engine has run a few minutes, bring the engine up to synchronous speed. This means that the frequency of the incoming unit will be the same as the frequency of the unit on line. The synchronizing lights will begin to blink.

NOTE:

The frequency of the incoming unit should be slightly greater than the line frequency, This will allow the incoming unit to assume some of the load rather than add to the system load.

4. Using the governor control, adjust the engine speed until the lights blink very slowly.
5. The lights are off when the voltages of the two units are in phase. At this point, very quickly close the breaker while the lights are out.
6. Use governor controls in order to share kW load between engines.
7. Generator temperature will be stabilized in approximately one hour. After the generator temperature has been stabilized, adjust the voltage droop rheostat of each generator in order to share the reactive load and in order to limit the circulating currents. Less droop increases the reactive current that is carried by the generator. Adjusting the voltage droop rheostat in a counterclockwise direction (CCW) will decrease droop. Adjusting the voltage droop rheostat in a clockwise direction (CW) will increase droop.

Once the two units have been paralleled, the units share of the kW load is determined by the governor control setting. If two units of the same capacity and the same governor characteristics have the same governor control settings, the units will share the load equally, The total load must not exceed the capacity of the one engine.

The generator set load sensor is used to establish load sharing for paralleled generator applications. This generator set load sensor is used with speed control governors. It measures the generator kilowatt load with current and potential transformers. It outputs an analog voltage signal which biases the speed reference of the engine speed control governor. The engine speed control governor affects the actual fuel level setting and precisely maintains its proportional share of system load while maintaining a fixed frequency.

(For more specific information concerning operation of the generator, reference Section 4.2.3.8.1.1 of this manual.)

2.3.9 Control Systems

2.3.9.1 Direct Digital Control and Monitoring Equipment

The Direct Digital Control System (DDC) is the electronic automation and monitoring of HVAC systems throughout many of the buildings at McMurdo Station. The purpose of the system is to lower energy and maintenance costs. The DDC system is comprised of several hardware and software components. Typically, a controlled building will have an integrator and one or more controllers. The controllers have several inputs and outputs that are connected to a wide variety of devices such as: temperature sensors, valve actuators, damper motors, pressure sensors, fan motor starter relays, boiler controls, current sensors, etc. The inputs and outputs are defined as binary (On / Off), or analog (Variable), with specific signal types. Binary signals are 24VAC for On and 0VAC for off. Analog signals are 0-10VDC, 0-5VDC, or 0-20 mA. The choice of signal type is dependent upon the devices used in the DDC design. The controller is connected to all of the visual logic controller (VLC)s needed for a building, by a Master Slave Token Passing Local Area Network, MSTP LAN. This LAN allows communications between each controller. In addition, controllers have the capability of communication via Ethernet Lan's. This allows communications between all controllers, directly or indirectly, in a campus environment. McMurdo Station has a dedicated Ethernet LAN for DDC. This system also requires a server on the Ethernet LAN, and as many client computers as desired for monitoring the system. The software resides on these computers. The software is designed and configured to send and receive data from all controllers, and display that data in graphic packages for each building. For example, a graphic package may have displays for Boiler Room and Air Handler Unit (AHU) functions, as well as any alarm functions pertinent to that building's HVAC systems.

Schedules can be established for any control point in the system. Trends can be monitored for any control point on the system. This data can also be used for diagnostic purposes in the event of an HVAC component failure.

Each individual controller or visual logic controller has its own "Logic" or program designed to react to its Inputs and manipulate its Outputs accordingly. This logic is designed, viewed, or modified using an application called "Visio," which resides on the server.

The logic for each controller on the system is a file on the hard drive of the server. The application is located at C:\bactalk, and specifically, the files for DDC logic, graphics, bitmaps, devices, etc., are located at C:\backtalk\msi\mcmurdo.

Management of the system files requires care and periodic backups.

The controller and visual logic controllers are located in the Direct Digital Control Panel (DDC).

2.3.9.2 Controllers

The controller is a high performance, fully programmable logic controller (VLC) designed for control of central plant systems, air handling units, clean rooms, fume hoods, large terminal units and similar control and process equipment. The controller communicates using the standard protocol on a MS/TP LAN, which operates at up to 76.8 Kbps. An LED indicates communication activity on the MS/TP LAN. The VLC can also operate as a stand-alone controller. Its design includes support for an intelligent wall sensor unit offering convenient data display and setpoint adjustment.

(Further information on controllers can be found in the Appendix Section 4.2.3.9.1.1 of this manual.)

2.3.9.3 Control Valves

All control valves have position indicators, local manual overrides at the valve, and spring return for fail-safe operation (i.e., will fail in a safe position in the event of freeze, fire, power failure, or temperature protection).

Control valves are valves monitored and controlled by the DDC System used to change the operation of various devices throughout the facility based on feedback from that device. These valves are typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling units. Other common applications include unit ventilators, reheat coils, and bypass loops. These valves are suited for use in a hydronic system with variable flow.

As an example:

The temperature control valve serves the heating coils and the electric unit heaters. A sensor (room or duct) sends a signal to the VLC in its respective control panel.

The VLC compares the signal to the desired set point and in turn sends an electrical current, which can vary from 4-20 mA, to the valve. If more heat is required to maintain the desired set point, the current is increased up to 20 mA. As less heat is required, the amount of current is decreased.

(Additional information regarding control valves is available in Appendix Section 4.2.3.9.1.2 of this manual.)

2.3.9.4 Damper Operators

All damper operators have position indicators, local manual override at the damper, and spring return for fail-safe operation during conditions such as fire, power failure, or temperature protection.

The damper operators serve the mixed air dampers, return air dampers, relief air dampers, and exhaust air dampers. Some dampers are two position – either open or closed. The remainder of the dampers are modulating. A modulating damper (such as the dampers mounted on the inlets and outlets for the radiator fans) varies the amount of air flowing through the damper.

Two position dampers receive a low voltage electrical signal that moves the motor in the damper operator to a position that opens the damper. The low voltage signal is initiated from a manual or timer switch.

A sensor (duct or on-off switch in the DDC) sends a signal to the VLC in its respective control panel.

The VLC compares the signal to the desired set point and in turn sends an electrical current, which can vary from 4-20 mA, to the operator. If more air is required to maintain the desired set point, the current is increased up to 20 mA. The current determines the amount of air that is allowed to pass through the modulating damper. As less air is required, the amount of current also decreases.

(For additional information on Damper Operators, refer to Appendix Section 4.2.3.9.1.3 of this manual.)

2.3.9.5 Input / Output Sensors

There are several different types of input / output sensors, they include:

Damper position sensors typically use potentiometers mounted on the operator or crank arm to sense damper position. Relief-air dampers, as well as the outside-air and return-air dampers in the Air Handling Unit, all have damper-position sensors that output a 2-Volt to 10-Volt linear signal for position feedback.

Temperature sensors are generally resistance temperature devices (RTD). They vary in resistance according to the exposed temperature. Some temperature probes are long averaging type.

Duct temperature sensors - use a pre-calibrated, interchangeable thermistor that changes resistance relative to the temperature in the duct. This resistance value is then read by the VLC.

Room temperature sensors - use a pre-calibrated, interchangeable thermistor that changes resistance relative to the temperature in the duct. This resistance value is then read by the VLC.

Outside air temperature sensors - use a pre-calibrated, interchangeable thermistor that changes resistance relative to the temperature in the duct. This resistance value is then read by the VLC.

Air Pressure Sensors - are used to sense duct pressures and relay this information to a pressure transmitter or pressure switch.

Current Sensing Switch - these devices are used for monitoring of small motor loads.

Sensors used to measure fluids in piping or tanks use a well to protect the tip of the sensor. Analog level sensors measure differential pressure in liquids and transmit a proportional electrical signal to the DDC System.

Specialized sensors are used to detect and measure levels of oxygen and CO_2.

(Additional information regarding Temperature Sensors is contained in Appendix Section 4.2.3.9.1.4 of this manual.)

2.3.9.6 Transmitters

Differential pressure transmitters are used to compare interior building air pressure to outdoor (ambient) pressure, and to monitor the pressure difference across air filters in the air handling units. Each transmitter sends out a 4 to 20 mA signal proportional to the pressure difference between its two sensor tube connections. Differential pressure transmitters are used to determine the flow rate in the Main Distribution Loop. Pressure transmitters are located in the glycol make-up systems, the air compressor, the Domestic Water Boost System and the Engine Exhaust System. Pressure transmitters for glycol make-up systems are field adjustable for 0 to 25, 0 to 50 or 0 to 100 psi. They measure the system pressure at each glycol make-up pump. They transmit a 4 to 20 ma signal proportional to the pressure range.

Temperature transmitters convert low-level Resistance Temperature Device (RTD) outputs to standard current (4 to 20 mA) signals for transmission. Differential pressure transmitters are used in the various heat exchangers located throughout the Water Plant. These transmitters send out a 4 to 20 ma signal proportional a 0 to 20 psi difference between the heat exchanger inlet and outlet connections. Some temperature probes are long averaging types while others can be bent to traverse ductwork.

CO_2 monitors located in the HVAC ductwork transmit voltage or current outputs proportional to CO_2 levels detected. They are capable of measuring 0 to 2000 PPM (parts per million) of CO_2.

Fuel Storage Tanks are supplied with level transmitters. Variable Frequency Drives (VFD's) transmit motor speed signals. pH transmitters are used for well water and at the limestone contactors. There is a chlorine transmitter in the Water Treatment System.

Iron-bodied flow meters are located in the waste water side of Heat Exchangers. Bronze-bodied flow meters are used in Water Treatment System. These are turbine flow meters with direct read outs as well as flow transmitters. The turbine pulse is magnetically transmitted through the case to the register mechanism. A pulse to DC converter is used to output a 4 to 20 ma signal proportional to flow rate measured.

(Further information on transmitters can be found in the Appendix Section 4.2.3.9.1.5 of this manual.)

2.3.9.7 Transducers

The transducers installed throughout the Water Plant are designed to monitor duct and static pressure in commercial buildings. The differential pressure transducers use a highly accurate and stable sensor, which is microprocessor controlled for improved accuracy and reliability.

The transducers are controlled by a pushbutton and digital input terminal on a controller. A microprocessor algorithm is used to prevent accidental zero adjustment during normal operation.

The transducers use a ceramic capacitive sensor and temperature compensation circuity. Best accuracy is achieved after the transducer warms up. Readings at zero pressure and lowest pressure ranges will appear erroneous the first few minutes of operation.

The LCD display on the controller momentarily displays the range "set" when selections is made. Pressure is normally indicated on display. The range is measured in inches water column (W.C.)

The controller is used by pressing and holding the *ZERO* pushbutton for two (2) seconds, or by providing contact closure on the "AUX ZERO" terminal. This automatically resets the output and display to zero pressure to protect the unit from accidental zero. This feature is enabled only when the detected pressure is within 5% of factory calibration.

(For more specific information for the transducers, reference Section 4.2.3.9.1.6 of this manual.)

2.3.9.8 Actuators

Actuators are devices which transform an input signal (mainly an electrical command signal) into motion, such as opening or closing a valve. Actuators are used in several systems in the Water Plant, such as the Sootblower and the Exhaust Waste Heat Recovery System.

In case of a power failure, the actuators can be manually operated by turning the manual override handwheel after the actuator is electrically disconnected.

The rotation range of the actuator is controlled by the use of limit switches mounted at the extreme limits of a full rotation.

The proportional AC motor in the actuator is controlled by a proportional controller.

The actuator is controlled by comparing an external command signal to a feedback signal from a potentiometer linked to the actuator. Depending on the magnitude of the two signals, the controller will energize either the clockwise (cw) or the counterclockwise (ccwj motor output. This drives the actuator in the direction that will reduce the difference between the two signals. When the feedback signal equals the control signal, the controller will turn off the drive to the actuator.

The controller uses a 4 to 20 mA command signal, a 1 to 5 mA command signal, a 0 to 10V command signal, a 1 to 5V command signal, or a command signal potentiometer. The actuator must be calibrated before it can be put into use.

(For more specific information for the actuators, reference Section 4.2.3.9.1.7 of this manual.)

2.4 ELECTRICAL SYSTEMS

There are several different systems which make up the electrical systems at the Water Plant. These include:

The 120 / 208-volt, three phase interior electrical distribution system - which provides power to all interior equipment, lighting, and receptacles.

The 120 / 208-volt, three phase exterior electrical distribution system - provides power to the systems within the Water Plant and Pump House by the use of a new pad-mounted transformer. Pad-mounted medium voltage switches provide scalability for Station power from the Power Plant or the redundant power system in the Water Plant. Exterior load banks are used for testing and phasing of the engine generators.

The engine generator systems - consists of two (2) skid mounted diesel engine generators, control panels, starting systems, and charging systems.

The power generation system - consists of medium-voltage distribution switchboards and the paralleling switchgear.

The lighting system - which includes fluorescent lamp fixtures for interior area and egress illumination, incandescent lamp fixtures for the area lighting, and self-luminous egress fixtures and incandescent lamp emergency fixtures.

The heat trace system - which may be used to provide warmth to sub-floors, interior spaces, and prevents both fresh-water, sea-water, and waste-water piping from freezing.

The signaling systems - which consists of telephone, a local area land (LAN) system, a Closed Circuit Television System (CCTV), and a fire alarm system signals. The Closed Circuit Television System allows operators to view operation of the engine generators at the Water Plant and the Power Plant from either location. The fire detection and alarm system provides mechanical fan shutdown, smoke / fire damper closure, fire door closure, alarm signaling, area detection using heat detectors, and a mechanical air duct detection using smoke detectors.

2.4.1 Interior Distribution System

The interior power distribution system for the Water Plant consists of the following major components:

- power and light distributing panelboards,
- motor control centers,
- enclosed combination motor controllers,
- variable frequency drives (VFD),
- enclosed disconnect switches, and
- other miscellaneous electrical components.

2.4.1.1 Panelboards

Panelboards function as the smallest unit of the Interior Power Distribution System. Power feeds are connected to the panelboard by a main circuit breaker or main lugs and are then distributed to smaller load segments via properly sized branch circuit breakers installed within the panelboard. Panelboards in the Water Plant are equipped with either “bolt-on” or “plug-in” type branch circuit breakers.

The following table identifies panelboards by designation, voltage, phase, wire, and breaker-space counts:

WATER PLANT/PUMP HOUSE PANELBOARDS			
DESIGNATION	**VOLTAGE**	**MODEL**	**PHASES(P) / WIRES(W) / SPACES)**
LP-2	120/208	NQOD	3P / 4W / 41S
WPH	270/480	NQOD I-Line	3P / 4W / 41S
WP-1	120/208	NQOD	3P / 4W / 41S
WP-2	120/208	NQOD	3P / 4W / 41S
PHH	270/480	NF	3P / 4W / 41S
PHL	120/208	NQOD	3P / 4W / 41S

The Power Panel designated WPH is the main Power Panel in the Water Plant fed by transformer T-W-2 which is fed through the pad-mounted medium voltage switches from the switchgear in either the Water Plant or the Power Plant.

The Power Panel designed PHH is the main Power Panel in the Pump House fed by transformer T-PH-1 which is fed through the pad-mounted medium voltage switches from the switchgear in either the Water Plant or the Power Plant.

Both these main Power Panels then feed other subordinate panels in each facility.

The manufacturer recommends the following operation of all mechanical components:

- Check the operation of all mechanical components. Have all defective components replaced as soon as possible.
- Exercise switch operating mechanisms and external operators for circuit breakers to determine that they operate freely to their full on and off positions.

- Check the integrity of all electrical and mechanical interlocks and padlocking mechanisms.
- Whenever possible, check all devices for missing or broken parts, proper spring tension, free movement, corrosion, dirt, and excessive wear.

(For information about a specific panelboard, see drawing sheets E6.2 through E6.5 in Appendix Section 4.1.2 of this manual.)

2.4.1.2 Motor Control Centers

A Motor Control Center (MCC) is similar to a panelboard in that it provides a central location for the distribution of power. However, MCC's generally feed larger loads, typically motor loads.

One MCC is installed in the Water Plant. MCC-1 is fed from the new exterior transformer T-W-1. The VFD's for the two radiator fans and circulation pumps CP-13 and CP-14 draw power from the MCC Panel. The MCC has a 120/208 V, 3-phase, 4-wire, 400 Amp rated bus.

Automatic magnetic controllers with coil operating voltages of 120V/60 hertz (Hz) are provided for 0-3 horsepower (HP) motors. Motor controllers are energized via a momentary or maintained signal to the control circuit (by DDC control, external contacts or integral Hand-Off-Auto (HOA) switch), which then provides AC power to the coil pulling in the armature of the contact block. Full voltage is provided to the motor.

In the event of a motor overload, or a single phase condition, integral thermal magnetic overloads will shut down the operation of any motor supplied by the motor controller. Once the overload condition has been resolved and cleared, the motor controller may be reset and normal operation may resume.

Automatic softstart controllers with coil operating voltages of 120V/60 Hz are provided for motors of 5-HP and larger. Softstart motor controllers are energized in the same fashion as magnetic motor controllers. However, softstart motor controllers provide different starting and stopping characteristics. The softstart controllers provide field adjustable voltage ramp and current limit settings. Additionally, they provide freewheel or voltage ramp stopping settings. In the event of motor overload, solid-state thermal overload provides protection and has a manual reset.

VFD's are provided for motors whose associated equipment requires variation in speed to maintain system parameters. Variable speed frequency control is solid-state, microprocessor-based and is accomplished through a diode bridge rectifier and pulse width modulation.

The system includes protection and annunciation features including but not limited to:

- Current limit to automatically prevent over current trip on all phases due to momentary overload conditions.
- Instantaneous over-current, under-voltage, over-voltage trips.
- Ground fault protection.
- Power, motor temperature, voltage/current state indication.
- Acceleration/deceleration rate adjustment.

Sensors, devices, and wiring in conjunction with the DDC System provide a 4-20 mA and/or 0-10 VDC input signal to initiate and maintain the required speed control for the associated equipment.

(For more specific information for the motor control centers used in the Water Plant, reference Section 4.2.4.1.2 of this manual.)

2.4.1.3 Enclosed Combination Motor Controllers and Contactors

Motor controllers provide a means to control electrical equipment. Motor controllers are generally switch type or a combination of a contactor block assembly and overload relay block assembly. Motor controllers can be manual or automatic. Automatic controllers use contactors. Contactors are electro-mechanical devices that enable or disable electrical flow. The controllers used in Cryogen were single unit types with melting alloy type thermal overload relays

Manual switches (similar to light switches) are used to control small motors (fractional horsepower) and equipment with small electrical flows. The manual switch is directly connected (in series) to the equipment it serves. This means that the voltage and the electrical flow that goes through the equipment also goes through the switch.

CAUTION:

Do not attempt to remove the switch cover without first turning the circuit breaker that serves the switch to the "*OFF*" position. In some cases, the manual switch can be at a lower voltage and electrical flow. This occurs only when relays are used in the circuit. This is not the normal situation.

Failure to follow this caution can cause personal injury or major property damage.

Toggle the manual switch to the "*ON*" position to start the equipment. Toggle the switch to the "*OFF*" position to stop the equipment. If the equipment does not start when the switch is placed in the "*ON*" position, the following should be checked to determine the reason for the improper operation of the equipment:

1. Verify that the circuit breaker serving the equipment is "*ON*."
2. Verify that the thermal overload (if applicable) is operating properly.

Pushbutton switches are used to manually control large motors and equipment with large electrical flows. The pushbutton switch controls the operation of a set of contactors. The voltage and electrical flow through the pushbutton switch is normally not the same as that seen by the equipment. The voltage and electrical flow are considerably lower.

CAUTION:

Do not attempt to remove the pushbutton cover without first turning the circuit breaker that serves the switch to the "*OFF*" position.

Failure to follow this caution can cause personal injury or major property damage.

To start the equipment push the "*ON*" button. This causes the contactor to move to a position that allows electrical flow. To stop the equipment push the "*OFF*" button. This causes the contactor to move to a position that stops electrical flow. If the equipment does not start when the pushbutton is placed in the "*ON*" position, the following should be checked to determine the reason for the improper operation of the equipment:

1. Verify that the circuit breaker serving the equipment is "*ON*."
2. Verify that the disconnect switch located near, or on the equipment is in the "*ON*" position.
3. Verify that the fuses in the disconnect switch are not "blown."
4. VerIfy that the thermal overload (if applicable) is operating properly.

Multi-position switches are used to automatically control large motors and equipment with large electrical flows. The multi-position switch controls the operation of a set of contactors (for equipment) or starters (for motors). The voltage and electrical flow through the multi-position switch is normally not the same as that seen by the equipment. The voltage and electrical flow are considerably lower.

CAUTION:

Do not attempt to remove the multi-position cover without first turning the circuit breaker that serves the switch to the "OFF" position.

Failure to follow this caution can cause personal injury or major property damage.

If Multi-position switches are used, they can be placed in the "*HAND,*" "*OFF*" or "*AUTOMATIC*" position. The "*OFF*" position prevents the equipment from operating by placing the contactor in a position that stops electrical flow. The '*HAND*' position overrides the control circuit and operates the equipment by placing the contactor in a position that allows electrical flow to the equipment.

CAUTION:

The "*HAND*" position should be considered as a temporary TEST position only. Generally the "*HAND*" position overrides built in safety devices. The "*HAND*" position should only be used in an emergency or to TEST the equipment.

Failure to follow this caution can cause personal injury or major property damage.

The "*AUTO*" position is used to operate the equipment using a separate control circuit containing safety switches and controls for the desired day-to-day operation. Whenever all the safeties are satisfied, the contractor is placed in a position to allow electrical flow.

If the equipment does not start when the switch is placed in the "*AUTO*" position, the following should be checked to determine the reason for the improper operation of the equipment:

1. Verify that the circuit breaker serving the equipment is "*ON,*"
2. Verify that the disconnect switch located near, or on the equipment is in the "*ON*" position,
3. Verify that the fuses in the disconnect switch are not "blown,"
4. Verify that all safety devices are properly functioning, and
5. Verify that the thermal overload (if applicable) is operating properly.

Large motors use a piece of equipment called a motor starter. This device contains contactors, relays, coils and safeties. The safeties are called motor overloads (overload relays).

The motor overloads protect each electrical phase from improper electrical voltages or electrical flows. They serve to protect the motor. If the motor does not start and all of the checks made in the above paragraph are positive, it will be necessary to confirm the condition of the motor overloads.

(For more specific information for the enclosed motor controllers used in the Water Plant, reference Section 4.2.4.1.3 of this manual.)

2.4.1.4 Variable Frequency Drives

Variable Frequency Drives (VFD's) are provided for motors whose associated equipment requires variation in speed to maintain system parameters. Examples of equipment that use VFD's in the Water Plant would be the radiator fans and motors on various circulation pumps. Variable speed frequency control is solid-state, microprocessor-based and is accomplished through a diode bridge rectifier and pulse width modulation. The system includes protection and annunciation features including but not limited to:

Current limit to automatically prevent over-current trip on all phases due to momentary overload conditions.

Instantaneous over-current, under-voltage, over-voltage trips.

Ground fault protection.

Power, motor temperature, voltage/current state indication.

Acceleration/deceleration rate adjustment.

Sensors, devices, and wiring in conjunction with the DDC System provide a 4-20 mA and/or 0-10 VDC input signal to initiate and maintain the required speed control for the associated equipment.

(For more specific information for the motor variable frequency drives used in the Water Plant, reference Section 4.2.4.1.4 of this manual.)

2.4.1.5 Enclosed Disconnect Switches

Enclosed breaker (disconnects) switches are used to manually disconnect equipment from its electrical source. The disconnect may be fused or un-fused. This disconnect is used to de-energize the equipment, or when maintenance is performed on the equipment. Prior to any maintenance, the disconnect must be placed in the ***OFF*** position. In addition, a padlock and LOCKOUT / TAGOUT should be placed on the disconnect switch so that the switch cannot be placed in the ***ON*** position during maintenance. At all other times, the disconnect switch should be placed in the ***ON*** position.

The ***ON*** or ***OFF*** condition is determined by the position of an external handle in relation to the words ***ON*** or ***OFF*** stamped on the cover.

CAUTION:

Do not open the cover unless the handle is in the *OFF* position. The O*FF* position only disconnects electricity to the equipment it serves. If work is to be performed within the enclosure turn the circuit breaker serving the disconnect switch, to the *OFF* position.

Failure to follow this caution can cause personal injury or major property damage.

Refer to the caution above for any service work on the fuses. The fuse is used to protect the equipment and will need to be replaced if it has "blown" from excessive electrical flow.

(For more specific information for enclosed disconnect switches used in the Water Plant, reference Section 4.2.4.1.5 of this manual.)

2.4.2 Exterior Distribution System

The exterior power distribution system is a network outside the Water Plant consisting of pad-mounted medium voltage switches, transformers, and load banks.

The (6) Outdoor Pad-Mounted MV Switches are located in the MV Switch Yard. These switches are used to enable selective switching of 4160v power, in association with the Generators Automatic Paralleling Switchgear. Selectivity allows operation of various Utility feeders from Power Plant (PP) Generators, Water Plant (WP) Generators, or both.

Outdoor Pad Mounted Transformers are provided to transform the distributed 4160v. 3 Phase, 3 Wire, 60 Hz. Medium Voltage (MV) AC power to the equipment service power low voltage (LV) 277/480v and 120/208v, as applicable. Service distribution transformers are equipped as 'dead front' assemblies, with live bushings in the MV compartment. Load-break elbows connect the incoming MV cables to the dead front bushings. The transformer Low Voltage (LV) compartment comprises live front LV bus-bar connections to the LV service entry cabling.

The existing Load Banks comprise two (2) 500kW, 3 phase, 3 wire, 480v. 60Hz resistive load blocks. The load banks are connected to the existing Load Bank 1000kVA Transformer T-L.

2.4.2.1 Pad-Mounted Medium-Voltage Switches

The six (6) Outdoor Pad-Mounted medium voltage (MV) Switches are located in the MV Switch Yard. These switches enable selective switching of the 4160v power, in association with the Generators Automatic Paralleling Switchgear.

Selectivity allows operation of various Utility feeders from Power Plant (PP) Generators, the Water Plant (WP) Generators, or both.

The Outdoor MV Switch Cabs also contain the Utility feeders' over-load and short circuit protection fuses as follows:

- Switch 1: MV power feed to over-head power lines 'B' and 'D', at Poles 'B-1' & 'D-1".
- Switch 2: MV power feed to over-head power lines 'A', at Pole 'A-1'.
- Switch 3: MV power feed to Crary Bldg. circuit 'E'.
- Switch 4: MV power feed to over-head power lines 'C', at Pole 'C-1'.
- Switch 5: MV power feed to Generators Load Banks. (Transformer 'T-L')
- Switch 6: MV power feed to various Utility Buildings including the PP, WP and Waste Water Treatment Plant (WWTP) service power distribution transformers.

Selective WP and PP alternate power source switching is done from the 'front' lockable Switch compartment. Selective back-feeding of Switches S-1 to S-4 is done from the 'back' switch interlocked Switch compartment. Circuit protection fuses are also located within the 'back' compartment.

(For more specific information for the medium-voltage switches, reference Section 4.2.4.2.1 of this manual.)

2.4.2.2 Transformers

A Dry-type transformer was selected because oil-filled transformers may freeze, they require increased maintenance, and they raise environmental concerns over potential oil spills. Dry-type transformers are lighter than oil-filled, making them less costly to transport and easier to handle.

New outdoor pad mounted service distribution transformers are equipped as ANSI Specification, low loss, 'dead front' assemblies, with live bushings in the lockable MV compartment.

Load-break elbows connect the incoming MV cables to the dead front bushings. Load break elbows are equipped with hot-stick operated disconnect pulling eyes for operations / maintenance.

The transformer Low Voltage (LV) compartment comprises live front LV bus-bar connections to the LV circuit cabling. Single conductor XHHW cables run in Galvanized Rigid Conduit (GRC) conduit connect the transformers to the main service entry LV Switchboard, or Motor Control Center, as appropriate.

The service distribution transformers are as follows:

- XFR; T-W-1: 300kVA, 120/208v service power to existing MCC-1, located in existing Water Plant.
- XFR; T-W-2: 225kVA, 277/480v power to existing Panel WPH, located in existing Water Plant.
- XFR; T-PH-1: 250kVA, 277/480v power to New Panel PHH located in New Pump House.
- Existing XFR; WWTP: 250kVA, 277/480v power to the existing MCC-P1 Panel located in the existing Waste Water Treatment Plant.
- Existing XFR; T-P: 300kVA, 120/208v power to re-modeled Power Plant Bldg. (This transformer previously provided power to the Water Plant).
- Existing XFR; T-L: 1000kVA, 277/480v power to existing Load Banks.

DANGER:

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

Apply appropriate protective equipment (PPE) and follow safe electrical work practices.

This equipment must only be installed and serviced by qualified electrical personnel.

Replace all devices, doors and covers before turning on power to this equipment.

Do not remove access panels or plates while the transformer is energized.

Failure to follow these instructions will result in death or serious injury.

NOTE

Dry-type transformers should be tested before the unit is placed in service. The purpose of testing is to ensure the condition of the transformer is satisfactory for operation, and to provide test data for future comparison.

Dry-type transformers are generally designed to permit loading in line with the ANSI / IEEE Guide for Loading Dry-Type Distribution and Power Transformers C57.96. The following loading information is derived from that ANSI standard.

Average winding rises are 80EC, 115EC and 150EC with insulation systems limited to 150EC, 185EC and 220EC maximum hottest-spot operating temperatures respectively. The temperature rise of specific transformers is determined by the customer's requirements and winding design.

The loading guide is based on the life expectancy of the transformer's insulation system. The deterioration of insulation is a function of time and temperature.

The temperature rise on which the transformer rating is based takes into consideration the insulation life as affected by operating temperature and the ambient temperature assumed to exist throughout the life of the transformer.

The actual output that the transformer can deliver at any time in service without undue deterioration of the insulation may be more or less than the rated output, depending upon the ambient temperature, altitude, and other attendant operating conditions.

The average ambient temperature should cover periods of time not exceeding 24 hours with the maximum temperature not more than 10° C greater than the average temperature. For each degree C that the average temperature of the cooling air is above or below 30° C, the transformer may be loaded below or above its nameplate kilovolt-ampere rating for any period of time.

Loading on the basis of ambient temperature with the loads permitted will give approximately the same life expectancy as if the transformers had been operated at the nameplate rating and standard ambient temperatures over the same period of time.

The operation of transformers in cooling air above 50° C, or below 0° C, should be checked with the manufacturer.

Altitude also influences transformer loading. The effect of the decreased air density due to high altitude is to increase the temperature rise of the transformer since it depends on the surrounding air for dissipation of heat loss. Transformers may be operated at rated kilovolt-amperes at altitudes greater than 3300 feet (1000 m) without exceeding temperature limits. Altitude also affects electrical clearances in air. Unless specified at the time of purchase, air clearances may not be dielectric ally suitable for altitudes in excess of 3300 feet (1000 m).

The permissible load on dry-type transformers may be increased above the rated load for short times in a 30° C Ambient.

Humidity conditions are unimportant as long as the transformer is energized. However, follow the precautionary steps listed below if the transformer is de-energized, is allowed to cool to ambient temperature, and will exceed a shutdown of 12 hours (especially in high humidity conditions).

1. Place small strip heaters in the bottom of the unit shortly after shutdown to maintain the temperature of the unit a few degrees above that of the outside air.
2. Inspect the unit for evidence of moisture before returning it to service.

3. Check the insulation resistance. If evidence of moisture exists, or if the insulation resistance is less than 1 megohm, dry out the transformer by placing it in an oven or by blowing heated air over it.

The temperature rise on the enclosure exterior for ventilated transformers should not exceed 50° C (122° F), except as indicated in UL 1561.

When the transformer is initially energized, a loud hum may be heard for a brief time. This is caused by the transformer magnetizing inrush current. The sound is a normal occurrence, the intensity of which is governed primarily by the point on the A.C. wave at which the unit is energized. It will diminish after a few cycles.

(Additional information regarding dry-type transformers is located in Appendix Section 4.2.4.2.2 of this manual.)

2.4.2.3 Load Banks

The purpose of the Load Banks is to provide proportional load to the Generators, to ensure stable operation, when required. The Load Banks are also used to enable load testing of individual Generators, or to prevent low load condensate build –up in the exhaust gas system, and to apply stable 'black-start' load, if required.

The existing Load Banks consist of (2) 500kW, 3 phase, 3 wire, 480v. 60Hz resistive load blocks. The load banks are connected to the existing Load Bank 1000kVA Transformer T-L.

The Load Banks are also used to enable load testing of individual Generators, or to apply stable 'black-start' load, if required.

Use the following procedure to operate the load bank:

1. Connect the generator or other power source to be tested to the load bank.
2. Place all switches on the control panel to the *OFF* position.
3. Place the *VOLTAGE SELECTOR* Switch to the correct voltage to test the generator.

CAUTION:

DO NOT operate the load bank over the rated voltage as this will cause catastrophic failure in the load bank.

DO make sure that the *VOLTS SELECTOR* switch is in the proper position before applying the load.

4. Place the *POWER* Switch to the *ON* position. A pilot light will be energized, indicating control power present.

5. Place the *BLOWER* Switch to the *ON* position. Observe that the BLOWER *FAILURE* indicator flashes *ON* momentarily. When the blower motor has reached the proper speed, the *BLOWER FAILURE* Pilot Lamp will be de energized. Load voltage will not be connected to load bank resistance elements unless the airflow switch has closed.

CAUTION:

The operation of the blower is vital to the safe operation of this load bank. When the *BLOWER* switch is turned ON, the *AIR FAILURE* light will come on momentarily until the blower accelerates up to its operating speed, at which time the light will go out. If the load elements are energized when this blower is not operating, the load bank will burn up. If the *AIR FAILURE* indicator light stays on for more than a few seconds, shut down the load bank and do not operate the unit until the problem is corrected.

6. With the *MASTER LOAD* Switches in the *OFF* position, start the generator under test. Check for proper phase sequence.
7. The resistive loading is selected by toggle switches, using any one or combination of the toggle switches to make up a given load.
8. By placing the *MASTER LOAD* Switch to the *ON* position, the preselected load will be applied to the power source.
9. Any load switch can be added or removed as required with the *MASTER LOAD* Switch closed (*ON*).
10. To remove the load, open the *MASTER LOAD* Switch by moving it to the *OFF* position.
11. Shutdown: Reverse steps 1 thru 8. It is good procedure to allow the fan blower motor to operate for about 15 minutes after the loads are returned to their *OFF* position. This will cool the resistor elements and exhaust accumulated heat.

WARNING:

DO NOT touch the top exhaust screen during operation. The screen will become hot from the exhausted heat and may cause a serious burn.

DO NOT allow objects to enter or block the screens.

(Additional information regarding load banks is located in Appendix Section 4.2.4.2.3 of this manual.)

2.4.3 Engine and Generator Systems

In its simplest form the engine generator is a diesel engine rotating an armature through a magnetic field to produce power. Back-up Station electrical energy production is provided by two diesel driven generators installed in the new Generator Room in the Water Plant. Both of the engine/generator units are identical and provide base load power production, each with a net prime rating capacity at site conditions of 1825 kW, 2281 kVA and supplying 2400/4160 volts, 3-phase, 4-wire, 60 Hz, wye AC output.

Like all large machinery, there are safety issues all operators should be aware of before operating this equipment. Certain areas of the engine and the generator have safety signs posted to alert the operator of a possible impending danger area. All operators and maintenance personnel are responsible for reading and understanding all safety warnings listed here in this section, and in the manufacturer's manual found in the Appendix Section 4.2.3.8.1.1 of this manual.

Ensure that all of the safety signs are legible. Clean the safety signs or replace the safety signs if the words cannot be read, or if the illustrations are not visible. Use a cloth, water, and soap to clean the safety signs. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the safety signs. The safety signs that are loosened could drop off of the engine.

Replace any safety sign that is damaged or missing. If a safety sign is attached to a the replacement part. The manufacturer can provide new safety signs.

WARNING:

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Attention! Become Alert! Your Safety is Involved.

Do not operate or work on this engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death.

Proper care is your responsibility.

High voltage can cause electrical shocks. Electrical shocks can cause personal injury or death. Avoid contacting electrical components arid wiring.

When the engine is in the automatic mode. the engine can start at any moment. To avoid personal injury, always remain clear of the engine when the engine is in automatic mode.

When the engine is at operating temperature, the engine coolant is hot. The engine coolant is also under pressure. Allow cooling system components to cool before the cooling system is drained. Any contact with hot coolant or with steam can cause severe burns.

Do not climb on the crossbeams for the radiator. Personal injury may result. Use an adequate ladder or use an appropriate work platform for climbing.

Use diesel fuel only in the engine. The use of gasoline can cause the following problems to occur: engine damage, personal injury, and possible death. Avoid spilling diesel fuel on hot engine components. Spilling diesel fuel on hot engine components can cause a fire. Personal injury or death can occur. Use extreme caution when you are filling the fuel tank with diesel fuel. Always wear protective clothing.

The ECM sends a high voltage signal to the unit injectors. To help prevent personal injury, disconnect the unit injector connector. Do not come in contact with the harness connector for the unit injector while the engine is operating.

Do not connect generator to a utility electrical distribution system unless it is isolated from the system. Electrical feedback into the distribution system can occur and could cause personal injury or death.

Always operate this unit with the vandal door open. Operating the unit with the vandal door closed restricts access to the emergency stop button and could result in injury or death.

2.4.3.1 Engine-Generator Set Controls

The engines and generators installed in the Water Plant are monitored by the DDC System but operation is controlled by their own control systems.

The operating techniques outlined in the following sub-sections are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skills and techniques develop as the operator gains knowledge of the engine and its capabilities.

Before Starting Engine

1. Inspect the engine for potential hazards.
2. Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.
3. Ensure that the engine is equipped with a lighting system that is suitable for the conditions. Ensure that all lights work properly.
4. All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.
5. Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.
6. For the initial start-up of a new engine and for start-up of an engine that has been serviced, prepare to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel and/or the air supply to the engine.
7. Ensure all the air inlet piping and the air filters are in place.
8. Ensure all clamps and connections are secure.
9. Inspect and ensure the cooling system is operational and in good condition.
10. Ensure the main circuit breaker is open.
11. Ensure all electrical connections are connected and tight. Ensure all wiring is connected and in good condition.
12. Ensure the fuel system is operational with no leaks.
13. Verify the engine crankcase oil level is at the proper level.

Engine Starting

1. If a warning tag is attached to the engine start switch, or to the controls, DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.
2. Start the engine from the operators compartment or from the engine start switch. Always start the engine according to the procedure that is described in the manufacturer's Operation and Maintenance Manual. Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

   If the engine is to be manually started, turn the Engine Control Switch to the *MAN START* position. If the engine is to be started from the Switchgear Conversion Control Panel, place the Engine Control Switch in the *LOCAL* position.

NOTE:

Do not engage the starting motor when the flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the started switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

3. Operate the engine at low idle for two to three minutes. Allow the jacket water coolant temperature to begin to rise before increasing the engine rpm to rated rpm. More warm-up time may be necessary when the ambient temperature is below -18 ° C (0° F). Check all of the gauges during the warm-up period Make another walk-around inspection. Inspect the engine for fluid leaks and air leaks. The time that is needed for the engine to reach the normal mode of operation is usually less than the time that is needed for a walk-around inspection. The engine will reach normal operating temperature faster when the engine is operated at rated rpm and low power demand. This procedure is more effective than idling the engine with no load The engine should reach normal operating temperature in a few minutes.
4. To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working properly, check the water temperature gauge and the oil temperature gauge during the heater operation.
5. Observe the gauges frequently while the engine is operating. Record the data from the gauges in a log regularly. Investigate any significant change in the gauge readings. Monitor the engine operation and take action when discrepancies are found.

Engaging the Generator

1. Ensure that the gauges are reading within normal ranges for the engine rpm.
2. Increase the engine rpm, to rated rpm. Always increase the engine speed to rated rpm before applying the load. Adjust the voltage and the frequency if necessary.
3. Close the main circuit breaker in order to apply the load.
4. Continue to check the gauges and the generator.
5. Check the gauges and indicators frequently while the engine is running with the load connected.
6. Verify the total current in one phase does not exceed the nameplate rating. Each phase should carry the same load. An electrical unbalance can result in an electrical overload and overheating if one phase current exceeds the nameplate amperage.

Engine Stopping

1. To avoid overheating of the engine and accelerated wear of the engine components. Stop the engine according to the manufacturer's Operation and Maintenance Manual.
2. Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. DO NOT use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected. The Emergency Stop Button is in the OUT position for normal engine operation. Push the button to stop the engine in an emergency and lock it. The engine will not start again until the button is reset. Turn the button clockwise in order to reset it.

NOTE:

Emergency shutoff controls are for EMERGENCY use only. DO NOT use the emergency shutoff devices or controls for normal stopping of the engine.

3. On the initial start-up of a new engine, or an engine that has been serviced, make provisions to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

4. Automatic stopping will occur when the engine is operating in the automatic mode and the remote start/stop initiate contact opens. If the cool down feature is used, the engine will operate for a programmed period of time before the engine stops.

After Stopping Engine

1. Check the crankcase oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level gauge.
2. If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.
3. Observe the service hour meter reading and perform and scheduled maintenance.
4. Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (0.5 inch) from the bottom of the pipe for filling.

NOTE:

Only use antifreeze/coolant mixtures recommended in the coolant specifications. Failure to do so can cause engine damage.

5. If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture. if necessary.
6. Perform all required periodic maintenance on the generator.

Electrical System

1. Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.
2. When the engine is started from an external source, follow this procedure: First, connect the positive "i" jump start cable from the external power source to the positive "+" battery terminal of the engine that is being started. Then connect the negative "-" jump start cable from the external power source to the negative terminal of the starting motor. This will help to prevent sparks from igniting combustible gases that are produced by some batteries.
3. Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is operated. Repair all frayed electrical wires before the engine is started.

Parallel Operation

The above procedures are for single engine/generator operation. Parallel operating procedures are covered in detail in the manufacturer's Operation and Maintenance manual in Appendix Section 4.2.3.8.1.1 of this manual.

Engine Governor

This section describes the function of the engine governor in relation to load division between parallel electric sets. It is very important to understand two basic facts about load division between generator sets which are operating in parallel.

1. The power which is supplied to the generator and, thus, to the load is a function of the engine. The engine governor settings and the positions of the governor controls determine the amount of power that is delivered by the engine. Therefore, the engine governor settings and the positions of the governor controls determine the kW load which is carried by the generator. If the governor control setting is advanced, the engine and generator will assume more kW load. Likewise, decreasing the governor control setting will result in a reduction of load on the unit. Any other units on the line will, conversely, either reduce load or gain load at the same time. These other units will assume that no change in total load or no change in the governor settings of the other units has taken place.
2. The division of power is not determined by generator excitation or terminal voltage. The power factor at which a generator will operate when paralleled with other generators is determined by the excitation.

Governors that are used with powered electric sets can be of two types: governors with fixed speed droop or governors with adjustable speed droop. The values of speed droop which are commonly used are 3% and 0%. Governors with adjustable speed droop can be adjusted so their characteristics match quite closely the characteristics of governors with fixed speed droop. If the governor is adjusted for 0% speed droop (isochronous) operation, then the same speed from no load to full load can be obtained.

Alarms and Shutoffs

The operation of all alarms and shutoffs use components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures, or speeds in order to protect the engine from damage.

The alarms function in order to warn the operator when an abnormal operating condition occurs, The shutoffs function in order to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the equipment.

If an engine protective device shuts off the engine. always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

Become familiar with the following information:

- Types of the alarm and shutoff controls.
- Locations of the alarm and shutoff controls.
- Conditions which cause each control to function.
- Resetting procedure that is required before starting the engine.

Voltage Regulator

The digital voltage regulator (DVR) controls the generator output voltage. The DVR is a microprocessor based voltage regulator The parameters are preset at the factory, or the parameters can be modified in order to meet the specific requirements on the site. Certain system parameters can also be monitored on the display of the DVR. A keypad is used to change the information that is shown on the display. The display has two modes. These modes are the parameter code mode and the parameter value mode. The Function key is used to toggle back and forth between the two modes. The Scroll down and scroll up keys are used to change the display's value. The scroll down key will decrease the parameter number or will decrease the value number. The scroll up key will increase the parameter number or will increase the value number.

The regulator has voltage droop capability. The regulator has voltage level control however, the regulator does not have voltage gain capability.

Voltage droop and voltage level are controlled by multiple potentiometers. The adjusting screws on the potentiometers do not have a fixed stop. When the potentiometer reaches the end of adjustment, a ratchet action begins. The beginning of a ratchet action can be felt with the adjusting tool. The adjusting screw can be turned past the potentiometer stop (ratchet action) without further changing the potentiometer setting.

2.4.3.1.1 Engine Control Panel

The generator set engine is a electronically controlled diesel engine. The engine is equipped with gauges and indicators used to display engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings can indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your manufacturer for assistance.

The gauges and indicators provide the following information about the engine:

- Engine Oil Pressure
- Low Oil Pressure
- Oil Filter Differential Pressure
- Engine Oil Temperature
- Jacket Water Temperature
- High Coolant Temperature
- Low Coolant Temperature
- Low Coolant Level
- Separate Circuit after coolant Temperature
- Fuel Pressure
- Fuel Filter Differential Pressure
- Low Fuel Level
- Air Inlet Restriction
- Air Cleaner Service
- Inlet Manifold Air Temperature
- Exhaust Temperature
- Exhaust Port Temperature
- Tachometer
- Engine Overspeed
- Hour Meter
- Overcrank
- Voltmeter
- Low System Voltage

The Electronic Control Module (ECM) The electronic control module (ECM) is the computer which controls the engine. The personality module is the software which controls the behavior of the computer (ECM). The ECM and the personality module must work together.

The ECM has a microprocessor that is used to perform computing functions. The microprocessor is necessary for the ECM to execute governing, injection timing control. system diagnostics, and data link communications. The microprocessor receives instructions from the software that is stored in the personality module.

The ECM has a permanent memory that is used to store programmable parameters and diagnostic codes. Input circuits filter electrical noise from the sensor signals input circuits protect the internal circuits of the ECM from potentially dangerous voltage levels. Output circuits provide the high currents that are necessary to energize the injector solenoids, the lamps, and the relay. Power circuits provide high voltage for the injector solenoids. Power circuits provide clean stable electrical power for the internal circuits and the external sensors.

The ECM is cooled by fuel as the fuel circulates through a manifold. The manifold is inside the control module. The fuel enters the control module. The fuel from the fuel transfer pump enters the control module at fuel inlet. The fuel exits the control module at fuel outlet.

The personality module has all of the software and instructions for the ECM. Updating the personality module to a different version may cause some changes. Some of the characteristics of the engine operation may behave differently. A control map defines the fuel rate, the timing, and other similar values. These values are defined for various operating conditions in order to achieve the optimum engine performance and fuel consumption. These values are programmed into the personality module at the factory.

The ECM is also equipped with a comprehensive programmable monitoring system. The Electronic Control Module (ECM) monitors the operating parameters of the engine, The ECM can initiate responses if a specific engine parameter exceeds an acceptable range. Three (3) possible responses may be available for each parameter: “WARNING”, “DERATE”, and “SHUTDOWN”. Some of the responses are not available for all of the parameters. The settings for the parameters are programmed at the factory. If the application requires the settings for the parameters to be reprogrammed, then the parameter must be programmed with an ET service tool.

The Monitoring System is enabled after the engine is started. When the engine rpm exceeds 56 rprn below low idle, the ECM begins checking parameters. The ECM monitors the parameters in order to determine if the parameters exceed the set points.

The ECM will log the event if any response is made by the Monitoring System. A parameter may be programmed “OFF”: The ECM will log the event it the setpoint for the parameter is exceeded.

Any failure of a sensor will result in disabling the corresponding portion of the Monitoring System. The failure of a sensor will cause an “ACTIVE” diagnostic code for the sensor.

All of the derating is cumulative. A derating of 5% followed by a derating of 2% results in a total derating of seven percent. If the conditions that cause the derating are not corrected, the derating will continue. The process will continue until the engine is at low idle with no load.

The ECM warns the operator of engine conditions outside normal operating ranges such as engine oil pressure, engine temperature, exhaust temperature, and so on.

(Detailed information regarding the engine control panel is located in Appendix Section 4.2.3.8.1.1 of this manual. It is recommended all operators read the manufacturer’s Operation and Maintenance Manual found in this section)

2.4.3.1.2 Generator Control Panel

The Electronic Modular Control Panel II+ (EMCP II+) is used to control and operate the generator. The EMCP II is located above the generator distribution housing. The control panel consists of a panel with indicators, meters, and control switches. This control panel may be equipped with optional modules in order to match the customers' needs and requirements.

The left side of the control panel contains the Generator Set Control + (GSC+). This is the main component of the system, The GSC displays the following information: generator output, fault conditions, and key engine parameters. The center section of the control panel contains switches and an alarm module. The right side of the control panel contains the Synchronizing Lights Module and the Custom Alarm Module.

(Detailed information regarding the generator control panel is located in Appendix Section 4.2.3.8.1.1 of this manual. It is recommended all operators read the manufacturer’s Operation and Maintenance Manual found in this section)

2.4.3.1.3 Engine Start Batteries and Charger

The engine starter batteries consists of four (4) lead-acid wet cell 12 VDC high output batteries connected in series to produce the 24 VDC required to turn the engine starter motor. Two (2) batteries are then wired in parallel with the other two (2) to provide additional current for the starter motor.

The starter batteries are located in the Generator Room next to the engine generators with the wall mounted chargers a few feet away.

The battery charger was specifically designed for maintaining and recharging starting batteries of engine generator sets. The Controlled Magnetic Amplifier technology provides the highest reliability that is necessary for the continued operation of emergency standby equipment, and eliminates most starting problems by maintaining batteries at full charge, ensuring optimum performance and maximum life.

The charger is a completely automatic, solid state, constant voltage battery charger built to carry continuous and intermittent loads up to 80% of its maximum rated output capacity. It automatically senses the Battery and load conditions, and delivers the necessary amount of charge. Once the battery becomes fully charged, the output current will automatically decrease to a very low trickle charge to prevent overcharging of the batteries.

The charger is designed and built to charge Flooded Lead-Acid or Nickel-Cadmium Batteries containing a specific number of cells. However, it is not suitable to charge sealed Valve-Regulated Batteries since these require output filtering such as a power supply.

The front panel *Float/Equalize* switch is provided to manually initiate a periodic equalize charge to optimize battery longevity. This operation can also be achieved automatically by selecting one of our Electronic Equalize Timer options either by itself, or combined with the Digital C.A.P (Combined Accessory Package) System that incorporates several alarm contacts and status LED'S.

WARNING:

To ensure safe installation and operation, the information given in the instruction manual should be read and understood before installing or using the charger.

The charger can be very heavy, and top-heavy. Use adequate manpower or equipment for handling, Until the equipment is securely mounted, care must be used to prevent the charger from being accidentally tipped over.

To reduce risk of injury and/or damage to the batteries, use only the type of batteries specified on the charger.

There is a risk of explosive gasses when working in the vicinity of a battery. Some batteries generate explosive gases during normal battery operation. For this reason, it is of utmost importance that each time before using this charger, you read this manual and follow the instructions exactly.

Do not expose the charger to rain or snow.

Do not operate the charger if it has received a sharp blow, been dropped, or otherwise damaged in any way, take it to a qualified serviceman.

Do not disassemble the charger. Take it to a qualified serviceman when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.

To reduce risk of electric shock, disconnect the charger from the AC supply, or batteries and loads before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

Do not operate the charger in a closed-in area or restrict ventilation in any way.

Do not set any battery on top of the charger.

Do not pull on output cables when disconnecting the charger from the battery.

NOTE:

This charger is not recommended for use on sealed valve regulated batteries.

The charger is factory tested and preset so that no field adjustments are necessary. A resistor is provided for adjusting the float and equalizing voltages to the required levels. Should field adjustments be necessary, the float voltage may be adjusted by moving the red slider band on the voltage divider resistor RVl.

Moving the slider toward the green slider, or toward RV2, raises the taper and shutdown point. Moving the slider in the opposite direction lowers the point of shutdown. The green slider band is the equalizing voltage adjustment and may be adjusted in the same manner as the float slider.

In normal operation, the charger maintains a constant battery voltage from no load up to 80% of its rated load capacity as indicated by the nameplate. If the external loads exceed nameplate capacity, the charger will attempt to carry the excess load up to its current limiting capacity. Beyond this point, the battery will carry the excessive loads. If the battery is discharged, the charge will recharge the battery on a taper curve from its current limiting capacity to full charge.

The Float/Equalize Switch is used to raise the rectifier output voltage to 2.33 volts per cell for lead acid cells or 1.55 volts per cell for nickel-cadmium cells, so that the battery can be given an equalizing charge. To give an equalizing charge, it is only necessary to throw the switch to the *EQUALIZE* position. The rectifier will automatically hold the cell voltage at the equalizing voltage while the switch is in *HIGH* position and will drop back to float voltage when the switch is put back into the *NORMAL* or *FLOAT* position.

If a 24 or 72 hour equaling timer was provided, the timer switch replaces the manual Float/Equalize Switch. To operate the timer, it is only necessary to turn the timer knob to the desired equalizing time setting and push the start equalize button. The time switch transfers the charger from the float to the equalizing charge rate. The timer times out automatically and returns the charger to the float charge position.

The inherent design of the transformer reactor combination provides compensation for line voltage variations of +/- 10%.

Connecting and Disconnecting Batteries

1. If it is necessary to remove the battery connections, always remove grounded the terminal from the battery first. Make sure all loads are disconnected and unit is off, so as not to cause an arc.
2. Be sure the area around the battery is well ventilated while the battery is being charged.
3. When cleaning battery terminals, be careful to keep corrosion from coming in contact with eyes.
4. Study all the battery manufacturer's specific precautions such as removing or not removing cell caps while charging, recommended rates of charge, and maintenance procedures.

CAUTION:

Connect and disconnect DC output cables only after setting all of the charger's switches to the *OFF* position and after removing all AC power.

Do not pull on the output cables when disconnecting the charger from the battery.

The Combined Accessory Package (CAP) provides a selectable digital display for DC voltage, DC current (amps.), timer mode, and equalize time remaining in hours. The CAP also provides a summary alarm light for high or low voltage, high voltage shutdown, or low current.

Operation of the CAP is simple. Once the proper AC input and battery are connected to the system, the digital display will indicate the system output voltage, and the DCV "LED" will light. Toggle the *EQUALIZE/SELECT* Switch down to the *SELECT* position and the display will indicate system output amps and its "LED" will light. A third toggle and the time mode will indicate on the display and its "LED" will light. A fourth toggle and the equalize time remaining will indicate on the display.

To check or reset the alarm settings, hold the *EQUALIZE/SELECT* Switch in the *EQUALIZE* position for approximately five (5) seconds, the low voltage "LED-1" will blink and the display will read the low voltage setting for approximately five (5) seconds, the "LED" will turn off and the high voltage "LED" will turn on. The display will then indicate the high voltage alarm setting. The display and "LED" will change every five seconds. The remaining "LED'S" a= high voltage, low current timer mode and equalize time. After going through one cycle, the display will return to the normal mode. The alarm settings, timer mode, or equalize time can be reset while their function is active (i.e. "LED" is blinking) by using the *EQUALIZE* select mode Switch. Pushing the Switch to up will raise the setting, while pushing the *EQUALIZE* select mode Switch down will lower the setting.

NOTE:

The cycle must be allowed to complete in order to save any new settings.

(Additional information regarding the battery charger for the engine start batteries can be found in Appendix Section 4.2.4.3.5 of this manual.)

2.4.4 Power Generation and Distribution

All primary power generated for the McMurdo Station originates in the Power Plant with a redundant system in the Water Plant. Two power diesel engine generators are installed in the Generator Room located in the Water Plant.

2.4.4.1 Automatic Paralleling Switchgear

The Automatic Paralleling Switchgear (SG) comprises (2) complete metal enclosed Medium Voltage vacuum break circuit breaker switchgear assemblies, as follows:

- One, 2 high, 7 panel Switchgear assembly located in the Water Plant (WP).
- One, 2 high, 10 panel Switchgear assembly located in the Power Plant (PP).

The Generator Paralleling Switchgear controls the start-up, synchronizing and Generator application to the bus-bars to meet the load. Two (2) Prime rated Generators are located in the Water Plant, while two (2) Prime rated and two (2) Standby rated Generators are located in the Power Plant. The two (2) Switchgear assemblies are connected through cable bus tied bus couplers so as to operate as a selectable integral unit, ultimately controlled by the switchgear in the Power Plant.

Load sensing and generator application to the bus-bars is automatically controlled by two (2) independent controllers located on each of the two (2) switchgear assemblies.

A master controller is located in a dedicated panel on the switchgear in the Power Plant to assume overall control of both the generating stations in both facilities when operating both plants as an integral power generating unit.

The switchgear provides data display for engine operations, shutdown faults, and MV system distribution to the feeder lines.

Overall power management is performed by a Control Computer located in the Power Plant Switchgear Room.

Manually selective and start sequence control of all generators is initiated at a touch screen located on the Master Control Panel of the Switchgear Assembly.

Black Start operation of required generators is also initiated from the Master Control Touch Screen, which is powered from an Uninterruptible Power Supply (UPS).

An Engine Generator Control Panel (EGCP) is located on each generator to locally indicate operating parameters of each generator. The EGCP also enables off-line individual operation of a selected Generator.

(Additional information regarding the switchgear can be found in Appendix Section 4.2.4.4 of this manual.)

Two battery and charger systems are used for the switchgear. One 24 VDC battery and charger system is used as a backup power source for the control logic in case of main power failure. The other 120 VDC battery and charger system is used to charge the system used to throw the main breakers in the switchgear.

The battery and charger system used for the control logic uses two (2) 12 VDC batteries wired in series to give the 24 VDC required to maintain the logic should main power failure. These batteries are designed to be used in long duration discharge applications.

The charger used for these batteries is of the constant voltage type. operation, the battery is connected in parallel with a constant voltage charger and the critical load circuits. The charger is capable of maintaining the required constant voltage at the battery terminals and also supply the normal load where applicable. This sustains the battery in a fully charged condition and also makes it available to assume the emergency power requirements in the event of an AC power interruption or charger failure.

Modern constant voltage output charging equipment is recommended for the float charge method of operation for the batteries. This type of charger, properly adjusted to the recommended float voltages and following recommended surveillance procedures, will assist in obtaining consistent serviceability and optimum life.

After the battery has been given its initial charge, the charger should be adjusted to provide the recommended float voltages at the battery terminals.

Do not use float voltages higher or lower than those recommended. Reduced capacity or loss of battery life will result.

All batteries should be recharged as soon as possible following a discharge with constant voltage chargers. However, to recharge in the shortest period of time, raise the charger output voltage to the highest value that the connected system will permit. Do not exceed 2.40 VPC.

The 120 VDC battery and charger system is used to charge the system used to throw the main breakers in the switchgear. The batteries are two (2) VDC selenium lead-acid cells using either antimony or calcium as the hardening agent in the lead alloy. The batteries are wired in series to obtain the 120 VDC needed for the switchgear breakers. The capacity obtained from these cells depends on the discharge rate and the operating battery temperature. The nominal ampere hour capacity is referred to an eight (8) hour discharge to a final discharge voltage of 1.75 volt per cell at 77° F. The batteries reside in their own rack.

The charger is constant voltage, current limited, SCR controlled, and designed to float charge all types of stationary nickel cadmium and lead acid batteries.

The battery charger output voltage and current are factory set to meet battery load specifications, thus no further adjustments are usually required.

The AC input voltage is applied to the primary winding of the power transformer using the AC breaker. Transformer TI galvanically isolates the AC mains voltage from the secondary voltages and steps the AC voltage up or down to the required levels.

The secondary power winding is connected to a phase controlled full wave bridge rectifier comprised of two thyristors, two diodes and one free-wheeling diode. The phase controlled bridge converts the unregulated AC voltage to a regulated DC voltage. The bridge is connected using the inductor L1 and ammeter (or shunt) to the negative, and by the output protection to the positive output terminal.

For control of voltages and current, two independent feedback loops are used. Only one of these control loops is active at a time.

The DC voltage is fed back to the control card which controls the voltage setting, both for the “Float” and “High Rate” mode. Both voltage levels can be adjusted on the control card. Normally the rectifier is operating in “Float” mode. The “High Rate” mode is used for battery recharge. If the output current demands exceed the nominal rating, the rectifier will shift from constant-voltage to current-control mode. The voltage developed across shunt SH (proportional to the output current) is sensed and processed by a current-limit amplifier on the control card. The charger regulates its output voltage and current by controlling the thyristor bridge.

The bridge is designed as a full-wave rectifier, and the thyristors determine the amount of current delivered to the output. The thyristor is off until a trigger pulse is applied to the gate. Once triggered, the thyristor remains in conduction until the current through it is zero. By phase-angle control, (i.e. varying the delay of the trigger pulses), the firing angle of the thyristors can be varied and the required amount of energy is made available at the output terminals. If high current is required, the trigger pulse will start earlier during the half-cycle of the sine wave and vice versa. The AC voltage is also compensated for by this method.

Proper operation of the charger requires that all input, output, battery or load wiring be correctly connected.

CAUTION:

Charged cells contain a large amount of stored energy and care must be exercised when using any metal tools around the battery to avoid shorting.

Never leave the charger in the "high rate" mode for longer than recommended by the battery manufacturer. Excessive "high rate" charging will cause the battery to overcharge and gas (through electrolysis). This will consume water, reducing the electrolyte level and may be detrimental to battery life.

NOTE:

On filtered chargers, excessive current will flow from the battery into the capacitors when the DC protection is inserted/closed. To avoid this, the charger should be turned on so that the output voltage and the battery voltage are approximately equal. At this point, the DC protection may be inserted/closed.

With the wiring complete, activate the output protection (non-filtered chargers). The battery or load voltage should be indicated on the output voltmeter.

Turn "ON" the AC input breaker and the charger should slowly increase output power until either the voltage setting or current limit is reached.

The charger will start up in the "Float" mode but may switch to "High Rate" depending on the type of charge control supplied. Switch the charger into "High Rate" to commission charge the battery for the length of time specified by the battery manufacturer.

During normal operation the charger will be in "Float" mode. To activate a "High Rate" charge, the *High Rate* pushbutton must be momentarily depressed (latching). To return the charger to "Float", depress the same pushbutton (unlatched). Other "High Rate" charge controls.

(Additional information regarding the station battery and charger systems for the switchgear can be found in Appendix Section 4.2.4.4 of this manual.)

2.4.5 Lighting

2.4.5.1 Site Lighting

Weatherproof, incandescent light fixtures are used to illuminate the outside areas of the Water Plant and the Pump House. These fixtures are typically mounted above the platforms of exterior decks and stairways, above the entrance doors, in vestibule areas adjacent to exterior doors, and along walkways.
The fixtures are typically vapor-tight, with glass globes and cast guards. They are equipped with either 50 - 150 Watt bulbs, depending on the type of bulb used, to provide maximum visibility.

Fixtures used to illuminate exterior doors are mounted approximately 12” above the door, while other exterior lighting is typically 10 - 16 feet above grade.

Many of the fixtures are designed with a sharp off cutoff to reduce light trespass and high angle glare.

WARNING:

Read and follow the lamp manufacturer’s warning and use information before installing or replacing this light fixture.

Disconnect power before installation of servicing.

Install, operate and maintain to meet all applicable codes.

Protect all wiring connections with approved insulators.

Selected fixture voltage must match supply line voltage.

The light fixtures are controlled by single switches located inside outer doors.

(Additional information concerning site lighting for the Water Plant and Pump House can be found in Section 4.2.4.5.1 of this Manual.)

2.4.5.2 Interior Luminaries

Within the Water Plant and the Pump House are several styles of fluorescent fixtures, vaportight enclosed/gasketed incandescent lamps, ceiling mounted downlights, surface mounted square lighting, provide interior illumination. The fluorescent fixtures are typically configured with two, 48”, 40 Watt tubes each. Some of the fluorescent fixtures are louvered while other just have a top mounted reflector.

The incandescent surface downlights use 150 watt bulbs and the vaportight globes generally use 400 watt maximum wattage bulbs.

WARNING:

Read and follow the lamp manufacturer's warning and use information before installing or replacing this light fixture.

Disconnect power before installation of servicing.

Install, operate and maintain to meet all applicable codes.

Protect all wiring connections with approved insulators.

Selected fixture voltage must match supply line voltage.

Typical mountings include ceiling, grating, and wall. Incandescent fixtures provide lighting in unheated areas. The fixtures are vapor-tight, with glass globes, cast guards, and 100 Watt lamps.

Fluorescent fixtures provide the primary lighting source. Fluorescent fixtures use bulbs ranging from 32 - 54 watts. Fixtures are typically 4' long, contain 2 type fluorescent lamps, and use a 277 V magnetic ballast.

The fluorescent fixtures are controlled by the use of either lighting switches and / or occupancy sensors. Recessed and surface mount incandescent and compact fluorescent fixtures are used where architectural aesthetics are conducive.

Wall mounted light fixture are located either 10 or 12 feet from the floor depending on their function.

(Additional information concerning interior lighting for the Water Plant and Pump House can be found in Section 4.2.4.5.2 of this Manual.)

2.4.5.3 Emergency Lighting Units

Two-lamp, incandescent fixtures located throughout the facility provide emergency lighting in the event of AC power loss. Most of the units contain rechargeable sealed Lead-Calcium battery powered packs as part of the light fixture, while others may be remote units wired and draw power from the same battery packs. As required by the Life Safety Code, NFPA 101, emergency lighting units provide continuous illumination for a minimum of 90 minutes once main power is lost.

The fixtures containing back-up ballasts are equipped with a pushbutton that facilitates periodic testing of the emergency lighting lamps. Pressing the pushbutton illuminates the back-up fluorescent lamps to verify functionality. Single multi-chromatic LED indicator displays two-stage charging, test activation and three-state diagnostic status.

All the emergency lighting units provide minimal illumination during electrical power outages.

WARNING:

Do not use out doors.

Do not let power supply cords touch hot surfaces.

Do not mount near gas or electric heaters.

Use caution when servicing batteries. Battery acid can cause burns to skin and eyes, If acid is spilled on skin or in eyes, flush acid with fresh water and contact a physician immediately.

Equipment should be mounted in locations and at heights where it will not readily be subjected to tampering by unauthorized personnel.

The use of accessory equipment not recommended by the manufacturer may cause an unsafe condition.

Halogen lamp(s) may be used in this equipment. To avoid shattering: Do not operate lamp in excess of rated voltage, protect lamp against abrasion and scratches and against liquids when lamp is operating, dispose of lamp with care.

Halogen lamps operate at high temperatures. Do not store or place flammable materials near lamp.

Do not use this equipment for other than intended use.

The operation cycle of the actual units installed may vary slightly, but basically operation of the emergency lighting fixtures is automatic. Whenever electrical power is lost to the building, the emergency fixtures will operate on DC power. The solid-state charger (SCR) maintains the battery at full charge. Lighting heads and fixtures are automatically connected to the battery upon loss of utility A.C. While in emergency operation, battery damage from a deep discharge is prevented by a low voltage disconnect circuit. The unit will automatically extinguish the emergency lights when the battery capacity falls below 80%. When normal power is restored, the emergency lighting is extinguished and the charger recharges the battery to its initial state. Recharging is accomplished within acceptable Underwriters Laboratories (UL) time standards. Charge rate is indicated by a pilot light. A test switch may be provided for checking emergency operation. Operation is from standard 120 volt lines. Power consumption is 75 watts maximum.

Accidental discharge of the unit battery prior to energizing is prevented by an AC lockout circuit The unit's green *STATUS* LED located on the display panel illuminates to indicate the presence of ACI power. The unit's red Status LED will blink after application of AC power if the battery connection is not completed. During normal operation, the unit's charging circuit maintains battery at full capacity and the controller constantly monitors charger performance.

Should terminal voltage vary from design parameter values, the unit's red Status LED will blink indicating a malfunction of the battery or charger. Upon interruption of normal AC power, or brownout conditions exceeding a 20% drop from nominal voltage, the controller automatically switches the emergency lighting load to the battery, Emergency power will be provided for a minimum of 30 minutes. During emergency operation, the battery is protected from deep discharge by a low-voltage battery disconnect circuit. The circuit will then begin a recharge cycle. The charger will bring the battery back to full capacity within acceptable UL time standards. The controller automatically initiates a one-minute discharge diagnostic test every 28 days +/- 3.5 hours and a 30 minute discharge diagnostic test every six (6) months +/- 1 day.

These tests exercise the unit's battery to optimize its capacity and allows the controller to analyze emergency operation performance. Any malfunction of the unit's transfer circuit, or emergency lamps, causes the red Status LED on the unit's display panel to blink. During normal operation, all red Status LED blinking indications of unit malfunction remain latched until corrected and retested. A manual test switch allows a user to programmable 1**,** 5, 30, or 60-minute diagnostic discharge test at any time. During all automatic and user initiated self-tests, the unit's green Status LED will blink to indicate a diagnostic cycle in process

(Additional information concerning emergency lighting for the Water Plant and Pump House can be found in Section 4.2.4.5.3 of this Manual.)

2.4.5.4 Exit Lighting / Signs

Exit signs are located above each exit. The sign displays the single word "EXIT" in red illuminated letters on a white face. The sign is illuminated by two, internal, fluorescent lamps housed in a steel case.

Exit lighting signs / fixtures are battery-powered, rechargeable, Light Emitting Diode (LED) devices. Each wall mounted unit contains 3.8-watt LEDs.

A sealed, maintenance-free, nickel cadmium battery, contained in the fixture, delivers emergency direct current (DC) power to facilitate illumination for up to 90 minutes in the event of a power outage.

The self diagnostic emergency signs comply with NFPA *Life Safety Code* and automatically test the battery once a month for five minutes and once every six months for 30 minutes.

These units are hard-wired into the electrical system and are not controlled by local switches. All occupants of the building should become acquainted with the location of emergency exits and use them when emergency conditions exist.

(Additional information concerning exit lighting for the Water Plant and Pump House can be found in Section 4.2.4.5.4 of this Manual.)

2.4.6 Heat Trace

Heat trace within the facility was provided for vent-thru-roof piping, waste piping, fresh water piping, drains, and input sea-water piping system. Typically, all water supply piping are double traced while drain pipes are single traced. Exterior lines such as the lines to and from fresh water tank #4, untreated water lines, brine lines, sea water lines, lines to and from the Pump House, and 3 inch sprinkler lines may have been heat treated. Self-regulating, self-limiting cabling with thermoplastic insulation, parallel conductors, and a nominal output of 3.28 watts per linear foot is utilized.

The major components of the heat trace system consists of self-regulating heat cables, temperature detectors, and a control and monitoring unit. Since the system will not operate without a completed circuit, power connections and end seals are required. Splices and tees are used as needed.

Self-Regulating Heat Cables are designed for use in ordinary and hazardous areas and are intended for freeze protection and low process temperature maintenance. Self-Regulating cables are parallel circuit, low watt density electric heaters that regulate heat output in response to changes in surface and ambient temperatures.

Self-Regulating cable is constructed of a conductive polymer core extruded over two main wires. The heat output of the irradiated self-regulating core increases when the temperature falls and decreases when temperature rises. Thus, the cable can be safely overlapped without creating hot spots or causing burn outs.

The resistance temperature detectors used throughout the system are typically used with monitoring and control systems that require accurate temperature control

The control and monitoring unit located in the Power Plant is used for both the Power Plant and the Water Plant. The control and monitoring unit can control up to 80 heat tracing circuits and can monitor up to 1024 temperature inputs with additional devices added. The control and monitoring unit provides relay output to control heat tracing circuits, provides line current monitoring, ground fault monitoring/protection, RTD inputs and line voltage monitoring.

The control and monitoring unit has a user interface panel used by the operator to view status data, alarm messages, and control options. A set of four (4) indicator lights provide status for power, the control relay, and alarm conditions. Control keys are used for testing, acknowledging, resetting the system, user menus, escaping, and entering data or commands. The user display screen displays in three (3) modes: Normal, Alarm, and Menu Selection.

All vent-thru-roof venting pipe has heat trace tape installed around the perimeter of the pipe. The tape is a self-regulating type, that delivers more wattage as the material it is attached to cools and less as it warms. Power for the heat tape is supplied through locally installed junction boxes with a.7 KVA / 120 V variable transformer with a NEMA 4 enclosure.

(For additional information regarding heat trace system and all of its components, refer to Appendix Section 4.2.4.6.1 of this manual.)

2.4.7 Signal Systems

Signal Systems in the Water Plant consists of the telephone/LAN system, the new closed circuit television system, and the fire detection and alarm systems used to alert personnel of any fire related hazard.

The multi-port Telecommunications Outlets (TO) throughout the facility each contain a 4-pair, Cat5e copper cable, which runs to a cable management panel in the telecommunications rack (TR.) The Cat5e cables can then be cross-connected to another patch panel for telephone service, or to a network switch port for network service.

The telephone and local area network services are brought to the TR using campus backbone cabling. This cabling consists of a 200-pair copper cable, and a 24SM / 12MM fiber optic cable. The cabling enters the building and terminates in the telecommunications rack.

The network connections at the jacks throughout the facility depend upon building power to the access switches in the TR. There is no independent uninterruptible power supply (UPS) for the information technology (IT) equipment. Phone service however, uses an independent battery bank associated with the station private branch eXchange (PBX.)

A new closed circuit television (CCTV) system was installed to allow operators in either the Power Plant control room or the Water Plant generator control room to monitor the generators in the Water Plant or the Power Plant.

The fire alarm system in the existing Water Plant was modified as necessary for the remodel work being done to accommodate the new generators, switchgear and relocated RO unit. A new fire alarm system was provided for the new Pump House.

2.4.7.1 Telephone / Local Area Network (LAN)

The telephone system used in the building is an extension of an existing system. To access the system, follow the instructions provided with each telephone handset. Voice is typically a low speed, analog phone line, though may also be used for low speed data such as modem communications. The particular outlets have 6-pin modular jacks, connected via one Cat5e cable to the telecommunications rack, cross-connected for phone service only.

(Additional information concerning the telephone system installed in the Water Plant can be found in Section 4.2.4.7.1 of this Manual.)

Cables cross-connected to a network switch port carry Ethernet to the desktop at 100 Mbps (1 million bits per second).

The fiber carries Gigabit Ethernet (1 billion bits per second) data from the network core switch in Bldg. 182 to the access switches in the TR. The copper provides the phone lines and any low speed data services, which may need to be transmitted or received from other campus locations. Many computers are interconnected by a local area network. Follow the specific instructions furnished with the computer for access and operation.

Connections to the McMurdo LAN is via optical fiber at 1 Gbit / second. LAN signals travel from the facility to a layer-3 switch-router in the Network Operations Center (NOC), Building 165. The equipment in the NOC provide connectivity to file servers, E-mail, and the Internet.

The LAN is dependent on power in the building to power the hub and PC. If the hub fails, it will cause the LAN to become inoperative and connectivity to the Station LAN will be lost. Failure of either the PC or the copper connection to the facility will cause that PC to lose its connection to the LAN.

(Additional information concerning the LAN system installed in the Water Plant can be found in Section 4.2.4.7.1 of this Manual.)

2.4.7.2 Closed Circuit Television (CCTV)

A new closed circuit television (CCTV) system was installed to allow operators in either the Power Plant control room or the Water Plant generator control room to monitor the generators in the Water Plant or the Power Plant. Monitoring of both plants is necessary as the operators may have to be in either control room when generators in both the Power Plant and the Water Plant are operating.

The CCTV System consists of several key components:

- Color Monitor,
- Lenses,
- Quad Splitter,
- The Camera, and
- Power Supply.

The 15 inch monitor is a high-resolution monitor capable of being connected as a single unit or looped with two (2) other monitors.

Front panel controls are easily accessible. Controls include a power switch and indicator, video input selection, cursor and adjustment up and down, underscan control and a Menu Button for the OSD. The OSD Menu allows adjustment of volume, brightness, contrast, color, tint, sharpness, language and horizontal and vertical position.

WARNING:

To reduce the risk of fire or electric shock, do not expose this product to rain or moisture.

Do not insert any metallic object through ventilation grills.

CAUTION:

To reduce the risk of electric shock, do not remove cover (or back).

No user-serviceable parts inside.

Changes or modifications not expressly approved by the manufactured could void the user's authority to operate the equipment.

The VFI series varifocal lenses provide a variable angle of view (variable focal length), adjustable focus, and adjustable manual iris. On a varifocal lens, whenever the focal length is readjusted, the f w s must also be readjusted.

Since some of the lens adjustments are customized to the specific scene the camera is going to view, all of the following steps except step 1 should be performed with the camera in place in its final location.

1. Install the VFI lenses on the camera.
2. Connect the camera to a video monitor and to a power supply. Power up the camera and turn on the monitor.
3. The three (3) rings on the lenses functions as follows:
    - The ring labeled OPEN CLOSE controls the amount of light reaching the pickup device by adjusting the iris opening.
    - The ring labeled W T controls the size of the area included in the picture. W is for wide angle, T is telephoto (narrow angle of view).
    - The focus ring is used to make the image sharp from infinity to near.
4. Camera with linear shutter: make sure the linear shutter has been enabled by following the camera instructions, then adjust the iris ring to its maximum OPEN setting. At this point the image may be out of focus.
5. Loosen the small thumb screw on the focus ring and adjust the ring to bring the object viewed into focus. This will be adjusted again later.
6. Loosen the small thumb screw on the angle-of-view ring and adjust the ring to include the desired scene on the monitor. This will probably throw the scene out of focus.

7. Re-adjust the focus ring for the best picture. If a sharp picture cannot be obtained, adjust tine back focusing of the camera following instructions included with the camera.
8. Re-adjust the focus and the angle-of-view rings for the optimum picture. If the camera does not have a linear shutter, re-adjust the iris ring. Tighten the thumb screws on the angle-of-view and focus rings.

The digital color quad splitter accepts four (4) camera inputs, processes them digitally, and displays all four on a single monitor screen. The complete video from each camera is displayed. All operating and programming functions are performed with the front panel keys. The quad splitter may also be controlled remotely by a host computer using a simple RS-232 command set.

WARNING:

Power must be removed from this unit before removing circuit modules or ribbon cables.

This equipment generates and uses radio frequency energy and if not installed and used properly. that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. it has been type tested and found to comply with the limits for a Class A computing device in accordance with the specification in subpart B of part 15 of the FCC rules, which are designed to provide reasonable protection against such inference in a commercial installation. However, there is no guarantee that interference will not occur in a particular installation. if this equipment does cause interference to radio and television reception, which can be determined by turning equipment off and on, the user is encouraged to try and correct the interference by one or more of the following measures:

- **Reorient the receiving antenna**
- **Relocate the equipment with respect to the receiver**
- **Relocate the equipment away from the receiver**
- **Plug the equipment into a different electrical outlet so that the equipment and receiver are on different branch circuits.**

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions.

CAUTION:

To reduce the risk of electric shock, do not remove cover (or back).

No user-serviceable parts inside.

This unit contains circuit cards with integrated circuit devices that can be damaged by static discharge. Take all necessary precautions to prevent static discharge.

Normal operating selections are made using the eight (8) front panel keys, and functions are selected with a single key press.

The basic operation includes selecting the sequence, follow, VCR, or quad modes and selecting individual camera channels for hold viewing. When the unit is in the operational mode (that is, not in the programming mode), six (6) keys (SEQ/ALM, 1,2,3,4, QUAD/ENTER) perform the functions. The four (4) keys labeled 1,2,3, and 4 select video channels 1 through 4, respectively, and the QUAD/ENTER key selects the quad display.

The digital camera used in the CCTV System is a 1/3 inch digital color camera which combines excellent picture quality with advanced features. The camera produces color images with accurate color rendition provides by an automatic through-the-lens (TTL) color compensation system. A linear shutter with speeds up to 1/100,000 second allows use in varying light levels without having an autoiris lens.

WARNING:

To prevent fire or shock hazard, do not expose the unit to rain or moisture.

This equipment has been tested and found to comply with the limits for a Class A digital device. pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense

CAUTION:

To reduce the risk of electric shock, do not remove cover (or back).

No user-serviceable parts inside.

To prevent electric shocks and risk of fire hazards, do not use any power supply other than the one specified.

Any changes or modifications in construction of this device which are not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment

Basically the camera takes the analog signal, converts it to a digital format, adjusts specific video parameters and displays the image in analog format. Digital control offers crisp lines, detailed reproduction and assures that functions are unaffected by time and temperature. The camera has extremely low levels of lag, blooming, and transfer smear characteristic of CCD pickup devices.

All controls on the camera are located on the rear panel. Synchronization is selectable, internal or line-locking. Multiple cameras can be synchronized with the line-blocking function. Vertical phase is adjustable. Selectable backlight compensation permits the camera to generate correctly exposed images in a variety of difficult lighting situations.

A fully isolated power supply provides stable images when they are used on a common power supply with other cameras.

The power supply provides 24 VAC output for 4, 8, or 16 units. To compensate for voltage losses over long wire runs. The power supply has a selectable input of 120 or 230 VAC and are packed in an easy-to-install metal enclosure that has ample room for wiring connections and conduit entries.

(Additional information concerning the CCTV system installed in the Water Plant can be found in Section 4.2.4.7.2 of this Manual.)

2.4.7.3 Fire Detection and Alarm Systems

Two separate systems provide fire coverage for the Water Plant. A water-based sprinkler suppression system protects the Switchgear Room and a Carbon Dioxide (CO_2) chemical system provides protection for the Generator Room and the Day Tank Room.

The Carbon Dioxide System is activated automatically by multiple detectors or manual pull stations located throughout the facility. In the event of a fire, fans are shut-off and dampers are closed to the affected area by the DDC system.

To extinguish the fire, the system discharges carbon dioxide (CO_2) gas into the surrounding air. A pre-discharge alarm signal alerts any occupants to evacuate the area or facility. The DDC system monitors the fire alarm system zone contacts and generates an alarm at the central workstation if any of the contacts close.

WARNING:

All personnel must be instructed to evacuate the area at the first alarm.

After a CO_2 discharge, all personnel must stay out of the affected area until it has been properly ventilated, unless they are equipped with a Self-Contained Breathing Apparatus (SCBA).

CO_2 is colorless, odorless, and tasteless. It is an asphyxiant. A space that has been flooded with CO_2 does not contain enough oxygen to sustain human life. Failure to follow these instructions could result in severe injury or death.

The system installed was designed to protect only the Generator and Day Tank Rooms and not the remainder of the facility.

Activation of the sprinkler system in the Switchgear Room does not shut-down the Switchgear Equipment or the generators. If either one of the generators are operational and on-line, power will continue to flow to the Switchgear Equipment.

2.4.7.3.1 Fire Detection and Alarm Control Panel

The Fire Alarm Control System's primary function is to monitor zones of emergency detection devices for the presence of an alarm condition.

When an initiating device detects an alarm condition, the Fire Alarm begins an alarm sequence which includes automatic local annunciation, building evacuation, remote signalling, reporting, and optional extinguishing agent release. The following sequence illustrates alarm operation.

ALARM CONDITION - If an alarm condition exists on one of the zones in the Fire Alarm Panel, that zone will latch into alarm and at the same time:

- Pulse the respective individual zone's red alarm LED.
- Pulse the common red alarm LED.
- Activate the alarm indicating devices (horns, bells, strobes, internal buzzer, etc.)
- Acknowledging the alarm (operating the acknowledging switch) steadies the flashing LEDs.

- Subsequent alarms will pulse their respective zone LED(s) and the common red alarm LED.
- Subsequent alarms will re-activate the alarm indicating devices if they were previously silenced.

NOTE:
The alarm condition will not clear until manually reset by authorized personnel.

The Fire Alarm Panel also provides full supervision of the field wiring for each initiating zone and each audible indicating circuit. A detected fault produces the following sequence:

- **TROUBLE CONDITION** - Whenever a trouble condition exists on one of the zones in the Fire Alarm Panel:
- The amber trouble LED for the zone in trouble will light.
- The amber common trouble LED on the alarm control board will pulse.
- The panel's internal trouble buzzer will pulse.

In addition to a zone trouble condition, the Fire Alarm Panel monitor's, its own operational status for the following conditions:

- System Trouble,
- Boards Not Properly Inserted,
- Control Switches Abnormal,
- Control Cables Abnormal,
- Audible Circuit Trouble,
- Ground Fault Condition,
- Loss Of Primary Power, and
- Battery Trouble.

When any device (heat, smoke, or manual pull station) is activated, the control panel initiates an audible and visual alarm (horn / strobe) inside and outside of the building.

At the same time, the air-handling unit in the building shuts down. The AHU fan is shut off, and air dampers are commanded to fire-safe positions. An alarm signal is also transmitted to the fire alarm system in the existing station.

The system operates within a unique “Distributed Intelligence” architecture which distributes line processing power throughout all system components. This “Smart” architecture. which has a microprocessor. memory and software in each system component, provides major advances in system precision and reliability.

The system uses a fully digital BIP (Broadcast Index Polling protocol) for loop device communications. BIP reduces high speed data communication “traffic”, thereby reducing the risk of interference. BIP communications feature high immunity to EM1 and RFI. All of the 255 addressable input / output devices can be in alarm and operated at the same time. With this critical feature, even a major fire event involving a large number of detectors can be reported and logged by the system.

The Signaling Line Circuit (SLC) provides for unique “Face-lift'” operation. A redundant feature which allows field devices to report alarm even in the unlikely event of a failure in the system's loop-controller communications microprocessor. Under an alarm condition, the devices would sense the loss of communications with the loop controller and automatically revert to the “Face-lift” mode of operation,

Redundant circuitry in the panel, independent of microprocessor operation, would then report a zone alarm. Thus alarm reporting capability is maintained without costly requirements for processor redundancy.

With the addition of a modular CPU board and a transmitter board, the fire alarm panel is capably of automatic radio reporting one-way reporting of alarms, supervisory, and trouble conditions.

Operation of the Fire Alarm Panel is totally free from complicated controls and indicators. The Panel has been human engineered by keeping all six controls in order and grouped into three basic categories of Silencing, Restoration and Testing. The following is a description of the six (6) control functions.

Control Function Description

Alarm Silence - Silences Audible Alarm Devices, position monitored by visual and audible trouble signals.

Trouble Silence - Silences Audible Trouble Devices.

Acknowledge - Steadies flashing red LED on the Common Alarm Control Board and the zone(s) in alarm at that point in time.

Reset - Restores the KFRTI-20/52 Panel to normal condition and resets zone devices that are normal

Drill - Operates “Local Notification Appliance Circuit” only.

Lamp Test - Illuminates all Control Panel Common and Zone Indicators (momentary action).

The Fire Alarm Panel includes a complete array of controls and indicators which simplify the operation of the panel. Each zone has a separate indicator for alarm and trouble as well as a Master Box Zone Disconnect Switch to isolate defective zone conditions. Switches also silence Alarm or Trouble Audio signals. Indicators such AC Power, Common Alarm, and Common Trouble are provided for quick observation of the panel's status.

Panel Controls and Indicators:

Zone Alarm LEDs - Indicates zone(s) in alarm. Stays lit until device's contacts open.

Common Alarm LEDs - Indicates when any zone is in alarm.

Zone Trouble LEDs - Indicates a zone in trouble. Stays lit until ground fault or an open circuit on the field wiring is repaired.

Common Trouble LEDs - indicates a problem with zone wiring, AC power, battery power, or circuits.

AC Power LED - Indicates AC power is applied to the panel.

Alarm Audible Switch - Shuts off the internal buzzer when in *OFF* position.

Trouble Audible Switch - Shuts off pulsing internal buzzer when a trouble is present.

Master Box Zone Disconnect Switches - isolates a zone in alarm. Prevents transmission of alarm signals yet annunciates the alarm when in the *OFF* position. Zone trouble will occur during disconnect.

Internal Buzzer - Pulses when a trouble condition is present. Constant buzzer when an alarm condition is present.

Trouble Delay Jumpers - Programmable time delay which sets time between activation and transmission of a Supervisory message. The Fire Alarm Panel will send a supervisory message whenever a trouble condition exists with; the zone wiring, the panel's circuit board, the switches, and/or the AC & battery power. To avoid false signals and channel congestion, all supervisory signals are delayed. The delay time jumper settings are factory set at 2-3 minutes.

Fuse F1 (1.0 Amp) - Protects the power supply circuits.

Fuse F2 (1.5 Amp) - Protects the power supply circuits.

Fuse F3 (.25 Amp) - Protects the Z+ & M+ output lines going to zone wiring and transmitter for ground fault protection.

In-line Fuse (1 Amp) - Protects the primary 120 VAC side of the transformer.

Each of the initiating circuits uses normally open contacts, which in the alarm condition shunt a 6.8K ohm end of line resistor. When an alarm occurs, the panel operates a normally open contact of a de-energized relay in the transmitter, which causes an alarm signal corresponding to the appropriate zone to be transmitted. Exact zone wiring will depend on system specifications.

Initial Alarm Conditions - When an alarm condition does exist on one of the zones, the panel indicates the following:

'The respective RED Zone Alarm LED will light as long as the initiating devices contacts arc closed.

The RED Common Alarm LED will light.

The internal buzzer will be tuned on in the constant mode.

The Transmitter will send three rounds of an Emergency message.

Operator Acknowledgment - Upon dispatch recovery of a transmitted alarm message, the operator should perform the following tasks:

Observe all annunciated status indicators and record their current status.

If desired, silence the audibles by switching the alarm Audible Switch *OFF*.

Zone Disconnect - If you wish to test a zone without transmitting an alarm message, the zone disconnect switch may be placed in the *OFF* position prior to testing. This will cause a zone trouble condition until the switch is restored to the normal up position. This feature can also be used to isolate a defective zone until the fault is corrected.

Trouble Conditions

Each zone consists of an independent closed loop connecting the device's open contacts, interface panel, and radio master box together. In normal operation, a small supervisory current is maintained throughout. Should a fault such as a broken wire occur anywhere in the loop, the panel goes into a trouble condition. The panel will cause the transmitter to send a supervisory message whenever a trouble condition exists; panel's circuit board, switches and/or AC and battery power. To avoid sending during regularly scheduled maintenance operations, all supervisory signals are delayed 90 seconds.

Zone Trouble - A zone trouble condition occurs when the zone's field wiring or device has an open state or a ground fault, causing the zone to be inoperative. Whenever a trouble condition does exist on one of the zones, the following will happen:

1. The respective AMBER Zone Trouble LED will illuminate.
2. The AMBER Common Trouble LED will pulse.
3. The Internal buzzer will pulse.
4. The Transmitter will send three rounds of a SUPERVISORY message.

Common Trouble - Common trouble can occur when the panel's circuit board malfunctions, loss of AC or battery power, or blows a fuse. The following will happen when there is a trouble.

1. The AMBER Common Trouble LED will pulse.
2. The Panel’s Internal Buzzer will pulse.
3. The Transmitter will end three rounds of a SUPERVISORY message.

Switch Trouble - Switch trouble can occur when one or more of the panel's switches are out of position. All switches must be in the *UP* position. The following will happen when there is switch trouble:

1. The AMBER Common Trouble LED will pulse.
2. The Panel's Internal Buzzer will pulse.

The system is comprised of the following major subassemblies:

- Control Panel,
- Input Modules,
- Output Modules,
- Relay Modules,
- Switch Module,
- Matrix Modules,
- Battery Charger/Transfer Module,
- Battery Packs,
- Releasing Device Module, and
- the Power Supply.

Control Panel - Operates from a three-wire, 1201240 VAC 50160 Hz supply with grounded neutral, incorporating double supervision. Secondary power may be supplied with option standby battery. The green Power LED is illuminated to show that power is normal. Each input power line is separately fused within the power supply.

Loss of the main AC operating power or secondary AC supervisory power is signaled by the system audible and yellow visual trouble LED. Restoration of power returns the panel to normal condition. When standby battery is specified, loss of main power results in an audible and visual trouble signal and the batteries provide power to the system.

The control panel alarm section circuitry responds to any zone module alarm input signal either from the on-board zones or separate zone modules. The alarm condition is “Locked In” within the control panel and is cleared only by operation of the control panel “Reset” switch.

After operation of the *ALARM SILENCE* switch following a system alarm condition, the system visual indicator operates in a flashing mode. A subsequent alarm input from a different zone will cause a renewed high going signal on the silence able alarm output terminal, causing the associated or connected audible devices to be energized again. This operation may be repeated for up to ten (10) subsequent alarm conditions.

Simultaneous alarm input signals from two or more zone modules are considered to be but a single alarm input signal. Operation of the panel mounted *ALARM SILENCE* switch when no alarm is present has no effect. Operation of the key-operated momentary remote alarm station silence switch will cause a system trouble condition when the panel is not in an alarm condition.

The control panel audible trouble buzzer may be silenced by the control panel trouble silence switch or the remote trouble silence station switch, when used. Trouble ring back of this buzzer is provided to indicate that either the control panel trouble *SILENCE SWITCH* or the remote trouble station trouble silence switch is in the *OFF-NORMAL* or *SILENCE* position when no panel trouble condition is present.

Input Modules - Upon operation of a detector or shorting type device installed on the initiating circuit, the input module will lock into an alarm condition, initiating the start of the sequential functions designed into the system. These functions may include sounding audible devices, operating alarm transmitters, closing doors, shutting down fans and equipment, recalling elevators, and other similar functions required for life and property safety.

In addition to the system alarm, a red Alarm LED, on the face of the dual zone module will be illuminated for that particular detection circuit. A trouble on either detection circuit will be similarly annunciated with a yellow LED, one for each circuit.

The module supplies a current limited output signal for the circuit in alarm providing for activation of supplementary modules or annunciators.

Output Modules - Actuation of the module is caused by a high going input signal from a system control module. Dual input activation terminals are provided for programming or sequencing its operation

The output module contains a yellow LED “Trouble” indicator on the face of the module which indicates an open or shorted loop condition.This is operative at all times except when the system is in alarm.

The output module is placement supervised, providing a system trouble signal upon removal from the system. Power for the alarm circuit is fused within the module. The fused circuit requires an end of line resistor valued at 5.6 K ohms at.5 watts.

Upon receipt of a high-going DC actuating signal, the solid state circuitry supplies operating power for vibrating 24 VDC bells, 24 VDC horns or strobes. The maximum output current is limited to 1.5 amperes. The audible devices require a four wire fused, supervised circuit.

The output module contains a yellow LED indicator lamp to indicate an open or shorted alarm line when the system is in the normal condition. The LED can be lamp tested from the main control panel.

Relay Module - The relay module is designed to activate or de-activate external circuit controls such as fan shutdown, door releases, and other fire related equipment. The relay module contains eight independent relays with 2 amp SPDT contacts. Each relay can be selected to operate either on a high going input signal from appropriate modules, or an open collector input signal. Power to operate the relays is provided from the 24 VDC system power supply.

The relay module provides for control of external fire related circuits. The module contains eight (8) independent 24 VDC relays fitted with SPDT contacts. Each relay is provided with a program plug that will select either a high going input signal actuation or a low going signal.

A separate terminal is provided for individual actuation of each relay. All terminals are of the clamp type and will accommodate two (2) wires of up to #14 gauge.

Switch Module - In their “Normal” position during system operation, the switches provide a single pole double throw contact through screw terminals. The yellow LED indicators mounted on the face of the module (one for each switch) are not illuminated. When the switches are manually thrown to *OPERATED* position, the SPDT contact condition is reversed, and their yellow LED indicators are illuminated. The contact rating of the switches is 0.5 amp 30 VDC or 120 VAC.

Matrix Module - The program matrix module are designed to offer selective /multiple circuit activation from a variety of initiating circuits depending on the desired functions that are to be achieved upon system operation.

The matrix module is a printed circuit matrix board interconnected so as to accept any number of ten (10) inputs, any number or combination of which can activate any number of ten (10) preselected controlled circuits. This is accomplished through the use of diodes, properly placed and assembled to the matrix board. Typical application examples are: actuation of selected relays from two or more independent signal paths, operation of multiple annunciator circuits from a single input, activating audible signal circuit from a number of initiating device circuits, etc.

Battery Charger/Transfer Module - Under normal operating conditions, the system is powered directly from the main power supply. When the system is equipped with emergency power, the lead acid, or nickel cadmium, batteries are maintained at full charge through the operation of the combination charging circuit. In the event of an AC power failure, the system is transferred to battery power.

After main power has been restored and the emergency batteries have been fully recharged, the system continues to float charge the batteries.The module is fitted with a fuse to protect against the battery over-current and accidental reversal of polarity.

The battery is protected against overcharge and deep discharge. Failure of the charging system is identified by an indicator on the primary charging module and also by a system trouble, if AC power is functioning.

Battery Packs - The battery packs are used to provide stand-by power to the fire alarm panel if the main AC power should fail. For proper battery recharging it is recommended that the battery charger specifically designed for recharging the battery pack. The battery packs may be left on the battery charger indefinitely. Battery Packs in the maintenance mode will be kept at 100% state of charge as long as the battery is kept on the charger. Totally discharged batteries will normally be recharged to 100% state of charge within 48 hours.

Releasing Device Module - A supervised release circuit for the extinguishing system, sprinkler system, door control. or fan control is provided by the releasing device module.

The releasing device module is system interconnected by a ten pin plug and harness assembly and is operable with the main control panel.

Upon receipt of the two high going input activation signals, the solid state circuitry applies power for the solenoid valve(s) or 24 VDC relay.

A circuit disconnect switch is provided to deactivate the circuit during servicing of the system and indicates a trouble condition when the switch is in the *OFF* position

The module contains a yellow LED indicator to indicate an open release circuit when the system is in an otherwise normal condition. The LED lamp can be tested from the control panel.

Power Supply - The system power supply furnishes power for detector circuits and audible signal circuits, The detector circuits may be the two zones incorporated in the control panel, plus any mix of additional compatible zones, signal circuits, or other fire monitoring circuits, in addition, an output rated at 24 VDC 1.5A is provided on terminals 5 and 6 of the power supply for powering modules internally housed and wired within the control unit enclosure.

A new addressable class A Fire Detection and Alarm Control Panel (FACP) was installed in the Pump House. This FACP controls heat detectors, a pull station, and horn/strobe units located inside the Pump House. One of the horn/strobe units was placed inside the Pump House, and the other horn/strobe was placed outside the Pump House to alert personnel outside the Pump House of a fire condition. The FACP in the Pump House reports its status to the fire control system in the Power Plant.

(Additional information concerning the alarm control panels installed in the Water Plant and Pump House can be found in Section 4.2.4.7.3.1 of this Manual.)

2.4.7.3.2 CO_2 Fire Alarm Suppression Control

The CO_2 Fire Alarm Suppression Control System is a microprocessor-addressable-type system that provides early detection of smoke and / or heat produced by fire.

The control system which can be used for local, auxiliary, remote protective signaling and releasing device service. The system is a microprocessor based design for use with intelligent detectors and loop devices.

The system uses distributed intelligent field devices. These devices are typically smoke detectors, contact input devices relay outputs and signal output modules which represent a single fire alarm initiation/indicating zone. Each device contains its own data transceiver, micro controller, 4k of memory and applicable algorithms which allows each device to operate independent of the control system. These unique devices have the ability to analyze information, make decisions and store information within themselves. They communicate with the PEGAsys system using the BIP protocol which utilizes a two-wire (Style 4), four wire (Style 6) or isolated (Style 7) multiplex trunk. The system can support up to 255 device addresses per loop with a maximum of 8 loops for a total of 2040 Intelligent device points per system.

The system is capable of controlling a wide variety of auxiliary devices, such as relays, audible visual indicating signal devices and agent/sprinkler release systems. The system also supports the use of serial printers which provide hard copy of system status information.

The system is comprised of three major components: the Central Control Panel (CCP) communicates with the field devices and drives output devices such as alarm signals that communicate with central stations and various types of control equipment. A display panel located on the CCP provides system status LED.s, Control Switches and a 80-character LCD for alphanumeric display of system status information.

The single-loop CCP consists of the Central Control Module (CCM) assembly, display module, one receiver/transmitter (RX/TX) module, power supply assembly, a motherboard, and standby batteries.

The CCM assembly is the heart of the system and is comprised of two PCB assemblies, the display module and the main processor module. The CCM controls the operation and supervision of all the system modules and software within the system. It receives loop device data from the RX/TX module, processes the data based on pre-programmed instructions and transmits output commands to the output modules, field devices, and display module(s).

The display module assembly, attached to the main processor PCB, provides the system with the operator interface for control switches, system status LEDs, system trouble/alarm buzzer, a 80-character (2 x 40) LCD display and an integral numeric keypad. The keypad is used for entering the security password and navigating through the user menus. The system buzzer provides two distinctly different signaling patterns for audible warning of system alarms and troubles.

The RX/TX functions as the hardware & software interface between the field devices and the CCM. The RX/TX receives control requests from the CCM and establishes communications with the field devices. The RX/TX receives status changes from the field devices and reports these changes to the CCM. The RX/TX is capable of communicating with up to 255 intelligent devices and complies with the wiring requirements of NFPA Style 4, 6 & 7 (with the use of the loop isolator device). Style 4 initiation circuit wiring will permit "T." tapping, or branch circuitry.

The power supply/charger assembly is comprised of a printed circuit board (PCB) assembly and a AC/DC switching power supply unit. The switching power supply unit provides 4 amps of 24 VDC from the 120/240 VAC input power.

The basic I/O motherboard assembly is an assembly which can accept up to eight (8) I/O module circuit board assemblies. The motherboard is mounted to the back of the system enclosure and /or the auxiliary enclosures. It distributes the system 24 VDC power and I/O bus communications to the I/O modules. The I/O bus communications are provided by a RJ-12 (flat phone cable) style connection. The 24 VDC is provided by the system power supply via a 2-conductor wiring harness.

The input/output modules allow the system to interface with external auxiliary devices. These auxiliary devices can be audible/visual signal devices, HVAC systems, power shut down, remote annunciators, agent/ sprinkler release system and any other control type input or output which may need to be interfaced to the system.

The input and output modules plug into the motherboard assembly located on the back plate of the system enclosure. Each I/O module occupies one slot in the motherboard assembly which has eight (8) slots available. The I/O modules and the CCM communicate over the RS-485 based I/O bus, which uses a 6-conductor phone type cable to connect the CCM to the motherboard.

Space is provided within the central control panel enclosure for up to two (2) 12-V, 17 Amp Hour, sealed lead-acid batteries used for 24, 60 or 90 hour standby operation. If additional batteries are required, an optional battery enclosure is available. The enclosure is a heavy duty steel cabinet which can house up to two 40 Amp. hour batteries.

The system can operate in either the default mode or the non-latching mode. In the default operation, the panel will be set to latch all alarm inputs on the system.

The latching operation will not allow the loop input devices to generate an "alarm off" signal that would possibly interrupt a discharge time delay sequence. To return the panel to normal the "RESET" button will need to be pushed.

The second mode of operation is non-latching. This mode can be enabled, using the PCS Configuration Software to define if a loop device input is to be non-latching. The non-latching operation will allow the loop input devices to generate an "Alarm Off" signal to the panel. When this signal is received the panel would interrupt the discharge time delay sequence of operation. However, all outputs that had been activated previous to the "Alarm Off" signal will remain on and latched until the panel is reset.

The system provides three distinct levels of program protection, as required by UL Standard 864. The user can only access the system by entering a valid password. Typical valid passwords consist of three or four characters, but may be up to eight characters in length.

Controls and Indicators

The control and indicators of the system are located on the display panel. The display panel is mounted on top of the CCM. To gain access to the CCM, the panel door must be open.

The display panel contains an 80-character alphanumeric display. This LCD display is used to present system status and aids the user in the operation of the system.

The Display Panel also contains an audible device which generates two separate audible tones, one for alarms and one for troubles. This device sounds continuously when a new alarm condition is received until the condition is acknowledged. It also sounds intermittently when a trouble, supervisory, or pre-alarm condition is received until the condition is acknowledged.

WARNING:

Several different sources of power can be connected to this fire alarm control panel. Disconnect all sources of power before servicing. Control unit and associated equipment may be damaged by removing and/or inserting cards, modules, or interconnecting cables while the unit is energized. Do not attempt to install, service, or operate this unit without reading the manufacturer's manual.

CAUTION:

To ensure proper system operation, this product must be tested in accordance with NFPA - 1996 Chapter 7 after any programming operation or change in site-specific software. Re-acceptance testing is required after any change, addition or deletion of system components, or after any modification, repair or adjustment to system hardware or wiring.

All components, circuits, system operations, or software functions known to be affected by a change must be 100% tested. In addition, to ensure that other operations are not inadvertently affected, at least 10% of initiating devices that are not directly affected by the change, up to a maximum of 50 devices, must also be tested and proper system operation verified.

This system meets NFPA requirements for operation at 0 to 49° C and at a relative humidity of 85% RH (non-condensing) @ 30°C. However, the useful life of the system.s standby batteries and the electronic components may be adversely affected by extreme temperature ranges and humidity. Therefore, it is recommended that this system and its peripherals be installed in an environment with a nominal room temperature of 60-80°F.

Like all solid state electronic devices, this system may operate erratically or can be damaged when subjected to lightning induced transients. Although no system is completely immune from lightning transients and interference, proper grounding will reduce susceptibility.

The use of overhead or outside aerial wiring is not recommended due to the increased susceptibility to nearby lightning strikes. Consult with the Applications Engineering Department if any problems are anticipated or encountered.

A fire alarm system will not operate without electrical power. If AC power fails, the system will operate from standby batteries only for a specified time.

System Power-up

The following step-by-step procedure is for initial power-up of the CCP.

1. Perform the installation check-out procedure.
2. Set the circuit breaker for the CCP power to *ON*. Verify that the display reads “MAIN PROCESSOR POWER ON” and that the *CPU ERROR* indicator is lit. Ensure that the audible device is buzzing continuously.
3. Press the display module reset switch. Verify that the *CPU ERROR* indicator is extinguished and the audible device is silenced.

4. Verify that the display reads as follows:
   "MAIN PROCESSOR POWER ON".
5. After ten seconds, verify that the display reads as follows:
   "RXTX NON-MONITORING TROUBLE ON RXTX1".
6. Verify that the *POWER ON* and *TROUBLE* indicators are lit.
7. Connect the backup batteries to the CCP.
8. Press the *ACKLDGE* pushbutton. After approximately one minute the display will momentarily read:
9. "RXTX NON-MONITORING TROUBLE OFF".
10. Verify the display reads the incorrect time and date.
11. Set time and date.
12. The power-up procedure is complete at this point. The system is now ready for loop device registration and programming.

The system has a built-in menu structure. This menu structure has been implemented to aid users with system operating functions. The menu structure consists of a main menu, and multiple sub-level menus. The sub-menus may also contain multiple sub-level menus. The main menu displays after the user enters a valid password.

The system has four modes of operation. Each mode has different indications and action required.

In the Normal Standby Mode, no alarm, trouble, or supervisory conditions exist in the system. The system display will show the time, day of the week, and date.

In the Active Alarm Mode the system enters an alarm mode if a device (or devices) has detected an alarm condition, such as smoke / heat above the alarm threshold level. There are two types of alarms which can occur:

The system enters the Active Supervisory Trouble Mode when it detects an abnormal condition on the system that has been defined to be a much higher priority than a common trouble. This type of trouble is usually assigned by the installer/designer to monitor critical parts of the system.

The system enters the Active Trouble Mode when it detects an abnormal condition which may prevent proper operation or display a pre-alarm condition.

(Additional information regarding the CO_2 Fire Alarm Suppression Control System is contained in Appendix Section 4.2.4.7.3.2 of this manual.)

2.4.7.3.3 Initiating Devices

There are several types of initiating devices employed throughout the Water Plant to report both thermal and flame conditions to the fire alarm control panel.

Two types of these initiating devices are photoelectric / thermal type smoke detectors and flame detectors. Both types of detectors initiate an alarm if the surrounding air reaches the detector's programmable set temperature point (normally 135º or 200º F).

Photoelectric type smoke detectors The photoelectric / thermal smoke detectors use a photo chamber sensor to detect smoke particles in the air. They also use a thermistor sensor to sense temperature changes. A microprocessor in the detector uses inputs from both sensors to identify actual fire conditions while ignoring non-threatening phenomena such as cigarette smoke.

The detectors provide true distributed intelligence by storing and analyzing calibration data and pre-alarm and alarm values. The detector continuously makes real-time decisions and reports its status, as required, to the fire detection system.

The detector alarm and pre-alarm set point levels are factory set in units of percent obstruction / foot, or degrees (F), and may be changed by the operator. Both set points, however. can only be set within the UL allowable limits that are stored in the sensor's nonvolatile memory.

Should there be a failure in the communications link between the fire detection system and the detector, the detector will operate as a conventional sensor. That is, it will cause a general alarm by signaling line circuit when smoke density or temperature reaches the alarm point. It will not, however, report its status. Upon re-establishment of communications with the fire detection system, the detector will return to its prior program without further action.

An LED is provided to illustrate detector status. A two-second flash rate indicates alarm, while a nine-second rate indicates normal operation.

The ***Flame Detector*** is a high-performance and high reliability, self-contained, triple-spectrum flame detector. The Triple IR design offers two to three times the detection distance of any conventional lR or UV / IR detector.

The Triple IR scans for oscillating lR radiation (1 to 10 Hz) in the spectral bands ranging from 4.0 to 5.0 microns.

Each sensor bandpass has been selected to ensure the greatest degree of spectral matching to the radiant energy emissions of fire, and the lowest degree of matching to non-fire simulation. This highly advanced detector uses a programmed algorithm, which checks the ratio and correlation of data received by the three sensors. Only detection of radiation emissions matching the spectral fingerprint of fire will produce an alarm, making the flame detector immune to false alarms.

Other types of initiating devices include an optical flame detector, manual pull stations, rate compensation heat detectors, and smoke detectors located in the ducting system at the Water Plant.

The optical flame detector is used where the threat of accidental fire involves hydrocarbon fuels such as aviation jet fuels like JP-4, JP-5, or JP-8. These fuels are used for the boiler, the back-up furnace, and the engine generator sets.

The manual pull stations are wall mounted throughout the facility. The manual pull stations are high quality, reliable non-coded alarm initiating devices. They are constructed of heavy diecast aluminum for long life and reliability These manual stations are red gloss painted with raised white lettering, and black sides with a white trim border.

Some stations have a standard single pole, single throw switch, others have a double pole, single throw switch for local annunciation or remote signaling. Switches are gold plated for reliability when used in low current initiating circuits.

These manual stations are designed for quick, efficient response by personnel in an emergency while the standard double action PUSH/PULL prevent accidental operation The keylock allows the unit to be easily reset and tested.

The manual stations are operated by simply pushing the PUSH bar inwards, allowing the PULL handle to be grasped in a one-handed motion. The handle is then pulled down as far as it will go. If the optional bread rod is installed, it would break at this point. The handle is now locked in place, as is easily visible from up to 50 feet away. The handle is reset by opening the station with the key, placing the handle in the normal upright position, and re-locking the station. Protective plates have been installed over the manual stations to protect against physical damage (both accidental and intentional), dust, grime, as well as severe environments. When lifted to gain access to the actual alarm, it sounds a piercing self-contained 95 dB or 105 dB warning horn. The horn will sound until the cover is snapped back onto the frame or for the life of the battery.

Rate compensation detector units are used to release extinguish ants such as CO_2, water, or dry chemicals. The detector senses the surrounding air temperature regardless of the fire growth rate.

Operation of the air duct mounted smoke detectors is based upon an air sampling principle. Two (2) sampling tubes extend into the duct to transport air from the inside of the duct into the duct detectors sensing chamber and exhaust it back out into the duct. If the sampled air contains a concentration of smoke greater than or equal to the alarm threshold of the internal smoke detector, the unit will go into alarm status.

(Additional information concerning initiating devices installed in the Water Plant and Pump House can be found in Section 4.2.4.7.3.3 of this Manual.)

2.4.7.3.4 Signaling Appliances

Signaling devices, such as horns, strobes, horns / strobes, both indoor and outdoor, are audible / visual devices that provide the ability to transmit warnings of existing emergency conditions to personnel. These devices are typically a combination of audio and light alarms.

Generally, these strobes operate from a 16 to 33 VDC (using filtered or FWR voltage) sent from the fire alarm panel. Audio may be either a continuous horn or a temporal pattern. The visual display is set to occur at one (1) flash per second.

Modules used with the strobes provide independent operation of synchronized temporal pattern horn and synchronized strobe flash, as well as the ability to silence the horn while maintaining the strobe flash, while using only a single pair of wires.

The audible alarms used in the Water Plant are combination horn / strobe units. When the system goes into alarm, these systems activate to alert occupants of a fire so they can evacuate the building. These devices are placed throughout appropriate areas to alert personnel of possible dangerous conditions.

WARNING:

Failure to comply with the installation instruction sheets could result in improper installation, application, and / or operation of these products in an emergency situation, which could result in property damage and serious injury or death.

(Additional information concerning signaling devices installed in the Water Plant and Pump House can be found in Section 4.2.4.7.3.4 of this Manual.)

2.4.7.3.5 Batteries & Battery Charger

The back-up battery pack provides emergency power to the fire system in the event normal electrical power is lost.

The battery pack is pressure sealed, allowing it to be charged and discharged in any position. Cylindrical spiral-wound plate design results in low internal impedance and the highest energy and power density of any lead-acid battery.

CAUTION:

Do not short battery leads. The batteries are capable of extremely high short circuit currents, even when partially discharged. This high current can cause internal heating of the battery and permanent damage. A shorted battery can also be a fire and/or explosion hazard. Be sure to always use the polarized connectors supplied on the batteries. Never remove wires from the connector.

The 10-circuit battery charger is specifically designed for recharging the 12 volt lead-acid batteries used with the fire system. The Battery Charger operates on 115 VAC source, has solid state circuitry construction, a slow-fast rate charging. and a top loading battery charging rack.

The battery charger monitors up to TEN battery packs simultaneously. It has a built-in meter for instant readings of the amperes and voltage of each battery on charge. In addition, each charging circuit has a built-in charge mode indicator. The Battery Charger recharges discharged sealed lead-acid batteries to their “equalized” 100% state of charge condition.

The Battery Charger is equipped with a standard grounded line cord. This cord is covered with heavy duty material providing many years of service without any special attention. While the charger has been carefully designed to prevent any danger from electrical shock, it is proper (or recommended) safety procedure to use a properly grounded outlet for supply power.

Batteries may be left on this battery charger indefinitely. A battery in the maintenance mode (general operation instructions) will keep100% state of charge as long as the battery is kept on the charger.

Fully charged batteries are indicated by the high rate indicator lamp remaining OFF for 30 minutes or more depending on the ambient temperature. Each of the 10 charger circuits are totally independent and are equipped with its own rate indicator. This allows batteries of different states-of-charge to be charged side-by-side.

A battery to be charged is placed in the battery rack located on top of the charger unit and plugged into any of the ten charger outlets. Both the outlets and the battery connectors are polarized, so that they can be plugged together only in the correct position.

When the battery is initially charged, the high rate indicator light associated with that charger circuit will light for up to 12 hours. As the battery is left on the charger for several hours, the high rate indicator will continue to turn off and on. However. it will be noted that the amount of time the light is on each time should slowly be getting shorter and the amount of time the light is ON should be getting longer.

When the high rate indicator stays off for more than 30 minutes, this is an indication that the battery is almost fully charged and is ready for service. If the battery is on the battery charger for a sufficient period of time (a week or more), the indicator light will stay off. This indicates the charger is in its maintenance mode and that the battery is completely charged. It is recommended that the battery be left on the charger in its maintenance mode until it is needed.

The sealed lead-acid battery loses approximately 15% (at normal room temperature) of its capacity per month when stored on a shelf without maintenance charging. A battery stored for 3 months has already lost almost half of its charge. At 105° F. it would have lost 80% of its charge. Batteries left on the charger in maintenance mode will always be kept at 100% state of charge. IF SPARE BATTERIES CANNOT BE LEFT ON THE CHARGER. THEN THEY SHOULD BE FULLY CHARGED AND STORED 12; A REFRIGERATOR OR FREEZER AND THEN RE-CHARGED AT LEAST ONCE A YEAR.

The battery charger can monitor any of the batteries on charge. Both the voltage (under charge) and the charge current can be monitored.

The charger is designed to provide approximately 125 mA. or 250 mA. of charge current with a charge voltage of up to 14.7 volts. When the voltage exceeds 14.7 volts, the charger current drops to approximately 5 mA. or 10 mA. This charge current of 5 mA. is maintained until the battery voltage drops below 13.7 volts. The charger then automatically switches to the 125 mA. or 250 mA. charge rate.

A battery not accepting a charge can be monitored for a rise in its voltage. Voltage monitoring can also be used to check batteries being held in the maintenance mode. Batteries being held in the maintenance mode should show 5 mA. or 10 mA. of charge current and voltages as high as 16 volts. A voltage greater than 16 volts indicates an open circuit. either in the battery connector, cable, or internal to the battery itself. The rotary switch on the front panel selects which battery is being monitored but in no way affects the operation of the charger on the batteries that are not being monitored.

Occasionally, it may be desirable to discharge a battery to determine the actual capacity of a battery, or to condition a battery that has been abused. The discharge test provides a 1 amp load and metering terminals to monitor the output voltage of the battery. The only accurate procedure to determine the capacity of a sealed lead-acid battery is to discharge it and measure the length of time it takes to reach the discharged condition. You will then know what capacity the battery contains. A battery being discharge tested should be replaced when the voltage drops below 11 volts. The battery should be immediately put on charge after this test. Leaving a battery in its discharged state, even for a few hours can cause permanent damage to the battery.

A battery that refuses to take a charge can sometimes be restored by charging the battery for 1 hour, discharging it to 10 volts. then charging the battery again. If no improvement in battery voltage or discharge time results, the battery is irreversibly damaged and should be replaced. A fully charged 2.5 ampere hour battery should be able to maintain a test load position discharge voltage of greater than 11 volts for at least 45 minutes.

(Additional information concerning the back-up batteries and the charger used in the fire systems can be found in Section 4.2.4.7.3.5 of this Manual.)

2.5 REFERENCE INFORMATION

The following list includes all valves and miscellaneous equipment located in the Water Plant, the Pump House, and the Power Plant. The accuracy of this list had not been verified at the time of the writing of this manual. Because of design changes in the system, some of these valves may or may not exist. The settings indicated in the following list are for normal operations only, and not for other situations. Even after referring to the list, try to trace out the system and decide upon the valve position independently, and see that it concurs.

2.5.1 Valves

VALVE DESIGNATOR	VALVE SETTING
AV-2A	AUTOMATIC
AV-2B	AUTOMATIC
BFW-1	NORMALLY OPEN
BFW-2	NORMALLY OPEN
BFW-3	NORMALLY OPEN
BPV-1	ACTIVATED WHEN SEPARATOR IS IN USE
BPV-2	ACTIVATED WHEN SEPARATOR IS IN USE
1F1	NORMALLY OPEN
1F2	NORMALLY CLOSED
1F3	NORMALLY OPEN
1F4	NORMALLY CLOSED
1F5	NORMALLY CLOSED
2F1	NORMALLY OPEN
2F2	NORMALLY CLOSED
2F3	NORMALLY OPEN
2F4	NORMALLY CLOSED
2F5	NORMALLY CLOSED

VALVE DESIGNATOR	VALVE SETTING
ESFHCR2-1	NORMALLY OPEN
ESFHCR2-2	NORMALLY OPEN
FBW-GV2-1	NORMALLY OPEN
FBW-GV2-2	NORMALLY OPEN
FD2-1	NORMALLY CLOSED
FD2-2	NORMALLY CLOSED
H_2S-A1	NORMALLY OPEN
H_2S-A2	NORMALLY OPEN
H_2S-A3	NORMALLY OPEN
H_2S-B1	NORMALLY OPEN
H_2S-B2	NORMALLY OPEN
H_2S-B3	NORMALLY OPEN
H_2S-BV3-1	OPEN WHEN FILTERS NOT IN USE
PCV-1	AUTOMATIC SET AT 60 psi
PCV-2	AUTOMATIC
SEP-GV1-6A	NORMALLY OPEN
SEP-GV1-6B	NORMALLY OPEN
TCV-1	AUTOMATIC (OPENS WHEN TEMP > 140° F.)
TCV-2	AUTOMATIC (SET AT 180° F.)
P124-GV1-B1	NORMALLY CLOSED
P124-GV1-B2	NORMALLY CLOSED
P124-GV1-B3	NORMALLY CLOSED
P124-GV1-B4	NORMALLY CLOSED
P124-GV1-B5	NORMALLY CLOSED
P124-GV1-B6	NORMALLY CLOSED

VALVE DESIGNATOR	VALVE SETTING
P124-GV1-A1	NORMALLY OPEN
P124-GV1-A2	NORMALLY OPEN
P124-GV1-A3	NORMALLY OPEN
P124-GV1-A4	NORMALLY OPEN
P124-GV1-A5	NORMALLY OPEN
P124-GV1-A6	NORMALLY OPEN
P124-GV1-B1	NORMALLY OPEN
P124-GV1-B2	NORMALLY OPEN
P124-GV1-B3	NORMALLY OPEN
P124-GV1-B4	NORMALLY OPEN
P124-GV1-B5	NORMALLY OPEN
P124-GV1-B6	NORMALLY OPEN
P124-GV1-C1	NORMALLY OPEN
P124-GV1-C2	NORMALLY OPEN
P124-GV1-C3	NORMALLY OPEN
P124-GV1-C4	NORMALLY OPEN
P124-GV1-C5	NORMALLY OPEN
P124-GV1-C6	NORMALLY OPEN
P124-MOV2-1	OPEN WHEN SILENCER IS IN USE
P124-MOV2-2	OPEN WHEN SILENCER IS IN USE
P124-MOV2-3	OPEN WHEN SILENCER IS IN USE
P124-MOV2-4	OPEN WHEN SILENCER IS IN USE
P124-MOV2-5	OPEN WHEN SILENCER IS IN USE
P124-MOV2-6	OPEN WHEN SILENCER IS IN USE
Q177-GV2-A1	NORMALLY OPEN

VALVE DESIGNATOR	VALVE SETTING
Q177-GV2-A2	NORMALLY OPEN
Q177-GV2-A3	NORMALLY OPEN
Q177-GV2-A4	NORMALLY OPEN
Q177-GV2-A5	NORMALLY OPEN
Q177-GV2-A6	NORMALLY OPEN
Q177-GV2-B1	AUTOMATIC
Q177-GV2-B2	AUTOMATIC
Q177-GV2-B3	AUTOMATIC
Q177-GV2-B4	AUTOMATIC
Q177-GV2-B5	AUTOMATIC
Q177-GV2-B6	AUTOMATIC
Q177-GV6-1	NORMALLY OPEN
Q177-GV6-2	NORMALLY OPEN
A500-BV3/4-1	NORMALLY CLOSED
A500-B3/4-2	NORMALLY CLOSED
A500-BV3-1	NORMALLY OPEN
A500-BV3-2	NORMALLY OPEN
A500-BV3-3	NORMALLY OPEN
A500-BV3-4	NORMALLY OPEN
A500-GB4-1	NORMALLY CLOSED
A500-BV6-1	NORMALLY CLOSED
A500-GV6-1	NORMALLY OPEN
A500-MOV6-1	AUTOMATIC
B502-BV3-1C	NORMALLY OPEN
B502-BV3-1B	NORMALLY OPEN

VALVE DESIGNATOR	VALVE SETTING
B502-BV3-1A	NORMALLY OPEN
B502-BV6-1	NORMALLY OPEN
C506-GV2-1A	NORMALLY OPEN WHEN EVAP IS IN USE
C506-GV2-1B	NORMALLY OPEN WHEN EVAP IS IN USE
C506-BV3-1A	NORMALLY OPEN
C506-BV3-1C	NORMALLY OPEN
C506-BV3-1B	NORMALLY OPEN
C506-BV3-2A	NORMALLY CLOSED
C506-BV3-2B	NORMALLY CLOSED
D510-BV3-1	NORMALLY OPEN
D510-BV3-2	NORMALLY OPEN
Q513-GV1/2-1	NORMALLY CLOSED
Q513-GV3/4-1	NORMALLY CLOSED
Q513-GV3/4-2	NORMALLY CLOSED
Q513-GV6-1	NORMALLY OPEN
Q513-GV10-1	OPEN WHEN SEPARATOR IS IN USE
Q513-GV10-2	OPEN WHEN SEPARATOR IS IN USE
O516-GV4-1	NORMALLY OPEN
O516-GV4-2	NORMALLY OPEN
O516-GV4-3	NORMALLY OPEN
O516-GV8-1	OPEN WHEN SEPARATOR IS IN USE
O516-GV8-2	OPEN WHEN SEPARATOR IS IN USE
P521-GV1-1	NORMALLY OPEN (CLOSED WHEN STARTING)
P521-GV3-1	NORMALLY OPEN
P521-GV3-2	NORMALLY OPEN

VALVE DESIGNATOR	VALVE SETTING
P521-GV3-3	NORMALLY OPEN
A526-GV2-1	NORMALLY OPEN
A526-GV2-2	NORMALLY OPEN
A526-GV2-3	NORMALLY OPEN
B528-GV2-1	NORMALLY OPEN
B528-GV2-2	NORMALLY OPEN
B528-GV2-3	NORMALLY OPEN
B528-GV1 1/2-1	NORMALLY OPEN
B528-GV1 1/2-2	NORMALLY OPEN
P534-GV1-1	NORMALLY OPEN
P534-GV1-2	NORMALLY OPEN
P534-GV1-3	NORMALLY CLOSED
P534-GV1-4	DEPENDENT ON SEPARATOR IN USE
P534-GV1-5	DEPENDENT ON SEPARATOR IN USE
P534-GV1-6	NORMALLY OPEN
P534-GV1-7	NORMALLY OPEN
P534-GV1-8	NORMALLY CLOSED
P534-GV1-9	NORMALLY OPEN
P534-GV1-10	NORMALLY OPEN
P534-GV1-11	NORMALLY OPEN
P534-MOV1-1	AUTOMATICALLY CONTROLLED
P534-MOV1-2	AUTOMATICALLY CONTROLLED
E544-GV6-1	OPEN WHEN SEPARATOR IS IN USE
E544-GV6-2	OPEN WHEN SEPARATOR IS IN USE
J547-GV3/4-1	NORMALLY CLOSED

VALVE DESIGNATOR	VALVE SETTING
K551-GV3/4-1	NORMALLY CLOSED
K551-GV3/4-2	NORMALLY CLOSED
K551-GV1 1/2-1	NORMALLY OPEN
K551-GV1 1/2-2	NORMALLY CLOSED (OPEN FOR MORE HEAT)
K551-GV1 1/2-3	NORMALLY OPEN
K551-GB1 1/2-1	NORMALLY CLOSED
K552-GV1-1	NORMALLY CLOSED
K552-GV1-2	NORMALLY CLOSED (OPEN FOR MORE HEAT)
K552-GV1-3	NORMALLY OPEN
K552-GV1-4	NORMALLY CLOSED
K552-GV1-5	NORMALLY CLOSED (OPEN FOR MORE HEAT)
K552-GV1-6	NORMALLY OPEN
K552-GV1-7	N.C. (N.O. WHEN L.P. STM IS HEAT SOURCE)
K552-GV1 1/2-1	N.O. (N.C. WHEN L.P. STM IS HEAT SOURCE)
T552-GV1-1	NORMALLY OPEN (CLOSE WHEN NOT IN USE)
T552-GV1-2	NORMALLY OPEN (CLOSE WHEN NOT IN USE)
T552-GV2-1	VARIES WITH FEED PUMP IN USE
T552-GV2-2	VARIES WITH FEED PUMP IN USE
T552-GV2-3	VARIES WITH FEED PUMP IN USE
T552-GV2-4	VARIES WITH FEED PUMP IN USE
T552-GV2-5	VARIES WITH FEED PUMP IN USE
A557-GV2-1	NORMALLY OPEN
A557-GV2-2	NORMALLY OPEN
L562-GV2-1	NORMALLY CLOSED
L562-GV2-2	NORMALLY CLOSED

VALVE DESIGNATOR	VALVE SETTING
L562-GV2-3	NORMALLY CLOSED
L562-GV2-4	NORMALLY OPEN
L562-GV2-5	NORMALLY CLOSED
L562-GV2-6	NORMALLY CLOSED
L562-BV4-1	NORMALLY OPEN
L562-BV4-2	NORMALLY CLOSED
C567-GV3-1	NORMALLY OPEN
C567-GV3-2	NORMALLY OPEN
C567-GV3-3	NORMALLY OPEN
C567-GV4-1	NORMALLY OPEN
C567-GV4-2	NORMALLY OPEN
D570-B1-1	NORMALLY OPEN
D570-B1-2	NORMALLY OPEN
D570-BV2-1	NORMALLY OPEN
D570-BV2-2	NORMALLY OPEN
D570-GV4-1	NORMALLY CLOSED
D570-GV6-1	NORMALLY OPEN
E571-SV1/2-1	AUTOMATIC
E571-GV1-1	NORMALLY OPEN
E571-GV1-2	NORMALLY CLOSED
G574-GV1/2-1	NORMALLY OPEN
G574-GB3-1	NORMALLY CLOSED
G574-GV3-1	NORMALLY OPEN
G574-GV3-2	NORMALLY OPEN
M575-GV2-1	NORMALLY OPEN

VALVE DESIGNATOR	VALVE SETTING
M575-GV2-2	NORMALLY OPEN
M575-GV2-3	NORMALLY CLOSED
N576-GV1-1	NORMALLY OPEN
D578-GV1-1	NORMALLY OPEN
D578-GV1-2	NORMALLY CLOSED
D578-GV2-1	NORMALLY OPEN
C579-GV1/2-1	NORMALLY OPEN
C579-GV1/2-2	NORMALLY OPEN
C579-GV3/4-1	NORMALLY CLOSED
C579-GV1 1/2-1	NORMALLY OPEN
C579-GB1 1/2-1	NORMALLY CLOSED
C579-GV1 1/2-2	NORMALLY OPEN
H580-GV3/4-1	NORMALLY CLOSED
H580-GV1-1	NORMALLY OPEN
H580-GV1-2	NORMALLY OPEN
H580-GV1-3	NORMALLY CLOSED

2.5.2 Water Tanks

Seawater Surge Tank
Equip # TN00008
NSF Tag# 07796
Mfr. unknown
Volume 18,047 gal
Usable volume 15,000 gal
Radius 8'

Freshwater Tank 1
Equip # TN00009
NSF Tag# 07797
Mfr. unknown
Volume 54,000 gal.
Usable Volume 50,000
Radius 12'
Overflow level 14' ***6"***
Note: Tank bottom is 17" below floor level.
1/4" steel

Freshwater Tank 2
Equip # TN00010
NSF Tag # 07798
Mfr. unknown
Volume 54,000 gal.
Usable Volume 50,000
Radius 12'
Overflow level 14' ***6"***
Note: Tank bottom is 17" below floor level.
1/4" steel

Freshwater Tank 3
Equip # TN00011
NSF Tag # 07843
Mfr. unknown
Volume 54,000 gal.
Usable Volume 50,000
Radius 12'
Overflow level 14' 6"
Note: Tank bottom is 17" below floor level.
1/4" steel

Freshwater Tank 4
Equip # TN00016
NSF Tag # none
Volume 55,000 gal.
Usable volume 55,000 ga

Calcium Carbonate Tank #1
Equip # TN00017
NSF Tag # none
Mfr. Dun-Rite Corp.
Serial # 7476-1
Volume 600 gal.
Diameter 54"
Max work psi 100

Calcium Carbonate Tank #2
Equip # TN00018
NSF Tag # none
Mfr. Dun-Rite Corp.
Serial # 7476-1
Volume 600 gal.
Diameter 54"
Max work psi 100

Overhead Monorail Hoist
Equip # H000034
NSF Tag # 07849
Mfr. Yale
Model KEL, 1/2-15LG15S1
Serial # D-6-88
Capacity 1000lbs.
Voltage 115/230, 60Hz., 1 Phase
Note: Cover contains asbestos.

Boiler
Equip # BH00031
Mfr. Superior
Model 250HS
Serial # 6357
Firetube

3 MAINTENANCE

3.0 GENERAL BUILDING MAINTENANCE

The intent for the newest upgrades is to replace aging water treatment equipment, provide a redundant power plant system for use in stand-alone situations, and install a new fire suppression system with CO_2 coverage in certain areas. This was accomplished by adding room for two new power generators, cooling radiators for the generators, switchgear, and a fuel oil daytank. The water treatment process was also improved by replacing the seawater surge tank with several expansion tanks and eliminating the reverse osmosis (RO) high pressure pump. The upgrades also added a new pump house to accommodate additional equipment for the reverse osmosis (RO) unit #3 to operate as a stand alone system. All this new equipment along with the remaining must be maintained.

Maintenance is the work necessary to keep equipment operable. **Replacements, repairs, or adjustments must be made immediately to ensure that the systems will operate when needed**. The frequency of maintenance and cleaning depends upon the type of equipment, and the local ambient conditions.

An inspection is a visual examination of the system to verify that it appears to be in operating condition and is free of physical damage. The visual inspection is generally done from floor level by walking through the protected building. Testing is conducted to ensure the system is fully operational. Any system that fails an inspection or testing, should have maintenance performed immediately to correct the problem, then inspected and tested again. Records should be kept of the inspections, tests, and maintenance.

To ensure that critical and elementary components of the architectural, mechanical, and electrical systems consistently operate at their maximum performance levels, preventative, predictive, and corrective maintenance practices are required. Corrective maintenance shall be performed in accordance with the latest editions of the *National Electrical Code* (NEC), Intern *ational Fire Code* (IFC), *International Building Code* (IBC), *International Mechanical Code* (IMC), and the *International Plumbing Code* (IPC).

The information contained in these Maintenance sub-sections provides a basic outline of the general building systems, sub-systems, associated equipment, and their respective inspection, servicing and maintenance requirements. Preventative maintenance (PM) shall be performed per the applicable referenced PM procedures at the recommended intervals.

Referenced preventative maintenance frequencies are as follows:

Daily, Weekly, Monthly, Quarterly (every three months), Semi-Annual (every six months), Annual (every year), Bi-Annual (every two years), Tri-Annual (every three years).

SAFETY CONSIDERATIONS:

Before performing any maintenance procedures, personnel should review and adhere to all safety instructions taking the necessary steps to ensure personal injuries do not occur.

All personnel involved in handling, installing, testing, and performing maintenance on any of the systems or equipment covered by this section should be thoroughly familiar with the information in this section, and any reference material in the Appendices, before working on any system or equipment.

Personnel should be trained and qualified in the maintenance of the equipment being serviced, and have knowledge of the degree of severity of potential injury if the notes, cautions, warnings, and dangers are not followed.

Most accidents involving product operation, maintenance and are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Any system, equipment, components or parts not specifically covered by PMs, or manufacturer's inspections and maintenance steps, in this Section that require maintenance can be addressed during the daily rounds per PM3401FW.

3.1 ARCHITECTURAL / STRUCTURAL SYSTEMS

3.1.1 Building Systems

3.1.1.1 Foundation

The foundation should be inspected annually for damage, rust, obstructions, and structural integrity. Repair as necessary.

3.1.1.2 Stairs / Landings / Walkways / Grating

All exterior stairs, landings, walkways and grating assemblies are supported by a cold rolled "C" channel steel stringer with a galvanized finish. All steps, landings, and walkway surfaces are covered with galvanized grate tread.

Stairs, landings, and walkways are provided for entrance into the Buildings for both personnel and equipment. The galvanized steel stairs and railings are corrosion resistant, resilient, and maintenance free.

Annually inspect all stairs, landings, walkways, and grating for damage, obstructions, and structural integrity. Repair as necessary.

(For additional maintenance information regarding stairs, landings, walkways and grating, see Appendix Sections 4.2.1.1.2 and 4.2.1.1.3 of this manual.)

3.1.2 Windows and Doors

3.1.2.1 Windows

All windows should be inspected annually for damage and structural integrity and adequate perimeter seal. Repair as necessary.

(For additional maintenance information regarding windows, see Appendix Section 4.2.1.2.1 of this manual.)

3.1.2.2 Interior & Exterior Man Doors

Annually inspect all doors for structural integrity, damage and proper operation. Additional periodic inspections of doors in heavy traffic areas shall be performed, repair as necessary.

Exterior doors are critical for maintaining the envelope of the building and protecting its contents from the environmental elements.

Inspect each door to insure integrity of all hardware, lubrication and smooth operation of moving parts, sealant condition in seams and joints, and door-gasket sealing.

Lubrication:

In normal service it is recommended that a few drops of light oil be used on all moving parts. Specialized cold environment lubricants may be used as applicable.

Wax the inner edge of the door to allow for smooth contact between door and gasket.

Sealant:

During the life of the door it is possible for the factory sealant in the seams and joints to come loose, either from abuse and / or normal use. It is critical that all seams and joints are kept vapor tight at all times. Inspections of seams and joints for loose or missing sealant should be performed. Replace sealant in problem areas.

NOTE

Failure to maintain the sealant in problem areas will affect the vapor seal integrity and cause deterioration of the door.

All operators should be inspected for smooth operation. Latches and strikes should be adjusted as required to maintain the proper pressure on perimeter gaskets. All fasteners should be checked and re-tightened as required.

The exterior sliding / bi-parting cold storage doors are critical for maintaining the building envelope and protecting its contents from the environmental elements.

Inspect the door to insure integrity of all hardware, lubrication and smooth operation of moving parts, sealant condition in seams and joints, door-gasket sealing action, and proper operation of the heat trace, in accordance with semi-annual PM #0128FS.

Lubrication: In normal service it is recommended that a few drops of light oil be used on all moving parts. Specialized cold environment lubricants may be used as applicable. Wax the inner edge of the door to allow for smooth contact between door and gasket.

Sealant: During the life of the door it is possible for the factory sealant (silicone) in the seams and joints to come loose, either from abuse and / or normal use. It is critical that all seams and joints are kept vapor tight at all times. Inspections of seams and joints for loose or missing sealant should be performed regularly. Replace sealant in problem areas.

CAUTION:

Failure to maintain the sealant in problem areas will affect the vapor seal integrity and cause deterioration of the door.

All operators should be inspected for smooth operation. Latches and strikes should be adjusted as required to maintain the proper pressure on perimeter gaskets. All fasteners should be checked and re-tightened as required.

(For additional maintenance information regarding interior and exterior doors, see Appendix Section 4.2.1.2.2 of this manual.)

3.1.2.3 Sectional Overhead Doors and Chain Hoist

Overhead Doors

Annually inspect all door hardware for proper operation. This includes inspecting the torsion springs and the door counterbalance system (if so equipped) and door rollers for cracks, weaknesses, and loose parts. Repair or adjust as necessary.

CAUTION:

TORSION SPRINGS IN TENSION ARE DAMGEROUS

The spring assembly of this door is or will be in tension and should not be adjusted except by someone with a thorough understanding of the entire mechanism.

When winding or adjusting tension into the springs, BE SURE that the DOOR IS SECURED IN THE FULL DOWN POSITION and that the ADJUSTING RODS ARE CORRECT for use in the spring assembly's adjustable plug.

KEEP CLEAR OF line of ADJUSTING RODS while winding turns into a spring. MAKE SURE the SET SCREWS ARE TIGHTENED onto the shaft once the spring is wound.

Do not attempt to wind the springs until you have read the manufacturer's instruction sheet! The instruction sheet shows the direction for the spring assembly to be wound when it is time.

The overhead doors are critical for maintaining the building envelope and protecting its contents from the environmental elements. Inspect the door to insure integrity of the perimeter seal. Repair or replace as necessary.

Sealant: During the life of the door it is possible for the factory sealant (silicone) in the seams and joints to come loose, either from abuse and / or normal use. It is critical that all seams and joints are kept vapor tight at all times. Inspections of seams and joints for loose or missing sealant should be performed regularly. Replace sealant in problem areas.

Lubrication: In normal service it is recommended that a few drops of light oil be used on all moving parts. Specialized cold environment lubricants may be used as applicable. Wax the inner edge of the door to allow for smooth contact between door and gasket. For normal to heavy traffic areas, a good commercial grease is sufficient for proper operation. For devices exposed to adverse conditions and / or abnormally high exposure to dust and dirt, a graphite or silicone-based lubricant can be used at more frequent intervals.

Inspect all hardware for missing or loose fasteners and replace and / or re-tighten as necessary.

Powered Chain Hoists

The chain hoist electric door operator is designed to give dependable service with a minimum of maintenance. After proper installation and adjustment by a qualified installer, little is required in the way of maintenance except for periodic inspection and lubrication as follows:

The operator are supplied with continuous rated motors and under normal conditions require little to no oiling.

Inspection and Adjustments:

WARNING:

Door must be properly balanced and free working before installing operator. Improperly balanced door can be hazardous and cause severe injury. Repairs to cables, spring assemblies and other hardware must be made by qualified door installer or service man.

Operator damage may result if installed on an improperly working door. Safety features of operator will not function properly if door is out of balance.

Do not connect to electric power until installation is completed.

Remove or make inoperative any locking device unless operator is equipped with door lock interlock feature.

Remove all ropes, step plates and lift handles connected to the door before operating the garage door opener.

Installation and wiring must conform to local building and electrical codes.

Do not operate the transmitter or wall push-button unless the garage door is in sight.

Do not allow children to play with or in the area of the door and controls.

Do not place hands in area of pulleys, V-belt, sprockets, chain or rotating shafts.

Install warning placard on wall next to push-button.

Attach instruction booklet to wall near push-button.

Do not attempt to make electrical repairs without shutting off power to the unit.

Traffic patterns (vehicular and personnel) should be evaluated and proper safety equipment or push-button wiring installed to prevent damage or injuries.

If a momentary contact or an automatic closure device such as radio control, treadle switch, loop detector or timer is used, the door must be equipped with a reversing device such as photo eyes or a reversing edge.

The safety clutch should be adjusted and checked periodically according to manufacturer's procedures.

Garage doors should NEVER be used as pedestrian doors.

Failure to follow these warnings may result in severe personal injury.

1. Inspect and tighten (if necessary) all bolts and nuts.
2. Adjust safety clutch. If necessary, adjustment may be required after a short break-in period.
3. If necessary, adjust limit nuts.
4. Check V-belt for wear and replace if necessary. Also check V-belt tension (about 1/2 inch deflection when applying pressure with finger). Adjust tension by loosening motor mounting bolts and move the motor toward the rear of the operator.
5. Manual Reset Overload: The overload is properly sized, at the factory, for normal door operation. if overload trips, manually check mechanical operation of door and operator to be certain both work freely.

(For additional maintenance information regarding over head doors and the closing mechanisms, see Appendix Section 4.2.1.2.3 of this manual.)

3.1.2.4 Finish Hardware

Annually inspect all door hardware for proper operation. This includes all passageway doors within the facility.

Mechanical door closers should operate smoothly, keep the door under orderly control at all times, and provide sufficient leverage to close against the latch.

Knobs/levers and latch bolts should operate smoothly without undue force. Latch bolts on passage/non-keyed entry devices shall operate from either side of doors at all times. Latch bolts on keyed entry devices shall be retracted by key outside of door or by knob/lever inside door.

Pay special attention to emergency panic bar exit devices during periodic inspections. Check the devices for smoothness of operation. Any binding or dragging may indicate worn parts or the need for lubrication.

Check the devices for full extension of the latch bolt and full retraction during operation. Short extension may indicate binding, and insufficient retraction indicates worn parts or vertical rods out of adjustment.

The latch bolt should retract fully when dogged. Check the deadlocking function by depressing the latch bolt when engaged with the strike. If the latch bolt fully retracts, strike or vertical rod adjustment may be necessary.

Periodic lubrication is required to inhibit excessive wear of working parts. For normal to heavy traffic areas, good commercial grease is sufficient for proper operation.

For devices exposed to adverse conditions and/or abnormally high exposure to dust and dirt, a graphite or silicone-based lubricant can be used at more frequent intervals.

Inspect all hardware for missing or loose fasteners and replace and/or re-tighten as necessary.

(For additional information on finish hardware see Appendix Section 4.2.1.2.4.)

3.1.3 Interior Finishes

3.1.3.1 Flooring Materials

The majority of the flooring in the Water Plant is made of precast concrete slabs covered with a epoxy anti-slip coating. Certain areas, such as storage areas, are made of steel decking coated with the same epoxy anti-slip material.

The nature of the maintenance program will depend on the amount or type of traffic and the desired appearance. A typical maintenance schedule for a commercial building would be similar to the following:

Wet mop the entire floor weekly, or more often if needed. Wet or damp mop soiled areas with a neutral cleaner. Wet spots or spills should be cleaned up immediately to prevent a slip hazard.

(For additional information regarding flooring materials used in the LDB Buildings, see Appendix Section 4.2.1.3.1 of this manual.)

3.1.3.2 Ceilings and Walls

Textured Acoustical Panels

The textured acoustical panels require no more maintenance then painted drywall ceilings according to the manufacturer. However, when maintenance is necessary. certain procedures should be followed to ensure continued high performance and attractive appearance.

Dust and loose dirt may be easily removed by brushing or using a vacuum cleaner. Vacuum cleaner attachments such as a hose designed for cleaning upholstery or walls do the best job. Be certain to clean in one direction only. This will prevent rubbing dust into the surface of the ceiling.

Pencil marks, smudges, or clinging dirt may easily be erased with an ordinary art gum eraser. However, a good grade wall cleaner may be preferred. Be certain to use fresh cleaner.

The textured acoustical panels can also be cleaned with a moist cloth or a sponge dampened with water containing a mild soap solution. The sponge should contain as little water as possible. After washing, the soapy film should be wiped off with a sponge slightly dampened in clean water.

Painting the panels could alter the surface burning characteristics, fire resistance ratings, acoustical performance, dimensional stability (sag), or light reflectance will remain the same.

If painting is necessary, the painter should be very careful that he/she does not close up the perforations or fissures in the panel. It is through these openings in the surface that sound waves enter the body of the acoustical material and are absorbed. Care should be taken that these perforations are not clogged.

Painted Gypsum Panels

Areas that have a ceiling are made from painted gypsum drywall should be periodically inspected and cleaned using a mild soapy water solution containing no abrasive cleaners. Panels, and wall trim, that is stained should be inspected and cleaned using a good natural wood cleaning solution.

Any fiberglass reinforced plastic panels (FRP) should be cleaned to remove the accumulation of dust and dirt, which can combine with sunlight and wind to attach exposed surfaces, both chemically and abrasively.

Cleaning should be done periodically, especially when there is a reduction in light transmission caused by accumulation of dirt on the panels.

(For additional information regarding ceiling materials, see Appendix Section 4.2.1.3.2 of this manual.)

3.1.3.3 Wall Base Finishes

A 1/8" rubber base cove is installed in certain areas within the Water Plant. The nature of the maintenance program will depend on the amount or type of traffic and the desired appearance.

A typical maintenance schedule for a commercial building would be similar to the following: Many products are available that can do a good job of cleaning and polishing the rubber cove base.

CAUTION:

Oil, grease, sweeping compounds containing oil, or treated mops, should never be used. Do not use gasoline, kerosene, naphtha, or similar solvents to remove spots from the base cove. Paste wax, paint, varnish, lacquer, shellac, or other solvent containing coatings should not be used on the base cove.

The rubber base cove should be regularly swept, mopped with lukewarm water, and buffed to maintain appearance. Spills should be removed promptly to avoid staining. If the polish wears off in certain sections of the base cove, these areas should be cleaned and repolished.

Periodically, when heavy layers of polish build up, it may be necessary to strip the polish from the base cove using a stripping compound recommended for use on rubber products. The base cove should be kept wet during the stripping process. When finished stripping, rinse thoroughly, polish and buff.

(Additional maintenance recommendations are contained in the manufacturer's data sheets, in Appendix Section 4.2.1.3.1 of this manual.)

3.1.4 Interior Specialities / Fixtures

3.1.4.1 Fire Extinguishers and Cabinets

Maintenance is the work necessary to keep the extinguisher operable or make repairs. Repairs to the extinguisher must be made immediately or a replacement extinguisher provided.

Maintenance should include a thorough examination of the extinguisher's mechanical parts, the extinguishing agent, and the expelling means. The purpose of the maintenance program is to make sure that the extinguisher will operate properly and will not pose a potential hazard to the operator or people nearby.

Maintenance should be performed not more than one year apart or when specifically indicated by an inspection.

Annual maintenance of type A:B:C or multi-purpose extinguishers is performed by the Station Fire Department in accordance with *National Fire Protection Agency (NFPA) Publication 10*. The ADX-1 SPS Bottles should be inspected and maintained per PMs 5275M and 5275FA.

Inspections:

Fire extinguishers shall be inspected when initially placed in service.

An inspection is a visual examination (a quick check) to see that the fire extinguisher is in its proper location, that it is not blocked, is fully charged, and that it appears to be in good working order. Inspections are required at approximately 30-day intervals. Fire extinguishers may need inspections at more frequent intervals where conditions warrant, such as highly corrosive atmospheres or areas where vandalism may be a problem.

The inspection generally consists of walking to the extinguisher / cabinet and doing the following:

1. Confirm that the extinguisher is in its proper place. Whenever an extinguisher is used or removed from service, a replacement extinguisher should immediately be provided. Also, this check is to make sure that the appropriate extinguisher is provided for the hazard. For example, an extinguisher containing an electrically conductive agent, such as water, should not be located in a high-voltage switch-gear room.

2. Confirm that access to and visibility of the extinguisher are not obstructed. This requires constant vigilance to make sure that, as room arrangements change, the extinguisher is not blocked.
3. Confirm that the extinguisher operating instructions are legible and face outward.
4. Confirm that seals or tamper indicators are intact. This will often require a gentle tug on the wire or plastic tamper indicator to make sure it is not broken. If the indicator has been broken, a more thorough examination is required.
5. Confirm that the pressure gauge is in the normal range. The pressure gauge can have numbers indicating pounds per-square-inch (psi), or can just have a zone indicating "normal." If the indicator is not in the normal range, the extinguisher should be removed and recharged. Extinguishers without a pressure gauge are weighed, or fullness is determined by "hefting."
6. Record any obvious physical damage. This involves a quick scan of the extinguisher to observe obvious physical damage such as severe corrosion, broken hose, or badly dented shell. If an); physical damage is observed that could make the extinguisher inoperative or dangerous to operate, the device should be removed from service until repairs can be made. For wheeled units, the condition of the tires, wheels, carriage, hose, and nozzle should be checked. Storage cabinets should be inspected for damage, or a malfunction, that may prevent access to the extinguisher.
7. Confirm that HMIS (Hazardous Materials Identification System) label is in place.

NOTE:
Any time an extinguisher is removed for servicing, a replacement extinguisher should immediately be provided.

Periodic Testing:

All refillable fire extinguishers require hydrostatic testing at intervals varying according to the type of extinguisher. The frequency for hydrostatic testing is specified in NFFA 10, *Standard for Portable Fire Extinguishers*, and OSHA, *Part 1910-157*, NFPA, and OSHA requirements.

The preferred method of hydrostatic testing is the water-jacketed, volumetric-expansion method. (Air or other gases shall not be used as sole medium for pressure testing.) This method involves emptying the extinguisher and filling it with water. The extinguisher is then placed in a container of water and pressurized to 5/3 of its rated pressure.

This causes the extinguisher shell to expand slightly, which can be noted by a rise in the water level in the container in which the fire extinguisher has been placed. This increase in extinguisher shell volume is noted and, if it is below specified limits, the extinguisher passes the test. The extinguisher is then dried, the valve reattached, and the exchanger recharged.

Hydrostatic testing should only be performed by persons specifically trained in such testing, as the test pressures are high. Also, only equipment that is adequate to withstand such pressures should be used. Some states and localities require that companies and / or persons performing such tests be licensed.

If the extinguisher successfully passes the test, it is stamped with the date (month and year) and a symbol of the company doing the testing. This date and symbol are stamped directly into the heavy steel shell of carbon dioxide extinguishers. On lighter shell construction of pressurized water, dry chemical, and Halon extinguishers, the date and symbol are stamped on a durable metallic or plastic label that is glued to the extinguisher shell.

Fire extinguisher hose assemblies that are equipped with shutoff nozzles are also required to be hydrostatically tested at the same interval as the extinguisher on which the hose is installed.

Recording Keeping:

Records shall be kept of all fire extinguishers inspected, including those requiring corrective action. The date the inspection was performed and the initials of the person doing the inspection. Records shall be kept on a tag attached to the extinguisher on an inspection form maintained on file, or in an electric format that profiles a permanent record. Use the form 16-A found in Section 4.2.1.4.1 to record all maintenance and inspection.

(Additional maintenance recommendations are contained in the manufacturer's data sheets, in Appendix Section 4.2.1.4.1 of this manual.)

3.1.4.2 Collateral Equipment

Consult the vendor information contained in Appendix Section 4.2.1.4.2 of this manual for maintenance procedures.

3.2 CONVEYING SYSTEMS

3.2.1 Monorail Hoist

Regular inspection and maintenance is essential to the safe and efficient operation of the electric cargo hoist (Equip. HO00034). Proper operation, testing, and maintenance of the hoist shall be performed in accordance with PM3415FQ, *ASME/ANSI B30.16, B30.11, B30.17 and OSHA 1910.179*.

The periods between inspections will vary due t o the wide range o f duty cycles and operating conditions encountered with this type of equipment. The following inspection periods are based on average duty with single shift operation (40 hours per week) under normal environmental conditions. If the hoist is used in heavier applications or under adverse environmental conditions, it should be inspected more frequently.

The manufacturer recommends daily, monthly quarterly, and annual inspection criteria. The steps of the daily inspection should be performed before each use of the hoist.

CAUTION:

Follow all instructions and warnings for inspecting, maintaining and operating any hoist.

The use of any hoist presents some risk of personal injury or property damage. That risk is greatly increased if proper instructions and warnings are not followed. Before using any hoist, each operator should become thoroughly familiar with all warnings, instructions and recommendations in this manual, and any supplement.

Prior to testing, all supporting structures, anchorages, and/or suspensions must be approved by the appointed person for the test loads used.

Do not operate the hoist if it is functioning improperly or damage is noted.

Before Using the Hoist: Complete the manufacturer's daily inspection criteria listed below:

Controls:

Check all manual controls for proper operation.

Connections:

Check for worn or frayed wires, for loose connections and for damage to, or improper operation of, push button assembly.

Limit Switch:

Check the upper and lower limit switch by running the hook without load, and at the slowest speed obtainable, to the maximum up and maximum down positions. Then test with increasing speed up to maximum. The switch should shut the hoist off before the bottom block contacts the rod or weight type limit switch at the upper extreme. Wrap of rope should remain on the drum at the shut-off point at the lowest extreme. If adjustment is necessary, refer to geared limit switch section.

Hook:

Check for cracks or deformation. Check for a damaged or missing latch. A bent or twisted hook indicates overloading or abuse of unit. Other load bearing components of the hoist or trolley should be inspected if overloading is apparent or suspected. The bottom hook must swivel freely.

Wire Rope:

Check for proper seating in drum grooves. Check for wear, separated strands, fraying, kinks, or broken wires in the wire rope, and condition of end connections.

WARNING:

NEVER Allow Wire Rope To Operate Dry.

Failure to follow this warning can cause serious personal injury, death or major property damage.

Load Chain

Check for nicks, gouges, corrosion, twist, and distorted links. Verify the load chain does not bind, jumps, or is noisy. Check for cleanliness and proper lubrication. Inspect chain for wear and stretch. Replace if necessary. Pay particular attention to the portion of chain that most often passes over the pocket wheel.

CAUTION:

The chain must be replaced if wear has increased the specified gage length beyond the maximum. The gage length should be checked on portion of chain that normally passes over the pocket wheel, and with a load on the hook.

When replacing load chain, use only chain stamped y*-1k or y1-1k. Install per manufacturer's instructions. Always replace end pins when replacing the chain. See following part numbers for pins:

1/2 ton - 6428951-00, 1 ton - 6428961-00,

2 ton - 6429353-00 and 3 ton - 6401549-07

Also check pin support holes in bottom block castings and replace castings if holes are worn.

Hook Drift:

With a load, the hook should stop promptly when the push button is released. Hook drift of more than 2 inches indicates the motor brake is malfunctioning.

Unusual Conditions:

Excessive noise, oil leaks, etc. should be investigated.

CAUTION:

Do not operate the hoist if above inspection indicates that maintenance is needed.

Failure to follow this caution can cause personal injury or major property damage.

Monthly - All Items Under Daily Inspection Plus:

Lubrication:

Check the level and condition of the gearcase lubricant. The level must be maintained at the gearcase level plug. If the level is low, check for leaks. Replace gaskets and shaft seals if necessary. An excessively black color lubricant indicates a chemical change in the lubricant caused by excessive heat from the load brake, which in turn is caused by heavy duty cycles.

Lubricant that is very black in color must be replaced to prevent shortened life of drive components. Lubricate wire rope and other points as required.

CAUTION:

For optimum lubrication and load brake cooling, oil level must be maintained at the level plug.

Failure to follow this caution can cause personal injury or major property damage.

Load Brake:

Check the function of the load brake by lifting a light load (approximately 25% of rated load) 6 to 12 inches above the floor. Disconnect electrical power and manually open the motor brake. The load may "creep" slowly while the motor brake is held open. This is normal. However, if the load falls to the floor the instant the motor brake is released, the load brake is not functioning properly and should be replaced.

Hook:

Replace the hook if the throat opening is in excess of maximum spread allowed by the manufacturer, or if there is 10 degree or more twist from normal plane of the hook. Check hook retaining nuts or collars and means used to secure them.

Contactors:

Check for burned or badly pitted contacts.

Push Button:

Check the ground connections to be sure that the wire cores from the push button cable and the power cord are secured. Tighten the grounding screw and replace the lock washer if it is missing.

Bearings:

Check all bearings for noisy operation, which is an indication of wear.

Hardware:

Check for loose bolts, nuts and rivets.

Warning Labels:

Check for absence or illegibility of warning decals and tags. Replace if necessary.

Supporting Structure or Trolley:

If used, should be checked for continued ability to support the imposed loads. Check for loose suspension or support bolts, axle nuts, etc.

Idler Pocket Wheels and Sprockets:

Replace worn pocket wheels, sprockets, load chain guide, and stripper. This is especially true if the load chain is worn and needs replacing.

Inspection Checklist:

Fill out inspection checklist at the back of the manufacturer's manual, sign, date and file for future reference.

Quarterly - All Items Under Daily And Monthly Inspections:

Motor Brake:

Check for excessive or uneven disc wear. On direct acting, check for excessive magnet gap. On solenoid actuated, clean solenoid plunger seat and check for uneven seating between the plunger and coil. Lubricate brake cams, pivot studs, and linkage as required.

Annual - All Items Under Daily, Monthly And Quarterly Inspections:

Equalize sheave, idler sheave and pins. Check for cracked or worn sheaves, pins and bearings.

Hooks:

Magnetic particle or other suitable crack detecting inspection should be performed if needed as indicated by external appearance. Check for loose retaining nuts and collars.

Load Bearing Parts:

Check for worn, cracked or distorted parts, such as suspension housings, outriggers, clevises, yokes, hook blocks, suspension bolts, shafts, locking devices and bearings on hoist (also on trolley, if equipped).

Load Brake (for all chassis and duty services except EEWX and FEW):

Check load brake for worn discs, check operation of one way holding pawl. If either brake disc is worn 1/32 inches or more, replace ratchet and disc assembly. New discs measure 3/16 inches thick.

Motor Brake:

Check for excessive or uneven disc wear. On direct acting, check for excessive magnet gap. For solenoid actuated, clean solenoid plunger seat and check for uneven seating between plunger and coil. Lubricate brake cams, studs and linkage as required.

Load Limiting Device:

If a load limiting device is used, check device with 150% of rated load. Attempt to raise the load. If the load limiting device is working properly the load should not move, or move only slightly. If the unit raises the load immediately, lower the load, then repair or replace the load limiting device.

CAUTION:

Prior to testing, all supporting structures, anchorages, and/or suspensions must be approved by the appointed person for the test loads used.

Failure to follow this caution can cause personal injury or major property damage.

Wiring and Terminals:

Observe that all connects are tight. Terminals are to be securely crimped to wires and the insulation sound. Bent terminals can usually be straightened to provide a tight fit. Replace terminals or wire if necessary.

Sheaves and Drums:

Inspect rope sheaves and drums for excessive wear. When the groove of a sheave or rope drum becomes worn excessively it should be replaced. Worn grooves on the drum or sheave can greatly reduce the useful life of the hoisting rope.

Bearing Lubrication:

The motor, sheave and outer drum bearings are packed with grease at the factory and normally will not need to be lubricated. If conditions require, repack with grease as needed.

WARNING:

When taking equipment out of service to perform maintenance or repair work, always follow the lockout/tagout procedures as required by OSHA 29 CFR Part 1910.147 and outlined in ANSI Z244.1.

Prior to testing, all supporting structures, anchorages, and/or suspensions must be approved by the appointed person for the test loads used.

Failure to follow this warning can cause serious personal injury, death or major property damage.

NOTE:

Any hook that is twisted or has throat opening in excess of normal, indicates abuse or overloading of the hoist. When a hook is found to be in this condition, other load bearing components of the hoist should be inspected for damage.

A hoist which has been idle for a period of one month or more, but less than six months, should be given inspections that cover those listed under daily and quarterly inspections. A hoist which has been idle for a period of six months or more, should be given a complete inspection.

Reference the warnings and operating practices established by the American National (Safety) Standard ASME/ANSI B30.16 dated 1989. These are intended to avoid unsafe hoisting practices which might lead to personal injury or property damage.

(For additional information regarding the hoist, see Appendix Section 4.2.2.1 of this manual.)

3.3 MECHANICAL SYSTEMS

The purpose of the mechanical system is to provide comfort and safety for individuals using the Water Plant.

There are several different systems which make up the mechanical system. These include:

The Heating Generation and Recovery Distribution Systems - where boilers, waste heat recovery components, heat transfer units, heating coils, heat exchangers, distribution pumps, water heaters, and furnaces are used to heat interior spaces.

The Ventilation System - which uses air handling units, fans, air hoods, outlets & inlets, and dampers to distribute outside air to the individual spaces, and an exhaust duct system that removes stale air from interior spaces and routes it to the outdoors.

Plumbing System - which provides plumbing fixtures and equipment.

Water Treatment & Storage System - which provides drinkable water for the entire Station.

Fire Protection System - provides both CO_2 and water deluge protection for the Water Plant.

Compressed Air System - used for general shop air blowdown of the generator's exhaust gas waste heat exchangers.

Fuel oil System - consists of monitoring meters, tanks filters, strainers, and all the fittings and valves necessary to supply fuel to all systems requiring fuel, such as the boiler and the engine generators.

Engine & Generator Systems - two diesel engines and high output generators used to provide back-up power to the Station.

The Control and Monitoring System - which consist of direct digital control of thermostats and associated devices interconnected to operate the mechanical systems.

This section describes the maintenance of the above systems required for their successful operation.

3.3.1 Heating Generation and Recovery Distribution Systems

All mechanical systems deteriorate with normal use. No system is maintenance-free. If these systems are not maintained at peak efficiency then premature failure will occur.

Preventive maintenance (PM), when performed regularly, will contribute directly to increased equipment life and consistent equipment efficiency/operation.

One important aspect of hot water heating systems that is often neglected is cleaning the system. It is sometimes drained for changes and adjustments but never actually cleaned.

How To Tell If A System Needs Cleaning

There are definite indications of an unclean system. Here is a check list. If any of these test positive, the system needs cleaning.

1. Obviously discolored, musky, dirty water.
2. Vented gases at high points in the radiation that will ignite and burn with an almost invisible bluish flame.
3. A pH or alkalinity test that gives a pH test reading below 7.

No matter how carefully a system is installed certain extraneous materials do find their way inadvertently into the system during construction. Pipe dope, thread cutting oils, soldering flux, rust preventatives or slushing compounds, core sand, welding slag, and dirt, sand, or clays from the job site are usually found. Fortunately the proportions of these are usually small and do not cause trouble. In some cases there are sufficient quantities to break down chemically during the operation of the system causing gas formation and acid system water.

Hot water systems, in most cases, naturally operate with a pH of 7 or better. The condition of the water can be quickly tested with Hydrion paper which is used in the same manner as Litmus paper except it gives specific readings. A color chart on the side of the small Hydrion dispenser gives the readings in pH. Hydrion paper is inexpensive and obtainable from any chemical supply house.

A system that tests acid (below 7 on the scale, sometimes as low as 4) will usually have the following symptoms:

- Gas formation (air troubles),
- Pump seal and gland problems,
- Air vent sticking and leaking,
- Frequent relief valve operating, or
- Piping leaks at joints.

Once in this condition the symptoms continue for years until corrected by cleaning. Many times, because of the gas formation, automatic air vents are added throughout the system to attempt a cure.

The promiscuous use of automatic air vents can defeat the function of the system because in a normal system the small quantities of air finding their way to the system and piping must be returned to the expansion tank to maintain the balance between the air cushion and the water volume.

If system deterioration i s permitted and leaks develop and water losses increase, it is possible to cause serious damage to the boiler. Therefore, our main aim is to have a closed system that is clean, neutral, and water tight.

Snow melting and radiant panels, because of the large quantities of pipe used, should be cleaned. Convertors and systems using anti-freeze solutions must be cleaned. If not, the anti-freeze solutions bring back the debris from the piping and deposit it on the convertor tubes. This destroys heat transfer ability shortly after placed in operation, cutting its capacity as much a s 50% in a few weeks time.

All hot water systems be cleaned on completion, making even the finest job better and helping to eliminate the few bothersome jobs that sometimes occur.

How To Clean A Hot Water Heating System

Cleaning a hot water system (either steel or copper piping) is neither difficult nor expensive. The materials for cleaning are readily available. Trisodium phosphate, sodium carbonate, and sodium hydroxide (lye) are the most common materials for cleaning. Their preference is in the order named and should be used in the following proportions using a solution of only one (1) type in the system:

- Trisodium phosphate, one pound for each fifty gallons in the system;
- Sodium carbonate, one pound for each thirty gallons in the system; Sodium hydroxide (lye), one pound for each fifty gallons in the system.

Fill, vent, and circulate the system with this solution, allowing it to reach design or operating temperatures if possible. After circulating a few hours, the system should be drained completely and refilled with fresh water. Usually enough of the cleaner will adhere to the piping to give an alkaline solution satisfactory for operation. A pH reading between 7 and 8 is preferred, and a small amount of cleaner can be added if necessary.

A clean, neutral hot water system should never be drained except for an emergency or necessary servicing of equipment which may be after years of operation. Anti-freeze solutions in systems should be tested from year to year as recommended by the manufacturers of the anti-freeze used. It is our contention that a clean system is a better system. Once cleaned, it will never need cleaning again.

3.3.1.1 Auxiliary Fuel-Fired Boiler

The fuel-fired boiler (Equip # BH00031) per PMs 3902FQ, 3901FA, and 0112FA requires quarterly and annual inspections to maintain proper operation and fuel economy. Besides these maintenance steps, the manufacturer recommends the following inspections and maintenance:

Weekly

1. Ensure the cleanliness of the equipment and the surrounding area. Check and record in the logs the glycol and stack temperatures, pressures, and glycol levels (check historical trends on logs to ensure there are no significant changes in the operating temperatures or pressures).

2. Inspect for leaks or problems with the burner linkages, pumps (seals, couplings, etc.) entire glycol and supply fuel piping from the tank to the equipment and report any immediately to the appropriate person. Inspect the burner flame.

Quarterly

1. Check, clean, and adjust the ignition assemblies, electrodes, air intake elements, and fuel filtering. Also, clean the flame detector lens. Check all indicator lamps and verify alarm indicators.

Annually

1. A complete and thorough inspection of the boiler (boiler tear down) is recommended in conjunction with inspection by a "Boiler Inspector." Hydrostatic tests should be performed. Fire-side and water-side sections should be torn-down and cleaned.
2. Proper lubrication of the motor will prolong its service life, Oil sleeve bearing motors with 6 drops of SAE 20 oil once a year. DO NOT OVER OIL. Ball-bearing motors do not require oiling under normal service conditions. The bearing type is printed on the motor nameplate.
3. The oil filter cartridge should be replaced once a year so the fuel oil will not become contaminated and plug up the fuel unit and nozzle of oil burner.
4. The nozzle should be changed at least once a year before the start-up of the heating season. Replace with proper nozzle.
5. If for any reason the burner parts have to be replaced, always use parts recommended by the manufacturer. Specify part numbers and description when ordering.
6. The condition and settings of the electrodes is very important for reliable ignition of the oil. Check these once a year in accordance with the instructions provided in the manufacturer's manual, Replace electrodes if worn excessively or if porcelain insulator is oil soaked or cracked.
7. The fan and blower housing must be kept clean, free of dirt and lint. Open the transformer and off cycle the damper to check fan blades from above.

CAUTION:

Be sure the electric power is off to the burner when the transformer is opened up for this inspection.

8. All boiler operational parameters should be inspected and verified to be in good working order.

9. The boiler stack system should be inspected for leaks, damage, over-heating, structural supports, etc., during the annual building inspection. Any discrepancies should be noted and corrected immediately.

WARNING:

Do not operate this equipment unless guides, shields, or covers are in place for moving components, rotating equipment, mechanically automate devices, and electrically and pneumatically operated control components.

Do not enter a furnace or fired vessel until an adequate cool-off period has been observed and your company's vessel entry procedures have been completed. Enter heater or furnace only in the presence of someone who is capable of rendering aid.

This burner uses fuel which is flammable and potentially explosive. Familiarize yourself with the specific welding, hot work guidelines, torquing, draining, venting, purging, bleed-down procedures, leak checks, and line-entry instructions for the component worked on before starting work on the fuel system.

Dust generated from castable refractory may contain crystalline silica, which is carcinogenic. The ceramic fiber refractory contains fibers, which may be carcinogenic, and after firing ceramic fiber material cristabolite could be present, which is carcinogenic. use proper and approved respiratory protective equipment to avoid exposure.

Do not bypass flame management sequencing and safety interlocks!

If information in these instructions is not followed exactly, a fire or explosion may result causing property damage, personal injury or death.

Vibration in any high RPM rotating mechanism can be a safety hazard. Failure to follow this warning can result in serious personal injury and / or property damage.

During startup, the operator must be ever mindful of possible dangerous conditions such as fuel leaks, electrical or mechanical malfunctions, overheating of the boiler or heater being fired, etc., and the location of all manual fuel shut-off valves.

WARNING

Always keep the main fuel valve shut "OFF" if the burner is shut down for an extended period of time.

When starting the burner, take special note of the requirement to make certain the combustion chamber and flues are clear of fuel and fuel vapor. The burner shall not be manipulated to by-pass "pre" and "post" purge requirements. Do not attempt to restart the burner when the combustion chamber is very hot.

Failure to follow this warning can cause serious personal injury, death or major property damage.

(For additional information regarding the boiler and its components, see Appendix Section 4.2.3.1.1 of this manual.)

3.3.1.2 Terminal Heat Transfer Units

3.3.1.2.1 Unit Heaters

The hydronic unit heaters (Equip. # HT00864, HT00881, HT00913, HT00920, HT00921, HT00922, HT00923, HT00924, and HT00931) in the Water Plant and the Pump House require yearly inspection and cleaning per PMs #3218FA and 3427FA.

Because of the simple design of the unit heaters, they are nearly maintenance free. However, depending on the environment, simple maintenance practices should be adopted.

The manufacturer also recommends the following yearly cleaning regimen:

WARNING:

Improper installation, adjustment, alteration, service or maintenance can cause property damage, injury or death. Read the installation, operating and maintenance instructions thoroughly before installing or servicing this equipment.

Open all disconnect switches and secure in that position before servicing unit. Failure to do so may result in personal injury or death from electrical shock.

Failure to comply with the general safety information may result in extensive property damage, severe personal injury or death.

Do not alter the unit heater in any way or damage to the unit and/or severe personal injury or death may occur!

Disconnect all power supplies before installing or servicing the heater. If the power disconnect is out of sight, lock it in the open position and tag it to prevent unexpected application of power. Failure to do so could result in fatal electric shock, or severe personal injury.

Insure that all power sources conform to the requirements of the unit heater or damage to the unit will result!

Do not depend upon a thermostat or other switch as sole means of disconnecting power when installing or servicing heater. Always disconnect power at main circuit breaker as described above. Failure to do so could result in fatal electric shock.

Select appropriate AMP, MCA, and MAX FUSE for the multiple voltage motors. For example, the AMP, MCA, and MAX FUSE for Models 360 with a 460 volt totally enclosed motor is 1.3, 1.6 and 2.9 respectively.

HAZARDOUS VOLTAGE! DISCONNECT ALL ELECTRIC POWER INCLUDING REMOTE DISCONNECTS BEFORE SERVICING. Failure to disconnect power before servicing can cause severe personal injury or death.

Do not use any tools (i.e. screwdriver, pliers, etc.) across the terminals to check for power. Use a voltmeter.

Allow all rotating fans to stop before servicing to avoid serious injury to fingers and hands.

1. Wipe all excess lubricant from the motor, fan and casing. Clean the motor thoroughly. (A dirty motor may run hot and eventually cause internal damage.)
2. Clean the coil.
3. Loosen the dirt with a brush on the fan side of the coil. Operate the motor allowing the fan to blow the loosened dirt through the unit.

4. Use high pressure air, or steam, on the side of the coil away from the fan.

NOTE:

A piece of cheesecloth or burlap bag may be used to collect the large particles during the cleaning process.

5. Clean the casing, fan blades, fan guard and diffuser using a damp cloth.
6. Any rust spots on the casing should be cleaned and repainted.
7. Tighten the fan guard, motor frame and fan bolts. Check the fan for clearance in the panel orifice and free rotation.

For cleaning and maintenance purposes, the fan and motor assembly may be removed easily from the unit heater.

NOTE:

Consult motor manufacturer's service facility for information on type of grease and oil to be used for lubrication purposes.

Motor Lubrication - Sleeve Bearings

Motors with oilers or oil holes are lubricated before shipment with a good grade of electric motor oil. Refill when necessary, with the motor at a standstill, until oil reaches the proper level.

For fans equipped with sleeve bearing motors, the manufacturer recommends periodic lubrication with SAE 200W oil in ambient temperatures of 32º F to 100º F, SAE 30W to SAE 50W above 100º F, and SAE 10W in lower ambient temperatures (below 32º F).

The frequency of oiling will depend upon operating conditions and length of running time. Inspect the oilers or oil holes when cleaning the unit. If the unit has a fractional horse-power motor, lubricate at least once a year. Under high ambient conditions or constant fan operation, fractional horse-power motors should be lubricate every 90 days. On those motors without oilers or oil holes, follow the instructions given on the motor nameplate.

Lubrication - Ball Bearings

Bail bearings motors are ore-lubricated and normally not equipped with grease fittings. However, motors are equipped with removable grease plugs to allow installation of grease fittings if desired.

Motor manufacturers do not recommend, or require, on the job lubrication of ball bearing motors. If on the job lubrications is required, use the following procedure:

When the motor is at a stand-still, remove the vent and grease plugs. Install grease fitting and add grease sparingly. Remove the old grease from the vent relief chamber, Operate the motor a few minutes before reinstalling the vent plug to allow excess grease to escape. If there is evidence of grease working out around the motor shaft, less grease should be added and the greasing periods lengthened. If grease continues to appear, take the motor to the motor manufacturer's authorized service station for repair.

NOTE:

Consult local motor manufacturer's service facility for information on the type of grease and oil to use.

(Additional information regarding unit heaters is contained in Appendix Section 4.2.3.1.2.1 of this manual.)

3.3.1.2.2 Cabinet Unit Heaters

The following table identifies electric cabinet heaters in the facility by designation / equipment number, heater type, and location.

DESIGNATION / EQUIP. NO.	TYPE	LOCATION
CUH-5 / HT30558	Vertical	Switchgear Room

WARNING:

Improper installation, adjustment, alteration, service or maintenance can cause property damage, injury or death. Read the installation, operating and maintenance instructions thoroughly before installing or servicing this equipment.

Always disconnect unit heater from power supply before attempting to service, clean, or disassemble any component from the unit. Failure to do so may result in injury or death due to electrical shock.

All unit panels and filters must be in place prior to unit star-up. Failure to have panels and filters in place may cause motor overload.

Allow rotating fans to stop before servicing to avoid serious injury to fingers and hands.

Perform annual inspection and cleaning of the cabinet heater in accordance with PM #3218FA or 3427FA.

Besides the annual maintenance steps mentioned above, the manufacturer also recommends the following inspections and maintenance be performed every three (3) months or sooner depending on operating conditions, unless otherwise noted.

Inspections

General:

1. Inspect the unit air filters. Clean or replace dirty filters.

NOTE:
Building conditions may require filter change more or less frequently.

2. Inspect the unit cabinetry for chips or corrosion. Clean or repair to provide unit protection.
3. Inspect the fan wheel and housing for damage. Rotate the fan wheel manually to be sure movement is not blocked by obstructions.
4. Clean and tighten all electrical connections.

Coils:

1. Inspect the coil fins for excessive dirt or damage. Remove dirt and straighten fins.
2. Check coil periodically for external cleanliness. If necessary, clean externally with a soft brush. Do not use any commercial solvent that could deteriorate coil. Good filter maintenance will minimize frequency of coil cleaning.
3. Periodic internal flushing of the coils is recommended in areas where water supply is suspected of causing scale. Use an alkaline cleaning solution and introduce it at the main pump of the hydronic system. Flush thoroughly.
4. Clean coils by brushing. blowing, vacuuming or pressure washing.
5. Use an industry name brand NON-ACID coil cleaner as necessary
6. Check fins for damage, use a fin comb to straighten and smooth damaged or bent fins.

Drain Pans:

1. Clean the unit's main drain panS to ensure the unit drains condensate properly and the condensate drain pan and drain line to assure the condensate drains properly. If evidence of standing water or condensate overflow exists, immediately identify and remedy the cause. If the drain pan contains microbial growth, clean and remove it immediately.

NOTE:

Standing water in drain pans can promote microbial growth (mold) which may cause unpleasant odors and health-related indoor air quality problems. If microbial growth (mold) is found, remove it immediately by cleaning and sanitizing the unit properly.

Motor / Blower / Fans:

1. Lubricate the motor annually with a few drops of SAE No.10 or SAE No.20 **non-detergent** oil, unless otherwise advised on motor dataplate. Motors permanent split capacitor (PSC) type and are fitted with permanently lubricated sleeve bearings. Longer life may be gained through yearly lubrication. Oiling holes can be accessed by removing the front panel.
2. Check motor shaft for excessive end play.
3. Inspect the motor mount for damage, cracks or corrosion.
4. Ensure all mounting bolts are in place and tightened.
5. Check running amps against nameplate information.
6. Check capacitors for proper sizing relative to motor name plate.
7. Check for noise and worn bearings. Repair or replace as required.
8. Check hub set screw for tightness.
9. Spin fans to making sure that there is no binding or interference.
10. Clean fans to ensure balanced operation.
11. Check blades or any moving part for cracks or excessive wear.
12. Check blades for dust or any foreign material build up and clean if needed.

Wiring Compartment:

1. Check electrical connections for tightness.
2. Check all components for evidence of arcing, overheating or deterioration. Replace if necessary.
3. Check components for proper mounting and tightness.
4. Check all relays for proper operation. Replace as needed.
5. Check the cabinet ground connection for tightness and presence of corrosion. Clean if necessary.

Resistance Heating Coil (If Equipped):

1. Check resistance heating coils for open circuits by isolating one of the wire feeds attached to the ceramic terminals. Replace if necessary.
2. Check the thermal cutout switches and fuses for open circuits. Replace if necessary.
3. Check the lay of the heating elements to avoid grounding or row to row shoe circuits.

Hot Water Coils (If Equipped):

1. Check for presence and proper operation of freeze starts on water coils.

WARNING

Lack of safety protection can result in frozen coils and severe water damage.

2. Check fittings, valves and stems for leakage and corrosion. Reset seats and seals by rotating all valves through their entire range of movement and then back to their original setting.
3. Check all piping connections and fittings for general condition or excessive corrosion.

(Additional information regarding cabinet unit heaters is contained in Appendix Section 4.2.3.1.2.2 of this manual.)

3.3.1.3 Heating Coils

Heating coils (HC-1 and HC-2) mounted in air handlers AHU-1 and AHU-2 are used to heat incoming outside air. The heating coils are controlled by the DDC System.

Heating coils (HC-1 and HC-2) are used to temper (raise the temperature of) outside air passing through the Air Handling Units AHU-1 and AHU-2.

WATER PLANT GLYCOL HEATING COILS		
COIL DESIGNATION	**FUNCTION**	**LOCATION**
HC-1	Heating Coil	AHU-1
HC-2	Heating Coil	AHU-2

WARNING

Follow directions provided with cleaners to avoid personal injury and/or coil damage.

Failure to follow this warning can cause serious personal injury, death or major property damage.

1. Clean the coil fins with steam and detergent, hot water spray and detergent, or one of the commercially available chemical coil cleaners, then rinsing the coils thoroughly after cleaning.
2. Check coil periodically for external cleanliness. If necessary, clean externally with a soft brush. Do not use any commercial solvent that could deteriorate the coil. Good filter maintenance will minimize frequency of coil cleaning.
3. Clean coils using brushing, blowing, vacuuming, pressure washing or steam. Use an industry name brand NON-ACID detergent coil cleaner as necessary. Rinse coils thoroughly after cleaning.
4. Periodic internal flushing of the coils is recommended in areas where water supply is suspected of causing scale. Use an alkaline cleaning solution and introduce it at the main pump of the hydronic system. Flush thoroughly.
5. Check fins for damage, use fin comb to straighten and smooth damaged or bent fins.
6. Check fittings, valves and stems for leakage and corrosion. Reset seats and seals by rotating all valves through their entire range of movement and then back to their original setting.

7. Check all piping connections and fittings for general condition or excessive corrosion.

(Additional information regarding heating coils is contained in Appendix Section 4.2.3.1.3 of this manual.)

3.3.1.4 Heat Exchangers

Two (jacket water waste heat recovery and exhaust gas heat recovery) waste heat systems each contain their own heat exchanger and control valves. Heat exchangers HX-1 and HX-2 are part of the water jacket waste hear recovery system. Heat exchangers EHX-1 and EHX-2 are part of the exhaust gas heat recovery system. These two waste heat recovery systems are then tied together by heat exchanger HX-12. The in-house heating loop is tied into the Station's main waste heating loop through heat exchanger (HX-7). The heat exchanges (HX-8 and HX-9) in the sea water system are of the shell & tube design, and the other exchangers mentioned are of the plate and frame design.

Heat exchangers subject to fouling or scaling (particularly the exchangers in the sea water system and the exchangers on the exhaust gas heat recovery system) should be cleaned periodically. A light sludge or scale coating on the tube greatly reduces its effectiveness. A marked increase in pressure drop and/or reduction in performance usually indicates cleaning is necessary, if the unit has been checked for air or vapor binding and this has been found not to be the cause. Since the difficulty of cleaning increases rapidly as the scale thickens or deposits increase. The interval between cleanings should not be excessive.

The manufacturer of the shell & tube designed heat exchangers used in the sea water piping recommends the following maintenance steps be performed:

WARNING

Proper precautions must be taken (special clothing. equipment. etc.) to protect personnel from injury due to escaping fluids or not heat I exchanger surfaces.

Care must be exercised when handling certain fluids. Follow manufacturers instructions. Use eye and skin protection. Wear a respirator when required

It is extremely important to follow a proper tightening sequence, If it is not followed, the flanges can become cocked and a leak will result. When tightening flanges with spiral wound gaskets, if cocking occurs, the result can be deformation and non-repairable damage to the gaskets in addition to a resultant leak. Any gasket leak can result in potential injury to adjacent personnel.

CAUTION:

Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes with consequent overheating of these tubes. resulting in severe expansion strains, leaking tube joints, and damage to the heat exchanger.

When tightening leaking tube joints:

1. **Do not roll tubes beyond the back face of the tube sheet. Maximum rolling depth should be the tube sheet thickness minus 1/8".**
2. **Do not re-roll tubes that are not leaking since this will thin the tube wall.**

The result of either of the above conditions can lead to failure of the tube and a leaking bundle.

Field repair of Diamondback™ double wall heat exchangers is not recommended. Re-rolling of the tube joints may result in the closing of the leak detector flow paths between the two tube walls preventing the heat exchanger from providing a positive indication of potential cross contamination.

When cleaning a tube bundle, tubes should not be hammered on with any metallic tool and, in case it is necessary to use scrapers, care should be exercised that the scraper is not sharp enough to cut the metal of the tubes.

1. Do not open heads until ail pressure is off equipment. the unit drained of all fluids, and the equipment surfaces cooled to ambient temperature.

2. Do not blow out heat exchangers with air when operating fluids are of a flammable or otherwise hazardous nature.
3. Do not attempt to clean tubes by blowing steam through individual tubes.
4. Observe the interior and exterior conditions of all tubes on a frequent and regular interval.
5. Use the following steps to clean the tubes:
    A. Circulating hot wash oil or light distillate through tubes or shell at good velocity will effectually remove sludge or other similar soft deposits.
    B. Soft salt deposits may be washed out by circulating hot fresh water.
    C. Some cleaning compounds on the market, such as “Oakite” may be used for removing sludge or coke, provided hot wash oil or water, as described above, does not give satisfactory results.
    D. If the above methods are ineffective for removal of hard scale, a mechanical means may be used.
6. It is essential that the installer follows the gasket manufacturer's installation guide lines when installing gaskets. Metallic gaskets, such as the spiral wound gaskets, usually have special installation instructions. One of these instructions includes a special procedure for tightening bolts/studs when installing new gaskets. The procedure recommends that the bolts/studs be torqued in four stages.When replacing the heads, use a torque wrench to tighten the bolts/studs and nuts. All torque values apply to well lubricated nut bearing surfaces. All bolted joints should be tightened uniformly and in a diametrically staggered pattern.
7. If after following the gasket manufacturer's recommended tightening procedure a leak still occurs, the bolts/studs should be tightened in the same torque increments used in the previous step until the leak stops.

NOTE:

When using spiral wound gaskets, both the head and the shell/tank gaskets must be spiral wound. You cannot mix one spiral wound and one compressed fiber gasket on a heat exchanger.

(Additional information regarding the shell & tube heat exchangers can be found on drawing sheet M5.6 in Appendix Section 4.1.2 and in Appendix Section 4.2.3.1.4 of this manual.)

The manufacturer of the plate-and-frame designed heat exchangers recommends the following maintenance steps be performed:

The heat exchangers (HX-1, HX-2, HX-7, and HX-12) used in the waste heat recovery and distribution system is of a water-to-water, plate-and-frame construction. The manufacturer recommends the following preventive maintenance procedure:

The heat exchangers should be inspected periodically for internal build-up of scale or sediment. If found, scale or sediment should be removed either chemically or mechanically. Cleaning the unit may be accomplished by either back flushing, circulating cleaning agents in unit (cleaning-in-place) or, by disassembling the unit and performing a manual cleaning. If the water contains suspended foreign material, deposits can accumulate in the flow passages. Under these circumstances, back flushing may be adequate to clean unit. If this method is ineffective for the removal of hard scale, you may want to circulate buffered cleaning agents as recommended by the manufacturer of the agents in unit to remove scale or disassemble unit for manual cleaning. Plates can be cleaned while hanging on frame or removed depending on how much work is required. Since the cleaning-in-place is the preferred cleaning method, the manual method is not discussed in this manual.

TYPE OF FOULING	SUGGESTED CLEANERS
Calcium Sulphate, Silicates	Citric, Nitric, Phosphoric or Sulfamic Acid
Calcium Carbonate	10% Nitric Acid (1 volume concentrated Nitric Acid with specific gravity 1.41 to 9 volumes of water), Oakite 131
Alumina, Metal Oxides, Silt	Citric, Nitric, Phosphoric or Sulfamic Acid
Barnacles, Mussels, Seaweed, Wood Chips	Back flush per cleaning-in-place procedure
Bilogical Growth	Sodium carbonate or sodium hydroxide

CAUTION:

Do not use chlorine or chlorinated water to clean stainless steel. Chlorine is commonly used to inhibit bacteria growth in cooling water systems. It reduces the corrosion resistance of stainless steel, HasteNoy, lncolloy, lnconel and 254SMO. The "protection layer" of these steels is weakened by chlorine and makes them more susceptible to corrosion. This increase in susceptibility to corrosion is a function of time and the chlorine concentration. For any applications where chlorination must be used with non-titanium equipment, please contact the factory.

Because of their importance, general guidelines for cleaning listed in the manufacturer's manual are repeated below:

NOTE:

Always add concentrated cleaning solutions to water before circulating through the unit, Never inject these solutions while the water is circulating, Remove rusted or pitted areas that appear on the plates with commercial scouring powder. Follow this by flushing with clean water.

Cleaning solutions should always be circulated with a centrifugal pump.

Do not use hydrochloric (muriatic) acid for cleaning plates.

Thoroughly rinse the plates with clean water following any type of chemical cleaning.

Never open the unit when hot, under pressure, holding liquid or operating.

Under no circumstances should phosphoric or sulfamic acid be used with titanium plates. Do not use hydrochloric acids, or water containing in excess of 300 ppm chlorides with stainless steel.

Do not use brushes with carbon steel bristles or steel wool. A fiber type brush is recommended, but as a last resort use a brush of similar material to the thermal plates Be careful not to scratch plates or damage gaskets if they are to be reused. After brushing rinse each plate with water.

Limit cleaning solution concentration to 4% in strength, with temperatures not exceeding 140° F unless otherwise specified.

The following solvents should not be used in contact with gaskets:

Ketones (e.g. Acetone, Methylethylketone, Methylisobutylketone) Esters (e.g. Ethylacetate, Butylacetate) Halogenated hydrocarbons (e.g. Chlorothene, Carbon tetrachloride, Freons).

NOTE:

Care must be exercised when handling certain fluids. Follow manufacturers instructions. Use eye and skin protection. Wear a respirator when required.

Always wipe the gaskets clean before closing the unit to prevent damage resulting from adhering particulate matter.

Always use clean water (free from salt, sulphur, chlorine or high iron concentrations) for flushing and rinsing operations.

If steam is used as a sterilizing medium, do not exceed 270° F steam temperature with nitrile gaskets, and 350° F with EPDM gaskets.

Cleaning-In-Place (CIP) Procedure:

In applications where extremely corrosive fluids are being used, a clean-in-place system is recommended to lengthen the life of the thermal plates. Because the CIP is the preferred method of cleaning, the manual process is not discussed here but the procedure is available in the manufacturer's manual.

1. Drain both sides of the unit. If it is not possible to drain, force liquids out of the unit with flush water.
2. Flush the unit on both sides with warm water at approximately 110º F until the effluent water is clear and free of the process fluid.
3. Drain the flush water from the unit and connect the CIP pump.
4. For through cleaning it is necessary to flow CIP solution bottom to top to insure wetting of all surfaces with cleaning solution. When cleaning multiple pass units it will be necessary to reverse flow for at least half the cleaning time to wet all surfaces.
5. For optimum cleaning, use the maximum flow rate of water, rinse or CIP solution that the CIP nozzle size will allow. A CIP operation will be most effective if performed on a regularly scheduled basis and before the unit is completely fouled.

NOTE:

If brine is used as a cooling medium, completely drain the fluid from the unit and flush the unit with cold water prior to any cleaning operation. Corrosion will be kept at a minimum if all traces of brine are eliminated before using hot CIP solutions on either side of the heat exchanger.

Back flushing:

1. Many applications use fluids that may contain solids and sediments that can be trapped and plug up a plate heat exchanger, If this problem is anticipated it is very beneficial to make provisions in your piping for back flushing the unit.
2. Back flushing should be done with water at 11/2 times the process flow rate.
3. It is recommended that fluids containing particulate enter at the bottom of the unit and exit at the top. This will cause some solids to collect in bottom of inlet nozzle instead of going into plate pack and clogging.
4. Another alternative to back flushing is to arrange piping so both fluids can be periodically reversed.

The following solvents should not be used in contact with gaskets

- Ketones (e.g. Acetone, Methylethylketone, Methylisobutylketone),
- Esters (e.g. Ethylacetate, Butylacetate),
- Halogenated hydrocarbons (e.g. Chlorothene, Carbon tetrachloride, Freons), and
- Aromatics (e.g Benzene, Toluene).

WARNING:

Care must be exercised when handling certain fluids. Follow manufacturer's instructions. Use eye and skin protection. Wear a respirator when required.

CAUTION:

The gasket may have to be stretched prior to installation to fit the gasket groove. Avoid excess stretching as damage to gasket can result.

(Additional information regarding plate-and-frame designed heat exchangers is contained in Appendix Section 4.2.3.1.4 of this manual.)

3.3.1.5 Glycol / Ethylene Pumps

The glycol heating system uses several pumps to distribute the heated glycol solution throughout the facility. Pumps CP-1 and CP-2 circulate solution through the unit and cabinet heaters for perimeter heating. CP-1 is the primary pump with CP-2 as a backup. Hot glycol is pumped through Boilers B-1 and B-2 to all heating coils, re-heat coils, water heaters, finned tube heaters, radiant heaters, unit heaters and the like, throughout the facility.

CP-3 (Primary) and CP-4 (Backup) are responsible for circulating glycol solution through the boilers. These pumps are used to fill the heating system, maintain system pressure, and supply glycol liquid to the boilers from the glycol tank. The pump is controlled by a local on / off switch. Once the system is filled, (the system reaches a stable operating level with air replaced with liquid), the pump is not needed unless there is a mechanical failure at some point in the system.

Two other pumps, CP-5 (Primary) and CP-5A (Backup), circulate glycol solution as part of the heat recovery system.

Although the pumps used were designed to be low maintenance, perform monthly, quarterly, and yearly maintenance using PMs 0241FM, 0241FQ, 0241FA, and 6218FA. The manufacturers also recommend the following preventive maintenance procedures by pump and manufacturer:

3.3.1.5.1 Vertical Split Case (VSC)

Pump:

Along with PMs 0241FM, 0241FQ, 0241FA, and 6218FA (Equip. # PU00096, PU00097, PU00099, PU00100, and PU00101), the manufacturer recommends the following preventive maintenance:

Lubricate pump bearings at least twice a year or flush bearings whenever necessary with NLGI Grade No. 2 mineral base or lithium base petroleum grease while the pump is running. On chilled water applications it is important to keep the bearing cavity full of grease to protect from condensation.

The pump should be inspected regularly for leaking seals, worn gaskets and loose or damaged components. Repair, or replace, as required. Drain the pump if there is a chance that the system will freeze by removing the plugs at the top and bottom of the volute shell.

If the pump has been used for pumping aggressive, or polluted liquids, it should be flushed through with clean water to avoid corrosion or sediment in cast the pump is not being used for some time.

CAUTION:

Before installing, using or servicing this product, read the warning notes and instructions in the instruction manual.

Electrical connections to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices.

When disassembling a gasketed joint, always use a new gasket upon reassembly. NEVER RE-USE OLD GASKETS.

Unexpected startup hazard, disconnect and lockout power before servicing.

Pressurize the pump body slowly while checking for leaks at all joints with gaskets.

Before draining the system, allow water to cool to at least 100° F, open the drain valve (take precautions against water damage) and leave the drain valve open until servicing is complete.

Make certain the internal pressure is relieved before servicing.

Allow pump temperature to reach acceptable level before proceeding. Open the drain valve, do not proceed until the liquid stops coming out of the drain valve. If liquid does not stop flowing from the drain valve, the isolation valves are not sealing and should be repaired before proceeding. After the liquid stops flowing from the drain valve, leave the drain valve open and continue. Remove the drain plug located on the bottom of the pump volute. Do not plug or close the drain valve until reassembly is completed.

Make sure all flange bolts have been adequately torqued.

Do not run pump dry, seal damage may occur. Inspect pump seal regularly for leaks, replace as required. for lubrication requirements, consult service instructions.

Rotating components disconnect and lock out power before servicing. Consult installation and service instruction sheet before operating or servicing.

Failure to follow this warning could result in personal injury, death and / or property damage.

Motor:

Lubricate motor bearings in accordance with the manufacturer's instructions. As a general rule; sleeve bearings are to be lubricated through the motor oil cups per the lubrication decal once every four (4) months, or more often under adverse conditions.

Use eight (8) to ten (10) drops in each oil cup. Ball bearings should be lubricated every six (6) months to two (2) years depending on conditions with soda soap or lithium base grease.

(For additional information on the VSC pumps and motors, See Appendix Section 4.2.3.1.5.1 in this manual.)

3.3.1.5.2 1510 Pumps

Pump:

Along with PMs 0241FM, 0241FQ, 0241FA, and 6218FA (Equip. # PU00108 and PU00109), the manufacturer recommends the following preventive maintenance:

While pump is running, grease pump bearing with NLGI Grade #2 lithium base petroleum grease after every 2500 hours of operation or every 6 months whichever occurs first.

The pump should be inspected regularly for leaking seals, worn gaskets and loose or damaged components. Repair, or replace, as required. Drain the pump if there is a chance that the system will freeze by removing the plugs at the top and bottom of the volute shell.

If the pump has been used for pumping aggressive, or polluted liquids, it should be flushed through with clean water to avoid corrosion or sediment in cast the pump is not being used for some time.

CAUTION:

Before installing, using or servicing this product, read the warning notes and instructions in the instruction manual.

Electrical connections to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices.

When disassembling a gasketed joint, always use a new gasket upon reassembly. NEVER RE-USE OLD GASKETS.

Unexpected startup hazard, disconnect and lockout power before servicing.

Pressurize the pump body slowly while checking for leaks at all joints with gaskets.

Before draining the system, allow water to cool to at least 100° F, open the drain valve (take precautions against water damage) and leave the drain valve open until servicing is complete.

Make certain the internal pressure is relieved before servicing.

Failure to follow this warning could result in personal injury, death and / or property damage.

CAUTION:

Allow pump temperature to reach acceptable level before proceeding. Open the drain valve, do not proceed until the liquid stops coming out of the drain valve. If liquid does not stop flowing from the drain valve, the isolation valves are not sealing and should be repaired before proceeding. After the liquid stops flowing from the drain valve, leave the drain valve open and continue. Remove the drain plug located on the bottom of the pump volute. Do not plug or close the drain valve until reassembly is completed.

Make sure all flange bolts have been adequately torqued.

Do not run pump dry, seal damage may occur. Inspect pump seal regularly for leaks, replace as required. for lubrication requirements, consult service instructions.

Rotating components disconnect and lock out power before servicing. Consult installation and service instruction sheet before operating or servicing.

Failure to follow this warning could result in personal injury, death and / or property damage.

Motor:

Lubricate motor bearings in accordance with the manufacturer's instructions. As a general rule; sleeve bearings are to be lubricated through the motor oil cups per the lubrication decal once every four (4) months, or more often under adverse conditions.

Use eight (8) to ten (10) drops in each oil cup. Ball bearings should be lubricated every six (6) months to two (2) years depending on conditions with soda soap or lithium base grease.

(For additional information on the 1510 pumps and motors, See Appendix Section 4.2.3.1.5.2 in this manual.)

3.3.1.5.3 Series 60/80

Pump:

Along with PMs 0241FM, 0241FQ, 0241FA, and 6218FA for pumps (Equip. # PU00106 and PU00107), the manufacturer recommends the following preventive maintenance:

Fill the bearing frame according to the oiling instruction decal. At the time of installation, or start of each heating season, add approximately 1 oz. of #20 weight non-detergent oil. A SAE 20, or 10W - 30W, (**non-detergent**) oil may be substituted.

NOTE:

Standard Services 60 pumps with K99, or later, codes do not need to be lubricated. The pumps are provided with sealed, permanently lubricated pump and motor bearings.

More frequent lubrication may be required under adverse conditions such as high ambient temperatures.

CAUTION:

Before installing, using or servicing this product, read the warning notes and instructions in the instruction manual.

Electrical connections to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices.

When disassembling a gasketed joint, always use a new gasket upon reassembly. NEVER RE-USE OLD GASKETS.

Unexpected startup hazard, disconnect and lockout power before servicing.

Pressurize the pump body slowly while checking for leaks at all joints with gaskets.

Before draining the system, allow water to cool to at least 100° F, open the drain valve (take precautions against water damage) and leave the drain valve open until servicing is complete.

Make certain the internal pressure is relieved before servicing.

Allow pump temperature to reach acceptable level before proceeding. Open the drain valve, do not proceed until the liquid stops coming out of the drain valve. If liquid does not stop flowing from the drain valve, the isolation valves are not sealing and should be repaired before proceeding. After the liquid stops flowing from the drain valve, leave the drain valve open and continue. Remove the drain plug located on the bottom of the pump volute. Do not plug or close the drain valve until reassembly is completed.

Make sure all flange bolts have been adequately torqued.

Do not run pump dry, seal damage may occur. Inspect pump seal regularly for leaks, replace as required. for lubrication requirements, consult service instructions.

Failure to follow this warning could result in personal injury, death and / or property damage.

CAUTION:

Rotating components disconnect and lock out power before servicing. Consult installation and service instruction sheet before operating or servicing.

Failure to follow this warning could result in personal injury, death and / or property damage.

Motor:

1. Sleeve bearings are to be lubricated through the motor oil cups per the lubrication decal once every four (4) months, or more often under adverse conditions. Use eight (8) to ten (10) drops in each oil cup.
2. Ball bearings should be lubricated every six (6) months to two (2) years depending on conditions with soda soap or lithium base grease.
3. The pump should be inspected regularly for leaking seals, worn gaskets and loose or damaged components. Repair, or replace, as required. Drain the pump if there is a chance that the system will freeze.
4. If the pump has been used for pumping aggressive, or polluted liquids, it should be flushed through with clean water to avoid corrosion or sediment in cast the pump is not being used for some time.

(For additional information on the Series 60/80 pumps and motors, See Appendix Section 4.2.3.1.5.3 in this manual.)

3.3.1.5.4 Hand Operated

The hand operated pumps are intended primarily for the transfer of fuel oil, lubricating oil, solvents, petroleum products, and other non-corrosive liquids. They are generally not satisfactory for pumping water.

WARNING:

If pumping hazardous or toxic fluids. system must be flushed and decontaminated, inside and out, prior to performing service or maintenance

Hazardous or toxic fluids can cause serious injury.

In some applications, condensation or water in the liquid will cause an accumulation of rust inside the pump, which may cause the pump to bind or turn hard. Pouring kerosene or penetrating oil into the pipe opening, and turning the crank several times will usually free the pump. Loosening the head cap screws one-half turn, and turning the crank several times should also solve the problem. Severely rusted pumps should be dismantled and cleaned.

If for any reason the pump should to be disassembled, the O-ring between the two (2) halves should be replaced if it is swollen, nicked, or cut. The O-ring is slightly smaller in diameter than the groove in the cylinder.

(For additional information on the hand operated pumps, See Appendix Section 4.2.3.1.5.4 in this manual.)

3.3.1.6 Waste Heat Recovery System

3.3.1.6.1 Differential Control Valve

The differential control valve (Equip. # RP00150) used in is used to maintain a constant differential pressure between two points in the waste heat recovery system.

This valve should be maintained monthly per PM0463FM. The manufacturer also recommends the valve be inspected and maintenance yearly by a qualified technician.

(For additional information on the differential control valve used in the waste heat recovery system, See Appendix Section 4.2.3.1.6 in this manual.)

3.3.1.6.2 Acturator

The E-Series Actuators used in the Waste Heat Recovery System as part of the sootblowers in the gas heat recovery silencers are rotary valve actuators with outputs from 300 to 30,000 in-lbs.

The manufacturer states these actuators contain a permanently lubricated precision cut, heat treated gear train for a long and reliable cycle life. There is no need to change gear train grease during normal life. In the event it becomes necessary to perform maintenance on the actuator upon reassembling, the manufacturer recommends using Lubriplate EMB grease.

CAUTION:

In the event the actuator requires maintenance, remove it from a hazardous location first before attempting maintenance.

DO NOT under any circumstances remove the actuator cover while in a hazardous location, this could cause ignition of hazardous atmospheres.

When removing the cover on the actuator, care must be taken not to scratch, scar, or deform the flame path of the cover or base of the actuator. This will negate the NEMA 7 rating of the enclosure.

When replacing the actuator cover, take care that the gasket is in place to assure the proper clearance after the cover is secured. After securing the cover screws check the clearance between the cover and the base, a .002" thick by 1/2" wide feeler gauge may not enter between the two mating faces mote than .125".

1. The gear motors used on the actuators have split capacitor thermal protectors. The thermal protectors guard the motor against overheating. The protectors opens the circuit to the motors and remains in this state until the motor cools to a satisfactory operating level.
2. The actuators should also be inspected periodically for leaks and linkage binding.
3. Inspect the actuators to make sure the valves are opening and closing properly.
4. The exterior case on the actuators should be kept clean.
5. Verify there is no debris around the actuators to interfere with their operation.

6. When servicing the valves with actuators, it is only necessary to disassemble the parts by loosening the actuator fastener (and possibly the anti-rotation device). That will separate the two orderable parts, the direct coupled actuator, and the valve/bracket assembly.

(Additional information for these actuators can be found in Appendix Section 4.2.3.1.6 in this manual.)

3.3.1.6.3 Flow Meters

The Turbine Flow Meters used in the Waste Heat Recovery System measure the velocity of flowing liquids by counting the frequency at which the blades of a rotating turbine pass a fixed electrode. Circuitry within the flow meter's electronics enclosure converts the rotational rate to digital and/or analog signals which are transmitted by a connecting cable to display devices, BTU meters, and/or a data acquisition system.

If the flow meters require any servicing, the manufacturer has requested it be returned to the factory. If servicing is required on site, the manufacturer requests you contact the factory before beginning any servicing.

CAUTION:

Please do not permit any persons to install, operate or maintain this equipment unless they have a complete knowledge of their trade skills and are competent to work on high voltage power wiring or high pressure hot and cold water and steam systems, according to their individual trades. Death or permanent injury may result from accidents with these systems.

Insertion Flow Meters may often be installed in pipes which are under high pressure. Accidents with these systems can cause serious injury or death. Only persons experienced with high pressure systems and related knowledge in the heating, cooling and fluid metering fields should attempt to install adjust or remove the flow meter.

When you are ready to refill the system, make sure that all lines are filled with water before inserting the turbine into the stream. If the lines are not filled, air may interrupt the flowing stream and damage the turbine assembly. A greater danger is that if this is a hot water system, some water may flash into steam and exceed the high temperature limit for the turbine and its mechanical assembly. This flash over could exceed the pressure ratings of the meter and the assembly could fail allowing steam and hot water to escape causing serious injury.

CAUTION:

Remember, the meter may be under high pressure, and while removal of the meter is basically the reverse of the insertion procedure detailed above, care must be taken to ensure that the meter is supported against the pipe pressure before the position clamping nut is loosened. Failure to do this will allow the pressure to suddenly and rapidly force the meter from the pipe causing serious injury.

Remember, the meter may be under high pressure, and while removal of the meter is basically the reverse of the insertion procedure detailed above, care must be taken to ensure that the meter is supported against the pipe pressure before the position clamping nut is loosened. Failure to do this will allow the pressure to suddenly and rapidly force the meter from the pipe causing serious injury.

Prior to removal of the meter, make sure that you are standing on a secure platform and have both hands available to manipulate the flow meter.

In hot water systems, even a small amount of water can cause serious personal injury. Use extra caution when working with hot water meters.

Do not attempt to make any connections inside the electronics case, or to remove factory installed connection fittings. Damage resulting from these actions may not be covered under warranty.

If adjustment of the meter depth is required. the same procedure must be followed as if the meter was being removed. Please carefully read the manufacturer's section on removal of the meter. Remember, the meter may be under high pressure and failure to follow the procedure may result in serious injury.

SYSTEM MAY BE UNDER HIGH PRESSURE. When adjusting the meter position or removing it, be sure to hold the electronics enclosure firmly by hand before SLOWLY loosening the positioning clamping nut. Failure to do this will allow the pressure to suddenly and rapidly force the meter from the pipe causing serious injury. The meter could also be damaged or break apart causing a break in the water seal with the resultant loss of large amounts of water. The hand effort required to hold the meter will be 0.11 times the pipe pressure.

Do not release the flow meter until you have tightened the position clamping nut enough to hold the flow meter in the desired position. This will require less torque than you might think, so be careful not to overtighten it and risk damaging the adapter, nut or stem.

All meter piping connections should be checked periodically for corrosion, leaks and damage. Repair as necessary. Verify the meter itself has not been damaged and all electrical connections are secure. Repair or replace as necessary.

(Additional information on flow meters can be found in Appendix Section 4.2.3.1.6 in this manual.)

3.3.1.6.4 Strainers

Strainer inspection is of utmost importance, especially the first few hours, days or weeks after the initial start-up. Foreign material should be removed and the screens or baskets should be washed with the proper solvent. Stainer inspection and cleaning should be continued until dirt accumulation ceases. Later, any time a valve pressure containment seal is released for service or maintenance, its companion strainer should also be inspected and cleaned.

Strainers shall be inspected internally and cleaned whenever necessary.

(Additional information on strainers can be found in Appendix Section 4.2.3.1.6 in this manual.)

3.3.1.7 Hydronics Specialities

3.3.1.7.1 Expansion Tanks

The expansion tanks (TE00018, TE00019, ET-2, ETG-1, and ETG-2) in the Gas Waste Heat Recovery Loop and in the Glycol Waste Heat Recovery Loop were all pre-charged to the design system operating pressure prior to being placed into operation. Although the tanks themselves require little maintenance, the manufacturer recommends the precharge should be checked yearly, and more frequently as the systems age.

WARNING:

Read carefully the manufacturer's installation, operating and maintenance instructions manual to avoid serious personal injury and property hazards, and to ensure safe use and proper care of this product.

Explosion or rupture hazard. The expansion tank must re operated so that the pressure does not exceed the maximum working pressure.

This product contains a chemical known by the State of California to cause cancer. This product contains a chemical known by the State of California to cause birth defects or other reproductive harm.

Domestic, potable or fresh water can cause serious corrosion in a tank. This can result in leakage and a potential explosion. Do not use for domestic, potable or fresh water. Failure to follow this instruction will result in serious personal injury or death and property damage.

Excessive pressure can cause tank to explode. Exercise care when filling a tank with air so the pressure does not exceed that required or does not exceed the working pressure of the tank as stamped on the nameplate. Failure to follow these instructions will result in serious personal injury or death and property damage.

Expansion tanks cannot be properly air charged other than at ambient temperature.

If the expansion tanks were not equipped with a precharge pressure gauge, an accurate pressure gauge (digital tire pressure gauge) should be used to check the pressure at the charging valve. Check the tank for indications of rusting and leaks, paying particular attention to connections. A valve, or faucet, must be opened first to remove system pressure.

Add air to the tank if it doesn't match the incoming water pressure. If the tank pressure is zero, or if water discharges from the air valve, then it should be replaced.

(For additional information on the expansion tanks, See Appendix Section 4.2.3.1.7.1 in this manual.)

3.3.1.7.2 Air Separators

The air separators used in the Water Plant do not normally require maintenance and includes no moving parts other than those in the vent head itself.

WARNING:

System fluid under pressure can be very hazardous. Before removing the vent head for inspection, reduce system pressure to zero, or isolate the air separator from the system.

Allow the system to cool to below 100° F.

Water Temperatures above 100° F can be very hazardous. Keep body away from connection while open.

System fluid under pressure can be very hazardous. Before removing the unit head, reduce system pressure to zero, or isolate the air separator from the system. Allow the system to cool to below 100° F.

Unit head and bundle are heavy. Keep body clear of the head and bundle when disassembling.

Corrosion or leakage from the air separator can cause damage or injury. Periodically inspect the air separator for signs of leakage or corrosion. If there is signs of leakage or corrosion, the air separator must be replaced.

Failure to follow this warning can cause serious personal injury, death or major property damage.

The air separator allows for dirt and sediment separation. The ball valve on the bottom of the unit should be opened on a regular basis to purge debris from the collection chamber, A container should be used to catch any debris. Frequency of purging is system dependent based upon the degree of sediment in the system. Frequent purging is recommended right after installation, and then scheduled as needed as the systems clears.

Units with optional removable head can be disassembled and the tube bundle removed for inspection or cleaning. The removable head is a user-specified feature and frequency of inspection and / or cleaning is user or system dependent.

Taking care to support the head, remove bolts and slide the bundle out. Clean the bundle using a pressure washer or hose and reinstall the bundle in the Spirovent unit, Be sure to check the gasket before reinstalling the head, and replace if necessary. Tighten bolts using a criss-cross pattern to proper torque. Before opening isolation valves, close ball valve.

If the system fluid contains large amounts of contaminants, the perforated metal diffuser and / or the air coalescing brush may become contaminated with foreign substances. The air separator cap unscrews from the body for easy cleaning of both the brush and diffuser.

When replacing the perforated metal diffuser, make sure the overlap portion of the diffuser is at 90° to the NPT body connection. The diffuser will have to be held during the assembly of the body and cap to prevent it from turning. This can be done through the NPT connections.

The automatic air vent can be replaced by unscrewing it from the air separator cap.

Enclosures and connections should be inspected periodically for leakage and repaired if necessary. Strainers need to be inspected and cleaned periodically. This is particularly true during the initial start-up period. The need to clean the strainer will be evidenced by a high pressure drop across the air separator, or by pump cavitation problems.

(For additional information on the air separators, See Appendix Section 4.2.3.1.7.2 in this manual.)

3.3.1.7.3 Flow Control Wafer Valve

If the system experiences large amounts of pipe scale due to poor water conditions, as sometimes found in older or retrofit systems, provisions should be made to keep the system clean. Proper water treatment is also recommended by the use of a special separator. If a special separator is not used for system cleaning, the flow control valve and connections should be inspected annually for leakage, damage, and reduced flow. The unit should also be disassembled for inspection of the O-rings. If the unit must be replaced, some of the important facts to keep in mind are:

- Cleanliness is important for proper seal action and long O-ring life.
- Foreign particles like dirt, metal chips, etc. in the O-ring groove may cause leakage and can damage the O-ring thus reducing its life.

NOTE:
Assembly must be made with care to protect the O-ring from damage during installation.

- Using silicon oil or grease lubricant at assembly helps protect the O-ring from damage by abrasion, pinching, or cutting.
- Do not use aerosol products or petroleum based lubricants. The lubricant should not excessively soften or harden.
- Depending on the application, the O-ring should be placed in the groove or stretched over the threads.

- O-rings should not be twisted, forced or rolled over sharp corners, threads, or other sharp edges.

(For additional information on the flow control wafer valve, See Appendix Section 4.2.3.1.7.3 in this manual.)

3.3.1.7.4 Hydronic Valves

This section details the maintenance procedures used for the valves installed in the hydronic heating, cooling, and recovery systems. This section starts out with common sense procedures that can be applied to all the valves, followed by procedures aimed at specific types of valves.

Since these are only general steps, not all steps may apply to every valve.

WARNING:

Personnel making any adjustments to the valves should use equipment and clothing normally used to work with the process where the valve is installed.

The line must be depressurized before replacing the valve.

Handling of all valves, operators, and actuators must be carried out by personnel trained in all aspects of manual and mechanical handling techniques.

Valves on liquid service, which may be subjected to rapidly increasing temperature in the closed position, will need a positive means for relieving excessive cavity pressures.

NOTE:

To prevent freezing, drain all test instruments and hoses before placing them in their storage cases.

Weekly:

1. The valves should be inspected on a weekly basis for proper position setting, signs of leakage, corrosion, and damage. Replace if necessary.

Monthly:

Externally inspect valves to verify:

1. The gauges indicate normal supply water pressure is being maintained.
2. The valve is free of physical damage.
3. All valves are in the appropriate open or closed position.
4. There is no leakage or corrosion present.

Every 5 years:

1. Valves and any associated strainers, filters, or restriction orifices shall be inspected internally (unless tests indicate a greater frequency is necessary) to verify that all components operate properly, move freely, and are in good condition.
2. Internal components shall be cleaned, repaired, or replaced as necessary in accordance with the manufacturer's instructions.
3. Any sign of leakage from the gland should be addressed immediately by tightening the gland nuts gradually and evenly in a clockwise direction 1/4 turn, or until the leakage stops. If no further adjustment is possible the packing should be replaced.
4. Whenever a stem is replaced, the packing should be changed also.

Balance Valves

Balance valves maintain the proportional volumes of fluid flowing through separate branches of a piping system. The balance valves are calibrated for use as a pre-settable balance valve, variable orifice flow meter, and positive shut-off service valve. Valves are furnished with a calibrated nameplate and memory stop indicator which permits the valve to be preset to a fixed position, and then closed for service without disturbing the valve setting.

Valves should be checked periodically for signs of leakage, corrosion, or damage.

WARNING:

Corrosion or leakage are indications that the valve must be replaced.

Failure to follow these instructions could result in serious personal injury or death, and property damage.

Ball Valves

General maintenance for ball valves consists of operating the valve periodically to ensure that it is functioning properly. This consists of tightening the packing to compensate for wear. The handle nut also provides the packing preload on the ball valve. When leakage occurs, the packing/handle nut should be tightened in 1/8 to 1/4 turn increments just enough to stop leakage.

WARNING:

DO NOT under any circumstances, solder the downstream end of this valve while there is upstream pressure/or with fluid trapped in the cavity around the ball. Thermal expansion of this fluid could produce excessive internal pressure which could damage seat or body materials. Always drain down the system and cycle the valve two to three times after drain down is complete before applying heat. Steam created from trapped fluid in the cavity around the ball could cause the valve to BURST if valve is heated excessively.

NOTE:

The manufacturer does not recommend disassembly of this valve to attempt internal repairs.

Butterfly Valves

Butterfly valves require no routine maintenance. Periodic cycling of the valve is highly recommended.

Check Valves

Recommended Maintenance:

1. If the bonnet joint leaks, the valve should be isolated and depressurized. The bonnet should be removed. The seating surfaces of the bonnet and body should be closely inspected. If there is any scratches or marks on these surfaces, then it is necessary that a flat surface sanding plate of 400 grit be used on the body to remove all the marks and scratches. After the marks and scratches are removed, blueing should be applied to a flat plate and put onto the bonnet surface, if there are no high spots on the bonnet surface, then it is ready for reassembly.

2. Leakage across the valve seat is generally due to foreign matter lodged in the sear. Occasionally, such foreign material can be washed away by allowing flow through the valve. If the leakage persists, disassemble the valve and examine the seat surface on the disc and the sear surfaces within the body.
3. For removing the bonnet, an open end wrench of the proper size to fit the bonner nut is required. Small wrenches are also required of the socket type to remove the side plugs. Needle nose pliers are recommended to pull the hinge pin out of the side of the valve body.
4. Flat plate glass with fine 400 grit sandpaper to polish the disc or bonnet sealing surface of body. Machinist blueing should be used to test for high spots on body seats and disc.

Control Valves

Hydronic flow controls (mixing valves) limit the volume of fluid that passes through a piping system to maintain a desired selectable temperature.

The manufacturer recommends the following preventive maintenance be performed:

WARNING:

To prevent the possibility of death, serious injury or property damage, turn off electrical power, depressurize valve, and vent fluid to a safe area before servicing the valve.

CAUTION:

Only qualified personnel should complete the maintenance procedures detailed in this manual and in the manufacturer's manual.

NOTE:

It is not necessary to remove the valve from the pipeline for repairs.

Cleaning:

1. All solenoid valves should be cleaned periodically. The time between cleanings will vary depending on the medium and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive noise or leakage will indicate that cleaning is required. In the extreme case, faulty valve operation will occur and the valve may fail to open or close. Clean strainer or filter when cleaning the valve.
2. Keep the medium flowing through the valve as free from dirt and foreign material as possible.
3. While in service, the valve should be operated at least once a month to ensure proper opening and closing.
4. Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. If parts are worn or damaged, install a complete rebuild kit.
5. Cartridges may need to be changed periodically. In most cases both the control range and the flow rate can be changed by replacing the cartridges.

Gate Valves

Recommended Maintenance:

1. If the bonnet joint leaks, the valve should be isolated and depressurized. The bonnet should be removed. The seating surfaces of the bonnet and body should be closely inspected.
2. If there is any scratches or marks on these surfaces, then it is necessary that a flat surface sanding plate of 400 grit be used on the body to remove all the marks and scratches. After the marks and scratches are removed, blueing should be applied to a flat plate and put onto the bonnet surface, if there are no high spots on the bonnet surface, then it is ready for reassembly.
3. Leakage across the valve seat is generally due to foreign matter lodged in the sear. Occasionally, such foreign material can be washed away by allowing flow through the valve. If the leakage persists, disassemble the valve and examine the seat surface on the disc and the sear surfaces within the body.
4. Leakage through the stuffing box packing may be stopped by tightening the packing nut. Do not overtighten as excessive tightening may cause difficult operation of the valve and could cause damage to the stem or packing nut.

CAUTION:

Only qualified personnel should complete the maintenance procedures detailed in this manual and in the manufacturer's manual.

5. Keep the medium flowing through the valve as free from dirt and foreign material as possible.
6. While in service, the valve should be operated at least once a month to ensure proper opening and closing.
7. Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. If parts are worn or damaged, install a complete rebuild kit.

Relief Valves

Recommended Maintenance:

1. The operating condition of the safety relief valve should be checked every 30 days to ensure it is protecting the system or component, or after any prolonged period of inactivity.
2. The relief valve is checked by manually operating the lever on top of the relief valve to the full open position, the lever is then released allowing it to snap closed. After the manual test is performed, the safety relief valve should be inspected for signs of leakage, corrosion, damage, or scale buildup.

WARNING:

Attempts to change safety relief valve settings will prevent it from relieving at rated capacity and thus causing the system/component to explode. Do not attempt to adjust the pressure setting of the safety relief valve.

The uncontrolled discharge of hot water from the safety relief valve can be very hazardous and could scald anyone in the vicinity. Make sure that proper discharge piping is in place at all times.

Corrosion, scale buildup, leakage or damage to safety relief valves are indications the safety relief valve may fail to provide over pressurization protection. Every 30 days the safety relief valve must be inspected and if any of the above conditions are noted it must be replaced.

Failure to follow these instructions could result in serious personal injury or death, and property damage.

(Additional information for the valves used in the hydronic system, See Appendix Section 4.2.3.1.7.4 in this manual.)

3.3.1.7.5 Glycol Make-up System

The Glycol Make-up System (GMS) was designed to replenish the fluid level in the heating system. The GMS (GT-1, GT-2, and GT-3) is designed to operate without the need of servicing or adjustment. The pump is equipped with self-lubricating carbon bearings, and the motor is a life-time lubricated type for standby make-up applications. The pump has a seal type packing that does not require adjustment.

1. Check the glycol solution level in the translucent solution container and replenish as necessary.

WARNING:

Only personnel familiar with the material safety data sheet (MSDS) for the glycol solution shall handle or replenish the solution container.

Failure to follow this warning can cause serious personal injury, death or major property damage.

2. Perform inspection and servicing of the GMS in accordance with manufacturer's recommendations.

(For additional information regarding Glycol Make-up tanks, see Appendix Section 4.2.3.1.7.5 of this manual.)

3.3.1.7.6 Gauges and Thermometers

No routine maintenance is assigned for the gauges and thermometers used in the hydronic system at this time.

CAUTION:

When installing or replacing the thermometer, do not tighten by turning the thermometer case.

However, they should be inspected annually for damage, leaks, obstructions, and breakage. Repair as necessary.

(For additional information regarding the gauges and thermometers in the hydronic system, see Appendix Section 4.2.3.1.7.6 of this manual.)

3.3.1.7.7 Air Vents

The high capacity air vents used in the Engine Jacket Cooling and Exhaust Gas Waste Heat Recovery Systems should be inspected periodically for corrosion and leakage. Corrosion or leakage are indications that the air vents may be at the end of their useful life or require maintenance. If corrosion or leakage is noted, the air vent must be replaced or serviced.

CAUTION:

The air vent may discharge air and possibly some liquid during its normal functioning. Avoid eye, face or skin contact with top area of air vent.

All work must be performed by qualified personnel trained in the proper application, installation, and maintenance of systems in accordance with all applicable codes and ordinances.

The air vent, like all pressure vessels, can, over time, corrode, fail, leak and flood.

System fluid under pressure and /or at high temperatures can be very hazardous. Before servicing, reduce system pressure to zero or isolate the air vent from the system. Allow system to cool below 100° F.

When the vent discharges air, or if foreign material from the system fouls the vent's operating mechanism, it is possible for water to also be discharged. Vent must be piped to a drain.

Explosion or rupture hazard. The high capacity air vent must be operated so that the pressure does not exceed the maximum operating pressure.

The use of Teflon impregnated pipe compound and Teflon tape on pipe threads provides lubricity which can lead to overtightening and breakage. Do not overtighten.

Hot venting water can be hazardous. Avoid contact with venting fluid and only manually vent when system temperature is below 100° F (37.8° C).

Failure to follow these cautions could cause property damage or personal injury.

(For additional information regarding the air vents in the waste heat recovery systems, see Appendix Section 4.2.3.1.7.8 of this manual.)

3.3.1.7.8 Suction Diffusers

The suction diffusers are used in the system for direct application to the pump suction and provides ideal flow conditions for the pump's inlet. Periodic inspection of inlet vanes and cleaning of the orifice cylinder is required to guard against damage to the pump. If the inlet vanes or the orifice cylinder are damaged, they must be replaced.

WARNING:

Corrosion or leakage are indications that the Suction Diffuser may be about to cause serious damage from leakage, rupture or parts entering the pump. The Suction Diffuser must be periodically inspected and if noted, the Suction Diffuser must be serviced or replaced. Failure to follow these instructions could result in serious personal injury or death and property damage.

High temperature and pressure hazard. Make sure that system temperature is below 100° F (38° C) and system pressure is reduced to and maintained at zero during servicing.Failure to follow these instructions could result in serious personal injury or death and property damage.

CAUTION:

Potential pump damage, Inspect and replace damaged or corroded Suction Diffuser inlet vanes and orifice cylinder so that parts will not be forced into the system pump. Failure to follow these instructions could result in property damage or moderate personal injury.

(For additional information regarding suction diffusers, see Appendix Section 4.2.3.1.7.9 of this manual.)

3.3.1.8 Water Heater

The only water heater (Equip. number HT00546) in the Water Plant is located at the Northeast corner of the Operator's Office. The water heater is used for the sink in the Lab and to pre-heat the water used for the emergency eyewash/shower station.

The manufacturer states the water heater was designed to provide a tank service life of many years. Components, however, may be subject to failures that require service. Failure to use the correct procedures or parts in these circumstances may make the unit unsafe.

DANGER:

Do not over-drain the tank. Improper thermostatic control could result and lead to damage to the heater.

Electrocution hazard, the heater must be electrically grounded.

WARNING:

Scalding Hazard: If the water temperature is over 120º F, users can suffer serious or fatal scalding and painful and permanent injury. The consumer products safety commission recommends an initial setting of 100º F, but notes a slower response time of infants, aged, disabled and other persons increases the hazard to them and may require lower settings. Always check the water temperature before using, including washing, bathing or showering.

Temperature limiting valves are available from your plumbing supplier.

Scalding Hazard: If the thermostat is not working properly or if this product is not installed in accordance with the manual, water temperature can reach excessive levels that may cause serious scalding, even if the temperature setting is correct. After installation and any servicing of the unit, verify that the thermostat is working and firmly inserted in the thermostat well by the following the thermostat testing instructions in the manual after installation and any servicing of the unit.

Scalding Hazard: A check valve must be installed in the boiler return line to prevent gravity flow through the heat exchanger. This can cause over heating and result in serious scalding.

If not installed by the boiler manufacturer, install a low water cut-off or pressure reducing valves must be installed on your boiler so that leaking from any plumbing fixture will not result in a dry boiler; If the boiler continues to fire, an explosion hazard exists.

Prevent pressure build-up in any existing internal tankless coil. Do not plug incoming or outgoing tappings in the internal tankless coil plate. Leave the coil in the boiler and leave system connections open, to prevent pressure build-up.

Electrocution Hazard: First disconnect all electrical power before doing any electrical work.

Electrocution Hazard: The water heater must be electrically grounded.

Do not over-drain the tank. Improper thermostatic control could result if the tank is over-drained and cause damage to the tank.

Failure to follow this warning can cause serious personal injury, death or major property damage.

WARNING:

Avoid risk of ingesting a toxic fluid. The heat transfer medium should be water. If glycol must be used, it should be used with double walled heat exchangers.

This tank, like most tanks under pressure, will over time corrode or fail and/or may burst and/or leak or flood (and in rare cases explode) which can cause serious or fatal personal injury and property damage. To minimize risk, a licensed professional must install and periodically inspect and service the unit. A drip pan, connected to an adequate drain must be installed if leaking or flooding can cause property damage.

Follow all of the instructions and recommendations contained in this manual, and the following additional specific warnings. Failure to do so is unsafe and can cause serious scalding, explosion, serious or fatal personal injury and property damage.

Do not connect the water heater's domestic supply with baseboard or other space heating units or elements. Any contaminants in the baseboard units will contaminate the potable water in the water heater and also adversely affect its performance.

Electrical supply must come from the boiler side of the boiler's emergency shut-off switch in order to prevent unsafe boiler operation.

Do not drain this appliance before shutting off the supply valve and opening the relief valve or another downstream fixture, as it will damage this unit. A vacuum breaker should be installed to avoid damaging the liner.

In limited circumstances, space heating can be lost when the water heater is used in the priority mode. Any demand for space heating is postponed until the water heater has reached its set temperature. This delay in supplying the space heating zones is usually not noticed by the inhabitants of the living spaces. However, in the event of certain malfunctions such as circulator or thermostat failure, space heating could be delayed indefinitely. If undetected and uncorrected, freezing damage to piping could result.

Explosion Hazard: Do not install to a high pressure steam boiler greater than 15 psig. An explosion could occur.

Explosion Hazard: The pressure of the heat transfer medium must be limited to a maximum of 30 psig by an approved safety or relief valve on your boiler. The tank pressure must be limited to 150 psig maximum by the installation of a temperature and pressure relief valve.

Damage to the unit and leakage can occur if a vacuum breaker is not installed.

Failure to follow this warning can cause serious personal injury, death or major property damage.

WARNING:

This unit must be installed as a separate heating zone. Do not connect this unit to an existing heating zone or feed boiler water directly through the coil as dangerous over-heating will result.

Failure to use the correct replacement parts may make your unit unsafe.

Painful scalding with possible serious and permanent injury can occur if the temperature is set too high or the thermostat is not functioning properly.

Some new boilers contain materials that may adversely affect heat transfer. To avoid causing poor performance, do not make the initial purge of a new boiler through the water heater.

Failure to follow this warning can cause serious personal injury, death or major property damage.

NOTE:

As in all plumbing products and water storage vessels, bacteria can grow in your hot water maker, especially during times of non-use. Consult your local plumbing official regarding any steps you may wish to take to safely disinfect your home's plumbing system.

If a steel hydropneumatic tank is in place, replace it with a properly sized expansion tank. Otherwise, significant heat transfer system has an expansion tank and the boiler temperatures are being changed, resize the expansion tank.

Besides completing the annual PM #6210FA, the following inspections and simple maintenance procedures should be completed at the frequencies suggested:

Monthly Visual Inspection Check:

1. Sediment - Depending on water conditions, a varying amount of sediment may collect in the tank. This is normal. Levels requiring service are indicated by a small temperature difference in the supply and return lines. (See also "Scale" below.)
2. Repeated flushing usually clears such material. As a preventive measure, each month water should be drawn from the tank at the drain valve until it runs clear.
3. Inspect all switch mechanisms, terminals, and all piping connections for corrosion and tightness.

4. Scale - A small temperature difference between the water entering and leaving the coil may indicate a scale build-up. A water softener will prevent this problem. (See also "Sediment" above.) Repeated flushing should also resolve the problem. If not, proceed as follows:

   A. To avoid water damage to nearby areas in subsequent steps, shut off the cold water supply to the water heater.

   B. Make a note of the temperature control setting on the water heater, then turn the unit off by depressing the power switch.

   C. Relieve the water pressure in the tank by opening a hot water faucet. This will reduce the risk of scalding injury.

   D. Remove the relief valve from the top of the water heater, taking care to avoid contact with the hot water which may drain out of the lines leading to the domestic uses.

   E. Drain the water heater until the water within the tank is even with the top of the heating element - roughly 15 gallons for 41-gallon units and 5 gallons for 26-gallon units. Do not over-drain the tank or improper thermostatic control could result during Step 6, and lead to damage to the water heater.

   F. Using a funnel, pour one gallon of commercial phosphoric acid solution (commercial ice maker cleaning solution) into the water tank through the top opening. Be sure that the manufacturer's directions, cautions, and warning on the container are followed.

   G. Set the temperature control to its highest setting and operate the system until the control is satisfied.

NOTE:

The boiler may cycle on its high limit several times during this period. If the tank temperature setting has not been satisfied after 45 minutes of boiler operation, turn it to its lowest setting to stop boiler operation.

   H. Allow the heated solution to set in tank for 30 minutes, then drain tank completely using fitting and a hose long enough to reach a floor drain.

   I. Fill water tank with fresh, cold, conditioned water and drain completely twice to flush all phosphoric acid mixture from the tank.

   J. Reinstall the temperature pressure relief valve, being sure the temperature pressure relief valve temperature probe reaches into the top portion of the tank and the top half union fitting is firmly in place.

K. Open the cold water supply and fill the tank with water. Then purge air from lines and tank by operating hot and cold water faucets throughout the facility.

L. Return the to the setting noted in Step 2, flip the power switch on and verify the water heater is functioning properly. As an alternative to the above, the heating element may be removed from the water heater, cleaned, and reinstalled (with a new gasket); or, in some cases, a simple high velocity washing by water from a wand may be used in place of Steps 5-9. The chemical cleaning process, however, is the most effective if done properly.

Yearly Visual Inspection Check:

1. Domestic Water Piping - Check all piping for a signs of leakage at joints, unions and shutoff valves. Remedy as needed.
2. Relief Valve - Inspect and replace if necessary.

(For additional information regarding the water heater, see Appendix Section 4.2.3.1.8 of this manual.)

3.3.1.9 Oil Furnace

The oil furnace in the Water Plant is intended to be used for comfort heating when no other means of heating the facility is available. Although the furnace was designed by the manufacturer to require only low maintenance, the unit still requires inspections, maintenance, and repair to maintain proper operation and fuel economy. Besides the monthly, quarterly and yearly maintenance steps listed in PMs 3401FM, 3402FQ, and 3402FA, the manufacturer recommends the following inspections and maintenance at the beginning of each heating season and during mid-heating season:

WARNING:

The appropriate test instruments must be used. Failure to do so could result in burner or appliance failure, causing potential severe personal injury, death, or substantial property damage.

This equipment must be serviced only by qualified service personnel.

Personnel using this manual, or any of the vendor manuals, are reminded to always follow and adhere to any notes, cautions, and warnings listed. Otherwise, a fire or explosion may result causing property damage, personal injury or death.

Improper servicing of this equipment may create a potential hazard to equipment and operators.

WARNING:

Before disconnecting or opening up a fuel line and before cleaning or replacing parts of any kind:

- **Turn OFF the main manual fuel shutoff valves including the pilot gas cock, if applicable. If a multiple fuel burner is used, shut OFF all fuels.**
- **Turn OFF all electrical disconnects to the burner and any other equipment or systems electrically interlocked with the burner.**

Do NOT use TEFLON® TAPE or compound with TEFLON® content as an oil or gas pipe sealant. TEFLON® can cause valves to fail creating a SAFETY HAZARD.

When servicing any fuel oil solenoid valve:

- **To prevent electrical shock, personal injury, or damage to property, turn off the electrical supply before installing or servicing valve. Label all wires prior to disconnection when servicing valve. Wiring errors can cause improper and dangerous operation.**
- **Turn off fuel oil supply before installing or servicing valve. Isolate, depressurize, and purge all interconnected piping.**
- **Inspect the complete system after installing the valve. Check for leaks and ensure the power circuit is properly connected and grounded.**
- **It is not necessary to remove the valve from the pipeline for maintenance.**

Failure to properly clean the system can result in tube blockage and severe corrosion plus damage to pumps, controls, and air removal devices.

1. The furnace should be cleaned and inspected at least every heating season. Under normal operating conditions, it is not necessary to clean the firebox. The secondary portion of tubes of the heat exchanger may be cleaned by first removing the flue connection, then the casing panels, and finally the cleanout cover and gasket. All of this is accomplished at the burner end of the unit without requiring the removal of the burner. This procedure will expose the tubes and tube collector box, so as to provide a sufficient space for cleaning.
2. If it becomes necessary to clean the firebox, the burner must be removed. This exposes the full diameter of the burner access, so that a thorough cleaning job can be done through the burner and observation tubes.

3. After cleaning, inspect all gaskets and be sure that seals are tight before putting unit into service. At the time of cleaning, oil all motor and blower bearings with a light oil containing no detergent
4. Remove and inspect vent piping vent piping for obstructions, soot accumulation, rust or corrosion. Clean and replace as necessary. Check tightness of joints; seal all joints where necessary.
5. Lubricate the circulator motor according to manufacturer's instructions. This information may be contained in labeling on the pump frame.

Furnace Burner

The manufacturer of the burner and its controls used in the furnace suggests the following annual maintenance schedule:

CAUTION:
Do not use gasoline, crankcase oil, or any other oil containing gasoline.

1. Replace the oil supply line filter per manufacturer's recommendations.
2. Clean boiler or furnace thoroughly and have serviceman check burner firing rate.
3. Clean burner thoroughly, remove and clean nozzles with care so that surface inside tip is not scratched; if badly caked, replace.
4. Clean and properly reset electrodes.
5. Clean burner fan, housing and blast tube.
6. Remove (8) cap screws from end cap of pump. Remove pump strainer. Clean thoroughly. Replace gasket on pump with a new one.
7. Replace filter cartridge (if filter is used).
8. Use a few drops of S.A.E. No. 20 motor oil for the two oil cups on burner motor (every six months).
9. Inspect all gaskets. Replace any that are damaged or would fail to seal adequately.
10. Clean the blower wheel, air inlet, retention head and static plate of any lint or foreign material.
11. Check all wiring for secure connections or insulation breaks.
12. Check ignition system for proper operation.
13. Check burner performance.

Oil Burner Controls

The safety switch must be tripped before performing any maintenance. To trip the safety switch, move the safety switch lever down until the red reset button pops out and the indicator light comes on. The burner will not operate until the safety switch is reset by pushing in the red reset button.

1. The control assembly for the furnace contains no field-serviceable parts. Do not disassemble the control unit. Replace the entire control if the unit is not operationally.
2. The control unit should be inspected yearly for damage and proper operation.

WARNING:

FIRE OR EXPLOSION HAZARD CAN CAUSE PROPERTY DAMAGE, SEVERE INJURY, OR DEATH.

Troubleshooting is done with the equipment powered. Observe all necessary precautions to prevent electrical shock or equipment damage.

CAUTION:

Tripping the safety switch shuts down the burner but does not disconnect the power supply. Turn off power at system switch or circuit breaker before servicing the control system, burner motor, oil valve, or ignition to avoid electrical shock.

(For additional information on the furnace, burner, and the furnace controls, see Appendix Section 4.2.3.1.9 of this manual.)

3.3.2 Ventilation Systems

The two (2) ventilation systems in the Water Plant are comprised of motorized dampers, heat coils, mixing boxes, and air handler units AHU-1 and AHU-2.

3.3.2.1 Air Handling Units

The two air handling units (AHU-1 and AHU-2) in the Water Plant require periodic inspections and maintenance to insure proper operation.

The red LED normally indicates if the unit controller is operating properly or not. Refer to the manufacturer's documentation for LED activity contained in Appendix Section 4.2.3.2.1.

The manufacturer recommends the following inspection and maintenance schedule:

WARNING:

Disconnect electrical power source and allow all rotating equipment to stop completely before inspecting or servicing the unit. Failure to do so may result in personal injury or death from electrical shock or moving parts.

Disconnect power source for motor lubrication. Failure to do so may result in injury or death.

Disconnect electrical power prior to access into a fan or ductwork. Even when locked out electrically, fans may cause injury or damage if the impeller is subject to "windmilling". The impeller should be secured to physically restrict rotational movement. Failure to secure impeller can cause severe personal injury or death.

Secure drive sheaves before servicing the unit to ensure that rotor cannot free-wheel. Failure to secure drive sheaves can cause severe personal injury.

Disconnect electrical power source when connecting or disconnecting electrical wires for test procedures. Do not open service access doors while the unit is operating. Failure to exercise caution when completing test procedures or while inspecting unit operation may result in injury or death from electrical shock, air movement or rotating parts.

Hazardous Voltage! Disconnect all electric power, including remote disconnects before servicing. Follow proper lockout/tagout procedure to ensure the power cannot be inadvertently energized. Failure to disconnect power before servicing could result in death or serious injury.

Hazardous Chemicals! Handle chemicals carefully. Proper handling should include goggles or face shield, chemical resistant gloves, boots, apron, or suit as required. For personal safety, refer to the cleaning agent manufacturer's Materials Safety Data Sheet (MSDS) and follow all recommended safe handling practices. Failure to follow all safety instructions could result in death or serious injury.

Hazardous Pressures! Coils contain refrigerant under pressure. When cleaning coils, maintain coil cleaning solution temperature under 150º F to avoid excessive pressure in the coil. Failure to follow these safety precautions could result in coil bursting, which could result in death or serious injury.

CAUTION:

Disconnect all electric power before opening door. Failure to disconnect power before servicing can cause severe personal injury.

Inadequate lubrication of fan motor or bearings may result in premature bearing or motor failure.

Improper lubrication can result in premature bearing failure.

Do not mix greases with different bases within the bearing. This can cause an audible squealing noise that may be transmitted through the system ductwork. Premature bearing failure may result.

Follow all directions provided with chemical cleaners to avoid personal injury and / or coil damage. Commercially available chemical cleaners may contain caustic or hazardous agents. Do not use acidic chemical coil cleaners. Also, do not use alkaline chemical coil cleaners with a pH value greater then 8.5 (after mixing) without using an aluminum corrosion inhibitor in the cleaning solution.

Tension Belts Correctly! Over-tensioning belts can cause damage to bearings, shafts, and drive components. Under tensioning belts is the primary cause of premature belt failure. Belts should not squeal at startup. Recheck belt tension after 8 hours, 24 hours, and 100 hours of operation and monthly thereafter.

Use Approved Glycol! If glycol is used in chilled water or hot water systems, use a glycol approved for use with commercial cooling and heating systems and copper tube coils. Failure to do so may result in equipment damage.

Coil Freezeup! Properly drain and vent the coils when they are not in use. Also, do not throttle or modulate the water flow for coils that are exposed to freezing temperatures. Failure to properly protect coils may result in equipment damage.

Twisted Tubes! Use care in removing header plugs from Type P2, P4, and P8 coils. Over-torquing may result in twisted tubes.

NOTE:

There is a label located on the bearing support on the drive side of the unit that lists all drive parts and the proper belt tension for the specific drive.

Fan belt tension should be checked at least three times during the first days of operation, since there is a rapid decrease in tension until belts settle in. Refer to the drive sticker for proper tension.

Filters must have an airtight seal to prevent air bypass. If using other than Trade-supplied filters, apply foam gasketing to the vertical edges of the filter.

Weekly:

1. Observe unit for any change in running condition and unusual noise.

Monthly:

1. Check Air Filters. Clean or replace if clogged or dirty. When replacing a throwaway filter, install the new filter with the direction arrows pointing in the direction of airflow.
2. Re-lubricate fan bearings, and motor bearings in accordance with motor manufacturer's recommendations, if operating conditions include high speeds, moist or dirty air, or high temperatures. The grease used in electric motor bearings is usually not compatible with the grease used in fan bearings. Never mix the two grease types.
3. Check and adjust fan belt tension. Belts tend to stretch after a period of time. They should be checked periodically for wear and tightness. When replacing belts, use the same type as supplied with the unit. Matched belts should always be used on units with multi-groove pulleys. For belt replacement, loosen the tensioning device far enough to allow removal of the belt by hand. Do not force belts on or off. This may cause cords to break, leading to premature belt failure. Once installed, tension belts for a 1/4" deflection at the mid-point of the span between the two pulleys.

Every 3 to 6 Months:

1. If present, check fan bearing grease line connections. Lines should be tight to the bearings.
2. Re-lubricate fan bearings. The grease used in electric motor bearings is usually not compatible with the grease used in fan bearings. Never mix the two grease types.
3. Check motor lubrication. Recommendations are provided on the motor tag or on a unit sticker. The grease used in electric motor bearings is usually not compatible with the grease used in fan bearings. Never mix the two grease types.
4. Inspect the fan motor for excessive vibration and/or excessive case temperature.
5. Check and adjust all component set screws.
6. Check bearing and motor bracket bolt torque.
7. Align fan and motor sheaves. Tighten sheave set screws to the proper torque.
8. Check and adjust fan belt tension.
9. Inspect and clean drain pans.
10. Tighten electrical connections.

11. Inspect coils for dirt build-up or coil freeze up.
12. Fan sections should be inspected for microbial (mold) growth. If mold is found, identify and remedy the cause immediately.
13. Wheels (fan blades or squriel cage) require very little attention when moving clean air. Occasionally, oil and dust may accumulate causing imbalance. When this occurs, the wheel and housing should be cleaned to ensure smooth and safe operation.

Annually:

1. Inspect the unit casing for corrosion. If damage is found, clean and repaint the surface with a rust-resistant primer and vinyl chlorinated lacquer.
2. Clean the fan wheels and fan shaft. Remove rust with an emery cloth and apply a coat of heavy duty rust inhibitor (LPS Laboratories LPS 3, or an equivalent).
3. Inspect the condensate drain pan and drain line, remove sludge or foreign materials that might obstruct proper drainage. Remove obstacles.
4. Clean damper linkages, set screws, and blade adjustment. Clean, but do not lubricate, the nylon damper rod bushings.
5. Clean damper operators.
6. Inspect electrical components and insulation.
7. Inspect wiring for damage.
8. Rotate the fan wheel and check for obstructions in the fan housing. The wheel should not rub on the fan housing. Adjust the center if necessary and tighten wheel set screws to the proper torque.
9. Re-lubricate motor bearings in accordance with motor manufacturer's recommendations The grease used in electric motor bearings is usually not compatible with the grease used in fan bearings. Never mix the two grease types.
10. Check the condition of gasketing and insulation around unit, door, and dampers.
11. Examine flex connections for cracks or leaks. Repair or replace damaged material.

(For more detailed maintenance information on the air handlers, see Appendix Section 4.2.3.2.1 of this manual.)

3.3.2.2 Ventilation Fans

Three (3) such ventilation fans are used in the Water Plant, two are located in the engine room and one is located near the boiler. VF-1 and VF-2 provide cooling and combustion air in the engine room, and the third ventilation fan provides combustion air for the boiler.

Once the fans has been put into operation, a periodic maintenance program should be set up to preserve the reliability and performance of the fan. The manufacturer recommends the following items to be included in a periodic maintenance program:

- belts,
- bearings,
- fasteners and set screws,
- lubrication, and
- removal of dust and dirt.

WARNING:

Disconnect and secure to the "off" position all electrical power to the fan prior to inspection or servicing. Failure to comply with this safety precaution could result in serious injury or death.

1. Check for proper belt tension. Premature belt failures are frequently caused by improper belt tension or misaligned pulleys. The proper tension for operating a V-belt is the lowest tension at which the belts will not slip at peak load conditions. Check belt tension two (2) times during the first 24 hours of operation and periodically thereafter. To adjust belt tension, simply loosen four fasteners (two on each side of the motor plate) and slide the motor plate away from the fan shaft until proper belt tension is attained.
2. Check for proper belt to pulley alignment. It is very important that the drive pulleys remain in proper alignment after adjustments are made. Misalignment of pulleys will result in premature belt wear noise, vibration and power loss.
3. Bearings are the most critical moving part of the fan and should be inspected at periodic intervals. In a clean environment and temperatures above 32° F and below 200° F, the fan bearings should be lubricated semi-annually using a high quality lithium based grease. If unusual environmental conditions exist such as temperatures below 32° F and above 200° F, moisture or contaminants, more frequent lubrication is required.

4. Any fan vibration has a tendency to loosen mechanical fasteners. A periodic inspection should include checking all fasteners and set screws for tightness. Particular attention should be paid to set screws attaching the propeller to the shaft.
5. Dirt clogs cooling openings on the motor housing, contaminates bearing lubricant and collects on propeller blades causing severe imbalance if left unchecked. The exterior surface of the motor, fan panel and entire propeller should be thoroughly cleaned periodically.

CAUTION:

Do not allow water or solvents to enter the motor or bearings. Under no circumstances should motors or bearings be sprayed with steam or water.

(For more detailed maintenance information on the ventilation fans, see Appendix Section 4.2.3.2.2 of this manual.)

3.3.2.3 Paddle Fan

The paddle fan located in the engine room is used for air movement and ventilation. Like all fans, it requires periodic maintenance to keep it fully operational. The manufacturer recommends the following maintenance:

WARNING:

Read instructions carefully before attempting to assemble or service the ceiling fan. Failure to comply with instructions could result' in personal injury aeib16r property damage.

Disconnect power before installing or servicing this equipment to reduce the risk of personal injury. Do not bend the blade brackets when installing the brackets or cleaning the fan. Do not insert foreign objects in between rotating fan blades.

This fan has an internal self resetting thermal overload protector. Always disconnect from power supply before servicing.

Before servicing or cleaning unit, switch power off at service panel and lock service disconnecting means to prevent power from being switched on accidentally. When the service disconnecting means cannot be locked, securely fasten a prominent warning device, such as a tag, to the service panel.

1. Cleaning - This fan may be wiped off with a damp cloth. Do not allow the motor to get wet. Do not use solvents or a harsh detergent.

2. Lubrication - All bearings are permanently lubricated and do not require further lubrication.

(For more detailed maintenance information on the paddle fan, see Appendix Section 4.2.3.2.3 of this manual.)

3.3.2.4 Exhaust Fans

A proper maintenance program will help the fans deliver years of dependable service. Establish a schedule for inspecting all parts of the fan. The frequency of inspection depends on the operating conditions and location of the fan.

1. Inspect fans exhausting corrosive or contaminated air within the first month of operation.
2. Fans exhausting contaminated air (airborne abrasives) should be inspected every three months.
3. Regular inspections are recommended for fans exhausting non-contaminated air.

WARNING:

Before servicing or cleaning unit, switch power off at the service panel and lock service disconnecting means to prevent power from being switched on accidentally. When the service disconnecting means cannot be locked, securely fasten a prominent warning device, such as a tag, to the service panel.

WINDMILLING: Even when the power is locked out, fans may cause injury or damage if the impeller is subject to "windmilling" which is the turning of the impeller and drive components due to a draft in the system. To guard against this hazard, the impeller should be secured to physically restrict rotational movement.

To reduce the risk of fire, electrical shock, or injury to persons - observe the following:

- **Use this unit only in the manner intended by the manufacturer. If you have questions, contact the manufacturer.**
- **Before servicing or cleaning unit, switch power off at service panel and lock service panel to prevent power from being switched on accidentally. When the service disconnecting means cannot be locked, securely fasten a prominent warning device, such as a tag, to the service panel.**

CAUTION:

For general ventilating use only. Do not use to exhaust hazardous or explosive materials and vapors.

Lubricating bearings with a high pressure gun can blow bearing seals and overfill the bearing withe grease. This condition can result in excessive churning and overheating. For normal operating conditions it is standard practice to fill only 30% of the bearing void with grease.

Do not allow water to enter motor.

Fan General Maintenance:

1. Belts on the exhaust fans tend to stretch after a period of time. They should be checked periodically for wear and tightness. When replacing belts, use the same type as supplied with the unit. Matched belts should always be used on units with multi-groove pulleys. For belt replacement, loosen the tensioning device far enough to allow removal of the belt by hand. Do not force belts on or off. This may cause cords to break, leading to premature belt failure. Once installed, tension belts for a 1/4” deflection at the mid-point of the span between the two pulleys.
2. Shaft bearings can be classified in two groups: relubricating and non-relubricating. All bearings on standard fans are factory lubricated and require no further lubrication under normal use (between -20° F and 180° F in a relatively clean environment). Units installed in hot, humid or dirty locations should be equipped with special bearings. These bearings will require frequent lubrication. Caution should be employed to prevent overpacking or contamination.
3. Grease fittings should be wiped clean. The unit should be in operation while lubricating. Extreme care should be used around moving parts. Grease should be pumped in very slowly until a slight bead forms around the seal. A high grade lithium base grease is recommended.
4. Wheels require very little attention when moving clean air. Occasionally, oil and dust may accumulate causing imbalance. When this occurs, the wheel and housing should be cleaned to ensure smooth and safe operation.
5. The unit should be made non functional when cleaning the wheel or housing (fuses removed, disconnect locked off, etc.).
6. All fasteners should be checked for tightness each time maintenance checks are performed prior to restarting unit.
7. At least once a year, tighten set screws to the full recommended torque.

Motor General Maintenance:

Motor maintenance is generally limited to cleaning and lubrication (where applicable):

1. Cleaning should be limited to exterior surfaces only. Removing dust buildup on motor housing ensures proper motor cooling.
2. Greasing of motors is only intended when fittings are provided. Many fractional motors are permanently lubricated and should not be lubricated further.
3. Motors supplied with grease fittings should be greased in accordance with manufacturer's recommendations.
4. Where motor temperatures do not exceed 104° F (40° C), the grease should be replaced after 2000 hours of running time as a general rule.

(For more detailed maintenance information on the exhaust fans, see Appendix Section 4.2.3.2.4 of this manual.)

3.3.2.5 Outside Weather Hoods

Building air intake is provided through the outside air hoods installed in the Water Plant's exterior envelope.

1. Accumulation of snow, ice, and debris should be checked around wire mesh inlet screen to prevent obstruction of air flow.
2. All outside weather hoods should be cleaned with a mild detergent suitable for painted surfaces every six (6) months, or more frequent if needed. DO NOT USE ABRASIVE CLOTH, STEEL WOOL PADS OR SCOURING POWDERS.
3. Inspect the hoods for corrosion or damage.
4. The wire mesh outlet screen should be checked for debris to prevent the obstruction of air flow.
5. The fan assembly may be vacuumed.

(For more detailed maintenance information on the weather hoods, see Appendix Section 4.2.3.2.5 of this manual.)

3.3.2.6 Air Outlets and Inlets

Check all grilles, registers, and diffusers periodically for:

1. Obstructions and accumulation of dirt and debris.
2. Inspect for any corrosion or damage.
3. Check adjustable louvers and diffusers for proper positioning.

(For more detailed maintenance information on air outlets and inlets, see Appendix Section 4.2.3.2.6 of this manual.)

3.3.2.7 Air Cleaning Devices

Air filters are provided to remove particulates from the air and protect the fans of air handling equipment and intake fans from dirt and debris build-up, which can adversely affect the performance of the equipment.

1. Ensure that the proper filters are placed in the system.

NOTE:

Filters must have an airtight seal to prevent air bypass. If using other than original-equipment-manufacturer filters, apply foam gasketing to the vertical edges of the filter.

2. A filter gauge is mounted on the outside of the filter housing. The clean-filter pressure drop is 0.22” water gauge at 400 feet-per-minute face velocity. Filter replacement is recommended when the pressure drop reaches 0.9” water gauge.
3. Dispose of the filter as directed for this building.

(For additional information on air outlets and inlets, see Appendix Section 4.2.3.2.7 of this manual.)

3.3.2.8 Dampers

To maintain proper volume control, air balance, and fire boundary integrity, dampers must operate properly. To insure proper operation, dampers should be checked regularly.

WARNING:

When operating dampers, keep fingers and clothing away from damper blades. Failure to do so may result in serious injury or death from moving parts.

Improper installation, adjustment, alteration, service or maintenance can cause property damage, injury or death. Read the installation, operating, and maintenance instructions thoroughly before installing or servicing this equipment.

1. Damper actuators, louvers, linkages, springs, counterweights, and seals should be inspected for damage and operability.
2. Volume control dampers should be checked for full range smooth operation. If dampers are motorized, then dampers should be checked for full range motor driven operation.
3. Check back draft dampers for spring-return full closure in the absence of airflow to prevent air infiltration.
   A. If dampers are motorized, then dampers should be checked for full range motor driven operation.
   B. Check back draft dampers for spring-return full closure in the absence of airflow to prevent air infiltration.
   C. Check closure springs. If defective, repair or replace.
   D. Operate the damper by allowing the blades to drop or close.
   E. Check the damper for rust and / or corrosion.
   F. Clean damper blades and lubricate the working parts. Do not use petroleum-based products as they could cause excessive dust collection.
   G. Check the blades to make sure they completely close and lock (if a lock is used).
   H. Care should be taken to ensure that such tests are performed safely and do not cause system damage.
   I. Over the course of time, dirt and grime may collect on damper surfaces. The damper surfaces should be cleaned to prevent hindrance to airflow.

J. Lubricating the linkage, bearings, blades, etc., can prevent possible rusting and unnecessary friction increase. Use only a moli-spray oil or similar graphite based oil as regular lubricating oil will attract dirt.

K. Ball bearings with grease fittings require only minimal grease.

Fire dampers shall be maintained at intervals as stated in National Fire Protection Association (NFPA) publications 90A and 92A.

(For additional information about dampers, refer to Appendix Section 4.4.3.2.8 of this manual.)

3.3.2.9 Thermometers and Gauges

No routine maintenance is assigned for the gauges and thermometers used in the hydronic system at this time.

CAUTION:

When installing or replacing the thermometer, do not tighten by turning the thermometer case.

However, they should be inspected annually for damage, leaks, obstructions, and breakage. Repair as necessary.

(For additional information regarding the gauges and thermometers in the ventilation system, see Appendix Section 4.2.3.2.9 of this manual.)

3.3.3 Plumbing Systems

3.3.3.1 Plumbing Fixtures

3.3.3.1.1 Emergency Eyewash

The portable emergency eyewash unit (Equip. number ES00033) installed in the Water Plant is of a portable pressurized design. This unit provides instant eye relief in emergencies where a plumbed water supply is not available.

In addition to the maintenance procedures detailed in the monthly PM3413FM, the manufacturer has recommended the following procedures also be completed:

1. The emergency eyewash unit should be checked periodically for leaks, corrosion, or damage.
2. Clean and polish the emergency eyewash unit regularly with a quality silver cream, mild detergent or liquid soap, or commercial chrome polish and water. Do not use abrasive or caustic cleaners.

WARNING:

Water preservatives protect potable water from bacteria, fungi and algae growth for up to four (4) months. If a water preservative is not used with this eyewash, it is recommended that the tank be cleaned weekly, or as often as needed. Infection, loss of vision or other serious injury may result from misuse of this eyewash. DO NOT use expired, cloudily, colored or contaminated preservative solution. DO NOT save unused preservative solution.

NOTE:

The eyewash unit should be tested weekly per American National Standards Institute (ANSI) Standard Z358.1 (latest issue).

ANSI Standard Z358.1-1998, paragraph 5.5.2, requires a weekly activation of plumbed eyewash equipment to verify proper operation

Inspect Eye Wash Unit:

1. Visually inspect the pressure gauge weekly to ensure the unit is maintaining the proper pressure.
2. If the unit is not working properly, remove it from the hazard area immediately and correct the problem.

Clean Eye Wash Unit - When using potable water only:

1. Empty the tank any time from once per week to once per month, depending on the quality of your water supply. The manufacturer is not responsible for variations in the water supply.

WARNING:

DO NOT open the cover until the pressure gauge reads "0".

2. Open the tank by pulling up on the wire handle located on top of the Quicklock cover, push down, rotate, and remove the cover. Clean the inside of the tank using warm water and mild soap. Rinse the tank thoroughly with warm water.
3. Fill the container with seven (7) gallons of potable water. Replace the cover. Pressurize the tank to 95 psi by applying air pressure to the valve located beneath the pressure gauge.

NOTE:

The relief valve is designed to automatically vent at 100 - 130 psi to prevent the tank from over-pressurizing.

When using potable water and water preservative (recommended):

1. Empty the tank at least once every 120 days, depending on the quality of your water supply. The manufacturer is not responsible for variations in the water supply.

WARNING:

DO NOT open the cover until the pressure gauge reads "0".

2. Open the tank by pulling up on the wire handle locatd on top of the Quicklock cover, push down, rotate, and remove the cover. Clean the inside of the tank using warm water and mild soap. Rinse the tank thoroughly with warm water.
3. Fill the container with seven (7) gallons of potable water and the contents of an 8-ounce bottle of water preservative.
4. Replace the cover. Pressurize the tank to 95 psi by applying air pressure to the valve located beneath the pressure gauge.

NOTE:

The relief valve is designed to automatically vent at 100 - 130 psi to prevent the tank from over-pressurizing.

(For additional information regarding the emergency eyewash station in the ventilation system, see Appendix Section 4.2.3.3.1.1 of this manual.)

3.3.3.1.2 Water Cooler

The water cooler (Equip. # CW00043) should be flushed, cleaned, inspected, and adjusted per PM6208FA. The manufacturer recommends the unit be sanitized every six to twelve months, depending on the amount of water used and the sanitary conditions of the cooler location:

1. Unplug the cooler from the electrical outlet.
2. At regular intervals, inspect the wire grid around the cooler for lint and dust build up. Vacuum or clean with a brush. Regular cleaning will help to keep the cooler running efficiently and economically. The compressor is hermetically sealed and requires no lubrication.

NOTE:

Do not use "Fantastic" cleaner or similar products on plastic parts. These products contain chemicals that can cause the plastics to become brittle and discolored.

3. Cleaning Plastic Parts – Periodic cleaning of drip trap, faucet paddles and top of cooler are recommended. To clean plastic parts, use liquid soap and warm water. Avoid using abrasive cleaners.
4. Cleaning Cabinet Exterior – The cooler exterior can be cleaned with liquid soap and warm water. Make sure the washed parts are rinsed thoroughly and all soap residues are removed. (Do not use abrasive cleaners which can scratch surfaces.)
5. The filter used to filter the incoming water should be replaced quarterly.

(For additional information regarding the water cooler, see Appendix Section 4.2.3.3.1.2 of this manual.)

3.3.3.2 Plumbing Equipment

3.3.3.2.1 Backflow Preventers

Backflow preventers are installed at points where auxiliary systems are connected to the domestic water supply system. Their purpose is to prevent reverse-flow contamination of the water supply system.

The backflow preventers (Equip. RP03198) should be inspected and tested annually using PM #5204FA. The backflow preventer should periodically be inspected for evidence of discharge from the relief valve and replaced if necessary.

WARNING:

Spring assembly is factory assembled. DO NOT DISASSEMBLE!

IMPORTANT:

It is important that this device be tested periodically in compliance with local codes, but at least once per year or more as service conditions warrant. If installed on a fire sprinkler system, all mechanical checks, such as alarm checks and backflow preventers, should be flow tested and inspected internally in accordance with NFPA 13 and NFPA 25.

NOTE:

Rubber seat disc can be replaced. However, the disc holder and disc retainer are permanently bonded to prevent failure.

Align holes and insert pin or small screwdriver to hold in open position.

(Additional information regarding the backflow preventers is available in Appendix Section 4.2.3.3.2.1 of this manual.)

3.3.4 Water Intake and Treatment System

3.3.4.1 Sea Water Intake System

The sea water intake system consists of all the components in Buildings 124 and 179, and the insulated piping from these Buildings to the Water Plant.

3.3.4.1.1 Sea Water Intake Pumps

The Constant Pressure (CP) Water System is a variable-speed water system that uses a variable-speed control system and sub-mergeable pumps (Equip. # PU00128, PU00131, and PU00134) to deliver water at a constant pressure. The control panel and the lead/lag configured pumps are contained in Building 179.

Although the manufacturer does not list any specific maintenance instructions, flow rates from the pumps should be checked annually. Reduced flow rates may indicate a problem with the pumps.

WARNING:

Serious or fatal electrical shock may result from failure to connect the motor, CP Water Controller, metal plumbing and all other metal near the motor or cable to the power supply ground terminal using wire no smaller than motor cable wires. To reduce the risk of electrical shock, disconnect power before working on or around the water system. Capacitors inside the CP Water Controller can still hold a lethal voltage even after power has been removed. Allow 10 minutes for dangerous internal voltage to discharge. Do not use the motor in swimming areas.

Should an application or system problem occur, built-in diagnostics will protect the system. The "FAULT' light on the front of the CP Water Controller will flash a given number of times indicating the nature of the fault. In some cases, the system will shut itself off until corrective action is taken. Fault codes and their corrective actions can be found in the manufacturer's Subdrive Installation Manual. That and additional information regarding the sea water intake pumps is available in Appendix Section 4.2.3.4.7 of this manual.

3.3.4.1.2 Filter / Compressor / Solenoid Valve

Both the filter (with controls) and the compressor are located in Building 124. The filter is used to filter the sea water coming from the sea water pumps before it enter the Water Plant. The compressor is used to operate a pneumatic flush valve through a controlled pneumatic solenoid valve. The solenoid is located on the pneumatic air line between the filter and the compressor. The flush valve is mounted on the outlet side of the filter. Two isolation valves (one on the filter's input and one on the filter's output) are used to isolate the filter for maintenance. A by-pass valve is used to keep water flowing while the filter is out of the loop.

Filter:

Since the flushing valve is used to remove the debris from the filter automatically, the filter requires very little maintenance. The manufacturer recommends:

1. Periodic cleaning of the pre-strainer to remove large debris trapped in the chamber.
2. All fittings should be checked monthly for leaks and corrosion. Repair as necessary.

Compressor:

Here are tips to help increase the productivity of the compressor:

3-Way Solenoid Valve:

The manufacturer of the 3-way electric solenoid valve recommends the following maintenance:

WARNING:

Turn off electrical power supply and depressurize solenoid operator and/ or valve before making repairs.

CAUTION:

Solenoid must be fully reassembled because the housing and internal parts complete the magnetic circuit. Be sure to replace insulating washer at each end of non-molded coil.

1. The solenoid valve should be cleaned periodically. The time between cleaning will vary depending on medium and service conditions. In general, if the voltage to the coil is correct, sluggish valve operations, excessive noise or leakage will indicate that cleaning is required. Clean strainer or filter when cleaning the valve.
2. Keep the medium flowing through the solenoid operator or valve as free from dirt and foreign material as possible.
3. While in service, the solenoid operator or valve should be operated at least once a month to insure proper opening and closing.
4. Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. Replace any parts that are worn or damaged.

3.3.4.1.3 Intake Valves

Several different types of valves are used in the sea water intake system. Since these are only general steps, not all steps may apply to every valve.

WARNING:

Personnel making any adjustments to the valves should use equipment and clothing normally used to work with the process where the valve is installed.

The line must be depressurized before replacing the valve.

Handling of all valves, operators, and actuators must be carried out by personnel trained in all aspects of manual and mechanical handling techniques.

Valves on liquid service, which may be subjected to rapidly increasing temperature in the closed position, will need a positive means for relieving excessive cavity pressures.

NOTE:

To prevent freezing, drain all test instruments and hoses before placing them in their storage cases.

Weekly:

1. The valves should be inspected on a weekly basis for proper position setting, signs of leakage, corrosion, and damage. Replace if necessary.

Monthly:

Externally inspect valves to verify:

1. The gauges indicate normal supply water pressure is being maintained.
2. The valve is free of physical damage.
3. All valves are in the appropriate open or closed position.
4. There is no leakage or corrosion present on the exterior surfaces of the valve and flange connections.

Quarterly:

1. Cycle all system valves through fully open/closed positions if not done in the last 90 days.
2. Inspect all valves for signs of packing/flange leakage and the need for lubrication.

Every 5 years:

1. Valves and any associated strainers, filters, or restriction orifices shall be inspected internally (unless tests indicate a greater frequency is necessary) to verify that all components operate properly, move freely, and are in good condition.
2. Internal components shall be cleaned, repaired, or replaced as necessary in accordance with the manufacturer's instructions.
3. Any sign of leakage from the gland should be addressed immediately by tightening the gland nuts gradually and evenly in a clockwise direction 1/4 turn, or until the leakage stops. If no further adjustment is possible the packing should be replaced.
4. Whenever a stem is replaced, the packing should be changed also.

Relief Valve

Monthly:

1. The operating condition of the safety relief valve should be checked every 30 days to ensure it is protecting the system or component, or after any prolonged period of inactivity. The relief valve is checked by manually operating the lever on top of the relief valve to the full open position, the lever is then released allowing it to snap closed.
2. After the manual test is performed, the safety relief valve should be inspected for signs of leakage, corrosion, damage, or scale buildup.

WARNING:

Attempts to change safety relief valve settings will prevent it from relieving at rated capacity and thus causing the system/component to explode. Do not attempt to adjust the pressure setting of the safety relief valve.

The uncontrolled discharge of hot water from the safety relief valve can be very hazardous and could scald anyone in the vicinity. Make sure that proper discharge piping is in place at all times.

Corrosion, scale buildup, leakage or damage to safety relief valves are indications the safety relief valve may fail to provide over pressurization protection. Every 30 days the safety relief valve must be inspected and if any of the above conditions are noted it must be replaced.

Failure to follow these instructions could result in serious personal injury or death, and property damage.

(Additional information regarding the filter, compressor, and valves used in the sea water intake system is available in Appendix Section 4.2.3.4.12 of this manual.)

3.3.4.2 Chemical Solution Tanks and Injection Pump Assemblies

Chemical Solution Tanks:

The chemical solution tanks (Equip. # TN00019 and TN00020) are made from polyethylene with hinged removable covers. Daily inspect all external surfaces and flanges on the tanks for signs of leakage. Repair as necessary.

Chlorine Injection Pumps:

Under normal conditions, the "dia-Pump" injection pumps (Equip. # PU0198A, PU0198B, and PU0198C) do not require any significant amount of maintenance. The manufacturer recommends the following preventive maintenance periodically:

1. It is advised that periodic visual observations be made of the oil level to make sure that it is within 114" of the threads of the fill opening. The liquid end of the pump should also be inspected for leakage. These observations should be made regularly, at least every 48 hours.
2. The hydraulic fluid should be drained and replaced about twice a year, using the drain plug on the side of the pump. This change can be scheduled with the normal factory maintenance at seasonal periods.
3. The "dia-Pump" incorporates a unique check valve design whereas the discharge and suction piping NEED NOT be disturbed in order to service the valve cartridges.

NOTE:

PVC Head Pump-Remove Suction Valve Cap (Part #P-550-C) by removing the Valve Cap Screws (Part #P-567) and remove Suction Valve Cartridge (Part #544-C) using the special round lug tool provided. PVC is fragile do not use excessive force

4. The valve cartridge is a complete and integral unit and should not be disassembled for cleaning. If the valves are found to be worn and in need of replacement, an entire valve cartridge, either suction or discharge, should be ordered. The suction valve is the longer of the two valve cartridges. To clean the valve cartridges, soak in strong detergent and then blow dry with compressed air.

Pump Motors:

1. Inspect the motor at regular intervals, as determined by service conditions.
2. Keep the motor clean and the ventilation openings clear.
3. In addition to a daily observation of the overall condition, it is recommended that a regular inspection routine be set up.

The manufacturer recommends the following inspections and preventive maintenance be performed on a routine basis:

WARNING:

Before initiating maintenance procedures, disconnect all power to the motor and accessories.

For machines equipped with surge capacitors do not handle the capacitor until it is discharged by a conductor simultaneously touching all terminals and leads, including ground. This discharge conductor should be insulated for handling.

1. The interior and exterior of the machine should be kept free from dirt, oil, grease and conducting dust. Oily vapor, debris or dust may build up and block off ventilation.
2. The motor should be disassembled and thoroughly cleaned periodically, as needed.
3. Motors may be blown out with dry, compressed air of moderate pressure (30 psi, 207 kPa or less).

WARNING:

To prevent injury to eyes and respiratory organs, safety glasses and suitable ventilation or other protective equipment should be used. Operator must not use compressed air to remove dirt or dust from his person or clothing.

4. Screens and covers are provided as necessary for protection of the equipment and personnel. All screens must be kept free of dirt and debris to ensure proper ventilation and kept in place for protection of personnel.
5. Motors should be inspected at regular intervals to check for dirt, moisture, friction, and vibration.
6. Keep the insulation and mechanical parts of the motor clean.

7. Dust that is free from oil or grease may be removed by wiping with a clean, dry cloth, or preferably, by suction.
8. When grease or oil is present, wipe with a cloth moistened (but not dripping) with a petroleum solvent of a "safety type" such as Stoddard solvent or similar materials.
9. Petroleum solvents are flammable, but comparatively nontoxic.

WARNING:

Carbon tetrachloride is non-flammable, but is highly toxic. Suitable ventilation should be provided to avoid breathing vapors. When ventilation is not sufficient to prevent a distinct odor or carbon tetrachloride, a chemical cartridge respirator or gas mask must be used.

Failure to observe these precautions may result in injury to personnel.

10. The motor should not be subjected to extreme moisture conditions such as high humidity during shut down periods, exposure to water under pressure (such as hosing down) or severe weather conditions.
11. During prolonged periods of storage, the motor should be run at least once a week, or should be provided with heaters to guard against moisture condensation.
12. The insulation resistance of motors not in regular use should be checked with a megger, and, if necessary, the windings should be dried by appropriate means before energizing.
13. Check misalignment which may be caused by foundation settling.
14. Check to see if any pump vibration is being transmitted to the motor.
15. Check the motor mounting bolts and bracket holes to be sure they are tight.
16. Check transmission from adjacent machine or to flexible motor support structure, as well as by motor unbalance itself.

NOTE:

If vibration of 0.005" (0.127mm) or more is experienced under running conditions after above checks have been made, then it is highly probable there is some resonance in the system.

17. The guide bearings are vacuum degaussed, single row width Conrad type greasable ball bearings.

CAUTION:

The thrust capacity of these bearings vary with supplier and care should be taken to ensure that replacement bearings are equivalent to the original.

18. The condition of non-reverse couplings should be checked periodically by removing the top cap.

NOTE:

Whenever the dismantling of couplings is necessary, the use of witness marks will assure a balanced condition when reassembly is complete.

19. Bolts on both bolted couplings and non-reverse couplings should be checked periodically to be sure they are tight.
20. When greasing, stop the motor, remove the grease outlet plug and add grease with a hand-lever operated gun only. Add only the amount of grease specified by the manufacturer. Run the motor for about ten minutes before replacing the outlet plug.

NOTE:

For motors over 1800 RPM or extra severe duty, dusty locations, more frequent lubrication periods is recommended by the manufacturer.

21. The oil should be changed at regular intervals. Maintain proper lubrication by checking or changing the oil level periodically and adding oil when necessary. With the motor at stand still, fill the top bearing reservoir with a good grade of lubricating oil having a viscosity equivalent to S.A.E. #10W; 150 SUS (IS0 32) @ 100° F for ball bearings and S.A.E. #40W, 600 SUS @ 100° F for roller bearings. Overfilling should be avoided.

CAUTION:

High voltage and rotating parts can cause serious or fatal injuries. Installation, operation and maintenance of electric machinery should be performed by qualified personnel. Familiarization with NEMA Publication MG-2, Safety Standard for Construction and Guide for Selection, installation and Use of Electric Motors and Generators, the National Electrical Code and sound local practices is recommended.

For equipment covered by this instruction book, it is important to observe safety precautions to protect personnel from possible injury. Among the many considerations, personnel should be instructed to:

- **Avoid contact with energized circuits or rotating parts.**
- **Avoid bypassing or rendering inoperative any safeguards or protection devices.**
- **Avoid use of automatic-reset thermal protection where unexpected starting of equipment might be hazardous to personnel.**
- **Avoid contact with capacitors until safe discharge procedures have been followed.**
- **Be sure the shaft key is fully captive before the motor is energized.**
- **Avoid extended exposure in close proximity with high noise levels.**
- **Use proper care and procedures in handling, lifting, installing, operating and maintaining the equipment.**
- **The motor should be lifted by the lugs provided. Do not lift anything but the motor with the motor lifting means.**

CAUTION:

Motors with oil lubricated ball or roller bearings (320-440 frame) that are going to be stored for any period of time should have the oil reservoir filled to the center of the sight gage with a good grade of rust inhibiting oil.

Safe maintenance practices by qualified personnel are imperative. Before starting maintenance procedures, be positive that:

- **Equipment connected to the shaft will not cause mechanical rotation.**
- **Main machine windings and all accessory devices associated with the work area are disconnected from electrical power sources.**

If a high potential insulation test is required, procedures and precautions outlined in NEMA Standard MG-1 and MG-2 should be followed.

Failure to properly ground the frame of this machine can cause serious injury to personnel or death. Grounding should be in accordance with the National Electrical Code and consistent with sound local practice.

(Additional information regarding the chemical solution tanks and metering pump is available in Appendix Section 4.2.3.4.1 of this manual.)

3.3.4.3 Calcium Carbonate Bed Tanks

Inspect all external surfaces and flanges on the tanks (Equip. # TN00017 and TN00018) for signs of leakage.Repair as necessary.

3.3.4.4 Thermometers and Gauges

No routine maintenance is assigned for the gauges and thermometers at this time.

CAUTION:

When installing or replacing the thermometer, do not tighten by turning the thermometer case.

However, they should be inspected annually for damage, leaks, obstructions, and breakage. Repair as necessary.

(Additional information regarding the thermometers and gauges is available in Appendix Section 4.2.3.4.3 of this manual.)

3.3.4.5 Fresh Water Storage Tanks

The fresh water storage tanks (Equip. # TN00010, TN00011, and TN00016) require the following inspections and maintenance:

1. Inspect all external surfaces and flanges on the tanks for signs of leakage.Repair as necessary.
2. Inspect tank stacks and covers for air restriction and corrosion. Clean and preserve as necessary.
3. Annually drain, clean, and inspect the interior of the fresh water tanks. Remove all rust and corrosion, and preserve as needed.

(Additional information regarding the fresh water storage tanks is available in Appendix Section 4.2.3.4.4 of this manual.)

3.3.4.6 Sea Water Surge and Expansion Tanks

Surge Tank:

The sea water surge tank (Equip. # TN000008) require the following inspections and maintenance:

1. Inspect all external surfaces and flanges on the tank for signs of leakage.Repair as necessary.

(Additional information regarding the sea water surge tank is available in Appendix Section 4.2.3.4.5 of this manual.)

Expansion Tanks:

The expansion tanks (ET-SW1 and ET-SW2) in the Sea Water Treatment System were pre-charged to the design system operating pressure prior to being placed into operation. Although the tanks themselves do not require maintenance, the precharge should be checked yearly, and more frequently as the systems age.

WARNING:

Read carefully the manufacturer's installation, operating and maintenance instructions manual to avoid serious personal injury and property hazards, and to ensure safe use and proper care of this product.

Explosion or rupture hazard. The expansion tank must re operated so that the pressure does not exceed the maximum working pressure.

This product contains a chemical known by the State of California to cause cancer. This product contains a chemical known by the State of California to cause birth defects or other reproductive harm.

Domestic, potable or fresh water can cause serious corrosion in a tank. This can result in leakage and a potential explosion. Do not use for domestic, potable or fresh water. Failure to follow this instruction will result in serious personal injury or death and property damage.

Excessive pressure can cause tank to explode. Exercise care when filling a tank with air so the pressure does not exceed that required or does not exceed the working pressure of the tank as stamped on the nameplate. Failure to follow these instructions will result in serious personal injury or death and property damage.

Expansion tanks cannot be properly air charged other than at ambient temperature.

If the expansion tanks were not equipped with a precharge pressure gauge, an accurate pressure gauge should be used to check the pressure at the charging valve. Check the tank for indications of rusting and leaks, paying particular attention to connections.

(Additional information regarding the expansion tanks used in the sea water treatment system is available in Appendix Section 4.2.3.4.5 of this manual.)

3.3.4.7 Sea Water Heat Exchangers

The shell and tube heat exchanger used to pre-heat the incoming sea water was designed to require low maintenance. However, to keep the heat exchanger operating at peak performance, it does require some maintenance. The manufacturer recommends the following preventive maintenance:

1. Frequently, and at regular intervals, observe the interior and exterior condition of all the tubes and keep them clean. Failure to keep the tubes clean may result in complete stoppage of flow and over-heating of the tubes.
2. When removing the tubes for inspection and cleaning, care should be taken to see that they are not damaged.

CAUTION:

Handle tubes carefully, they are made from thin metal.

Do not handle tube bundles with hooks or other tools which might damage the tubes. They should be moved about on cradles or skids.

Horizontal tube bundles should be lifted by means of suitable slings.

Bundles can be easily damaged by dragging a bundle over a rough surface.

CLEANING PRECAUTIONS:

Do not attempt to clean tubes by blowing steam through individual tubes. This over heats the tube and results in severe expansion strains and possible leaky tube joints.

Do not blow out heat exchangers with air when fluids normally handled are flammable.

In cleaning a tube bundle, tubes should not be hammered on to remove hard scale. In case it is necessary to use scrappers, make sure that the scrapper is not sharp enough to cut the metal of the tubes.

If scaling or other fouling is expected, provisions in the piping can be made to allow connections for flushing out or chemical circulation cleaning.

3. Circulate hot wash oil or light cleaner through tubes. Oil or cleaner shot at high velocity will effectively remove sludge or other similar soft deposits.
4. Soft salt deposits may be washed out by circulating hot fresh water.
5. Some commercially available cleaning compounds may be used for removing sludge, provided hot wash oil or water, as described above, do not give satisfactory results.
6. If none of the above methods are effective for the removal of a hard scale or other deposits, mechanical means may be used for straight tube heat exchangers.
7. Gaskets and gasket surfaces should be thoroughly cleaned. Gaskets and surfaces should be free of scratches and other defects. New gaskets should be used for re-assembling the heat exchanger.

(Additional information regarding the sea water heat exchangers is available in Appendix Section 4.2.3.4.6 of this manual.)

3.3.4.8 Pumps

Fresh Water Pumps:

The manufacturer recommends the following preventive maintenance be performed periodically:

WARNING:

Read all manufacturer's documentation before attempting to install, operate or repair these pumps. Properly installed, the pumps will give satisfactory and dependable service. The manufacturer urges that personnel read carefully all step-by-step instructions, to simplify any problems of installation, operation, or repair.

The manufacturer requires that all personnel that are responsible for installation, operation, or maintenance of the equipment, have access to and study the product instruction manual(s) BEFORE any work is done and that they comply with all local and industry based safety instructions and regulations.

Do not remove or paint over any safety labels. if labels are lost or damaged, contact your Peerless Pump representative for replacement.

Do not exceed the forces or moments specified on the outline drawing when connecting piping to the suction or discharge flanges.

The area around the pump unit must be kept clear of debris to reduce the possibility of fire or explosion due to debris coming into contact with hot surfaces of the unit.

Ensure that the driver is disabled and/or locked out when servicing the pump or coupling.

Access to the equipment should be restricted to the personnel responsible for installation, operation, and maintenance. These personnel must be trained, adequately qualified, and supplied with the appropriate tools for their respective tasks.

The manufacturer requires that all personnel responsible for installation, operation, or maintenance of the equipment, have access to and study the product instruction manual BEFORE any work is done and that they will comply with ail local and industry based safety instructions and regulations.

Do NOT wear loose or frayed clothing or jewelry that could catch on the controls or become trapped in the equipment.

WARNING:

Use only qualified personnel (riggers) to lift or move unit at any time. Never lift unit using hooks or slings on shafts.

Never place eyebolts in tapped holes except for removal of a part to perform service work (i.e. Use eyebolt in tapped hole in upper case half only to lift upper case half, not to lift entire pump).

Use proper lifting techniques when manually lifting components - keep component close to body, back straight, lift with legs, DO NOT BEND AT THE WAIST.

Do not place hands under component in such a way that the component would fall on the hands if dropped.

Do not place fingers, hands, arms, etc. into the suction or discharge openings or into any other opening (such as the air relief valve hole). DO NOT touch the impeller, if rotated, this can cause severe injury. To prevent ingress of any objects, retain the protective covers or packaging in place until removal is necessary for installation. If the packaging or suction or discharge covers are removed for inspection purposes, replace afterwards to protect the pump and maintain safety.

The area between the stuffing box and bearing bracket is left open to allow for inspection and adjustment of packing. DO NOT place hands or fingers into this area. DO NOT wear loose clothing, long hair, or jewelry around this area. Failure to abide by this requirement could result in entanglement or friction bums.

Do not use excessive force when adjusting packing glands as wrench slippage can result in impact of the hand against the casing.

Use only qualified electricians for electrical installation and maintenance.

Refer to manuals provided with electrical components and disconnect power supply as recommended for servicing. Ground the unit according to local codes.

Most surfaces on the driver motor can become hot during normal operation. The stuffing box and bearing bracket areas on the pump can become hot in the event of a malfunction or maladjustment. These surfaces may remain hot for some time after the unit has been shut down. Use care when touching these surfaces and wear protective gloves if necessary to touch these surfaces when hot.

If packing is too tight, the drain water from the stuffing box can become hot enough to scald. Ensure that drain water is not excessively hot before extensive contact.

WARNING:

Isolate the equipment before any maintenance work is done. Switch off the mains supply, remove fuses, apply lock-outs where applicable and affix suitable isolation warning signs to prevent inadvertent re-connection.

Shut down pump. Disconnect power to the pump driver before starting any repairs.

1. Clean all metal parts (except bearings) with a solvent. Use a bristle brush (NOT metal or wire) to remove tightly adhering deposits. A fiber scraper may be used to remove the gasket and shellac from casing flanges.
2. Periodically check elastomeric coupling sleeves for any visible evidence of deterioration. If deterioration is apparent, the coupling sleeve must be replaced.
3. Visually inspect parts for damage affecting serviceability or sealing. Emphasize inspection of mating parts having relative motion - wear rings, for example.
4. Check O-rings and bearing cover gaskets for cracks, nicks or tears; packing rings for excessive compression, fraying or shredding, embedded particles (dirt or metal). Replace if defective in any way.
5. Mount the shaft between centers or on vee blocks. Check for eccentricity throughout entire length with a dial indicator; eccentricity must not exceed 0.003 inch total indicator reading.
6. Measure the outside diameter (OD) of the impeller wear surface or impeller ring and the inside diameter (ID) of the casing ring. Compute the diametrical clearance (ID minus OD). If measured diametrical clearance exceeds manufacturer's values, repair to restore design clearance is recommended.
7. Examine impeller passages for cracks, dents, gouges, or embedded material.
8. Periodically clean bearings using a suitable solvent. Blow the solvent out of the bearing with dry filtered air. Lubricate bearings immediately after cleaning with a light spindle oil. DO NOT spin bearings during cleaning.
9. Inspect the inside diameter of the casing rings. Replace if grooved, scored, or eccentric.
10. Inspect and replace worn shaft sleeves.
11. Straighten or replace shafts having excessive run-out (eccentricity).

Lubrication:

Couplings with elastomeric drive parts do not require lubrication. Most other couplings require some form of lubrication. After completion of installation and alignment, and before operating the unit, lubricate coupling in accordance with manufacturer's specific instructions contained in the pump installation packet or on an instruction tag. Reasonable care and proper lubrication of pump bearings is essential. Lubricant is normally grease; oil is optional on some pump types. The lubricant provides a film between the rolling elements and races, giving low friction, and preventing excessive temperature rise and corrosion. Lithium soap base, meeting National Lubricating Grease Institute Grade 2 specifications is recommended. This has a safe operating temperature pop to 250° F.

Motor:

The key to minimizing motor problems is scheduled routine inspection and service. The frequency of routine service varies widely between applications. A motor may require additional or more frequent attention if a breakdown would cause health or safety problems, severe loss of production, damage to expensive equipment or other serious losses. The routine inspection and servicing can generally be done without disconnecting or disassembling the motor.

The manufacturer recommends the following inspections and maintenance:

1. Wipe, brush, vacuum or blow accumulated dirt from the frame and air passages of the motor.
2. Feel for air being discharged from the cooling air ports. If the flow is weak or unsteady, internal air passages are probably clogged. Remove the motor from service and clean.
3. Check for signs of corrosion.
4. In wet or corrosive environments, open the conduit box and check for deteriorating insulation or corroded terminals. Repair as needed.
5. Lubricate the bearings only when scheduled or if they are noisy or running hot. DO NOT over-lubricate. Excessive grease and oil creates dirt and can damage bearings. During scheduled greasing, remove both the inlet and drain plugs. Pump grease into the housing using a standard grease gun and light pressure until clean grease comes out of the drain hole.
6. Whenever the motors are disassembled for service, check the bearing housing. Wipe out any old grease. If there are any signs of grease contamination or breakdown, clean and repack the bearing system.
7. Feel the motor frame and bearings for excessive heat or vibration. Listen for abnormal noise. All indicate a possible system failure. Promptly identify and eliminate the source of the heat, noise or vibration.

8. Observe the brushes while the motor is running. The brushes must ride on the commutator smoothly with little or no sparking, and no brush noise (chatter).

Flush & Clean / Supply Pumps:

The manufacturer recommends the following preventive maintenance be performed on the clean and supply pumps:

1. Daily observe the pumps while in operation for unusual noises and if present, fix the pump before putting it back into operation.
2. Bearings on some pedestal pumps and some motors are prelubricated and require no additional lubrication. Schedule for regreasing other types of bearings will vary, depending on size, speed, duty, and environmmt. For example, a steady running, indoor installation in a relatively clean atmosphere at 104° F ambient should not require grease for two years. Care should also be taken not to over grense motors.
3. Pumps handling corrosive or otherwise aggressive solutions should be flushed with clean water after each use because stagnant conditions are usually most corrosive. In sea water, Ampco
4. To prevent crevice corrosion and pitting in pumps exposed to sea water, drain and then flush out the pump with fresh water when inactive for periods greater than one week.
5. The mechanical seal where the shaft enters the pump should be replaced at the first sign of leakage.

Motors:

The manufacturer of the motors used on these pumps recommends the following inspections and preventive maintenance:

WARNING:

Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

Be sure the system is properly grounded before applying power.

Do not apply AC power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code and Local codes must be carefully followed.

This equipment may be connected to other machinery that has rotating parts or parts that are driven by this equipment. Improper use can cause serious or fatal injury. Only qualified personnel should attempt to install operate or maintain this equipment.

WARNING:

Do not bypass or disable protective devices or safety guards. Safety features are designed to prevent damage to personnel or equipment. These devices can only provide protection if they remain operative.

Be sure the load is properly coupled to the motor shaft before applying power. The shaft key must be fully captive by the load device. Improper coupling can cause harm to personnel or equipment if the load decouples from the shaft during operation.

Use proper care and procedures that are safe during handling, lifting, installing, operating and maintaining operations. Improper methods may cause muscle strain or other harm.

Before performing any motor maintenance procedure, be sure that the equipment connected to the motor shaft cannot cause shaft rotation. If the load can cause shaft rotation, disconnect the load from the motor shaft before maintenance is performed. Unexpected mechanical rotation of the motor parts can cause injury or motor damage.

Disconnect all electrical power from the motor windings and accessory devices before disassembly of the motor. Electrical shock can cause serious or fatal injury.

UL Listed motors must only be serviced by UL Approved Authorized Service Centers if these motors are to be returned to a hazardous and/ or explosive atmosphere.

CAUTION:

To prevent premature equipment failure or damage, only qualified maintenance personnel should perform maintenance.

Do not over-lubricate motor as this may cause premature bearing failure.

Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load from the motor shaft before moving the motor.

If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20° angle from the shank of the eye bolt or lifting lug. Excessive lifting angles can cause damage.

To prevent equipment damage, be sure that the electrical service is not capable of delivering more than the maximum motor rated amps listed on the rating plate.

If a HI POT test (High Potential Insulation test) must be performed, follow the precautions and procedure in NEMA MG1 and MG2 standards to avoid equipment damage.

1. Inspect the motor at regular intervals, approximately every 500 hours of operation or every 3 months, whichever occurs first. Check that the motor is clean. Check that the interior and exterior of the motor is free of dirt, oil, grease, water, etc. Oily vapor, paper pulp, textile lint, etc. can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
2. Use a "Megger" periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance.
3. Check all electrical connectors to be sure that they are tight.

Relubrication & Bearings:

Bearing grease will lose its lubricating ability over time, not suddenly. The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions. Good results can be obtained if the following recommendations are used in your maintenance program.

Type of Grease A high grade ball or roller bearing grease should be used. Recommended grease for standard service conditions is Polyrex EM (Exxon Mobil).

Equivalent and compatible greases include: Texaco Polystar, Rykon Premium #2, Pennzoil Pen 2 Lube and Chevron SRI.

Some motor designs use different bearings on each motor end. This is normally indicated on the motor nameplate. In this case, the larger bearing is installed on the motor Drive endplate. For best relubrication results, only use the appropriate amount of grease for each bearing size (not the same for both).

CAUTION:

To avoid damage to motor bearings, grease must be kept free of dirt. For an extremely dirty environment, contact your distributor or an authorized service center for additional information.

Do not over-lubricate motor as this may cause premature bearing failure.

Be sure that the grease you are adding to the motor is compatible with the grease already in the motor. Consult your distributor or an authorized service center if a grease other than the recommended type is to be used.

High Pressure Pump:

Although the high pressure pump used in the RO Unit was designed to simply maintenance and make service easier, the manufacturer still recommends the following daily and monthly preventive maintenance procedures:

Daily:

1. Check the level of the crankcase lubricating oil. The crankcase holds 21/2 gallons for triplex models and (5 gallons for quintuplex models) of S.A.E. 40 standard motor oil, non-detergent. In extremely cold weather S.A.E. 30 may be used. In any case, S.A.E. 40 must be used at speeds below 50 R.P.M.
2. The pump requires a turbine oil of approximately 76 S.S.U.V. at 210° F.
3. Pumps equipped with grease fittings for lubricating the stuffing boxes should be greased daily when pumping crude oil, or as often as required when pumping
   non-lubricating fluids such as water, products, etc. If preferred, grease the packing with lithium-base grease, or with water pump grease. If a stuffing box force-feed lubricator is installed, check the oil level. Fill if necessary.
4. Use a spanner wrench to tighten the stuffing box nut. It should be wrench tight at all times.
5. Keep the pump clean.

Monthly:

1. Drain and refill the crankcase two weeks after initial startup, and every six months thereafter, or immediately whenever foreign matter enters the crank end.
2. Wash the crankcase air filter in kerosene.
3. Inspect the pump vales for signs of wear. Worn discs may sometimes be flipped over. Valve springs should be replaced if worn, broken, or bent out of shape. Seat faces may show uniform wear - but must be replaced if fluid cut, or grooved.
4. Crankshaft bearing and connecting rod wrist pins should be checked for excess "play" and corrective measures taken.
5. Tighten all studs, nuts, and cap screws.
6. Check for gasket leaks and inspect all connections. Observe plunger for signs of grooves or damage. Replace if worn.
7. Keep the pump clean. It will aid in spotting troubles before they become serious. Keep the stuffing box sump drain clean.

(Additional information regarding these pumps and motors is available in Appendix Section 4.2.3.4.7 of this manual.)

3.3.4.9 Turbocharger

The turbocharger has no scheduled maintenance. There are no shaft couplings to align, no shaft seals, no lubrication required, and no external auxillary services such as cooling water or pneumatic requirements.

However, if the installed pressure gauges indicate that the turbocharger is not producing the normal pressure boost (large pressure drop) in the feed stream, then it needs to be inspected. A small pressure drop may indicate a change in membrane performance or feed water salinity or water temperature change. If an inspection is required, the unit will have to be removed from the system and disassembled.

WARNING:

Relieve all pressure and drain water before attempting to remove this device from the system.

(Additional information on the turbocharger is available in Appendix Section 4.2.3.4.8 of this manual.)

3.3.4.10 Treatment Controller

Maintenance on the controller requires only that the operator periodically clean and calibrate the electrodes. The controller is designed for factory maintenance only. There are no field serviceable parts. Service should be performed only by factory authorized service personnel. Modification to or tampering with the circuit level components, makes all warranties, written or implied, andlor manufacturer's responsibility for this controller null and void.

(Additional information on the controller is available in Appendix Section 4.2.3.4.9 of this manual.)

3.3.4.11 Reverse Osmosis (RO) Units & Membranes

Although the RO Units (Equip. # RO00001 and RO00002) were designed to require low maintenance, improper service can result in problems. The manufacturer recommends the following preventive maintenance schedule:

WARNING:

When handling chemicals, always wear safety apron, gloves and glasses.

General Maintenance:

1. The seacock should be opened and closed monthly to ease operation.

2. The sea strainer should be checked every two weeks or when it is suspected that it needs cleaning.
3. To prevent the system from becoming clogged with small particles, the manufacturer recommends the system be backflushed periodically.

CAUTION:

No chlorine should be used in any of the RO system piping or supplies unless adequate precautions are taken to insure that the chemicals do not contact the RO membranes.

No cleaning chemicals, oils, solvents, or injection chemicals shall be introduced into the RO system pre-membrane piping without written permission from the RO manufacturer.

4. The system should be washed and rinsed routinely (except the control box).
5. Touch up marred or chipped painted surfaces.
6. Replace gauges when necessary. Clean the glass and base when needed.
7. Clean the flow meters with cleaning chemicals when necessary. Do not expose the flow meters to Zylene or similar products and thinners. Flush flow meters after cleaning with fresh water.
8. PVC threaded fittings should be removed and new Teflon tape applied when leaks occur. The fitting should be renewed if necessary. Fittings should be cleaned on the exterior when necessary. Stainless steel fittings should be cleaned and polished when necessary.
9. Maintain the chemical injection pumps per their manufacturer's recommendations.
10. Leaks should be attended to immediately to prevent corrosion damage. Threaded fittings should be removed and new Teflon tape applied when leaks occur. The fitting and ferrules should be renewed if necessary.
11. Electrical components should be replaced as necessary.
12. Fuses - Replace as is necessary.
13. Change the high pressure pump crankcase oil after the first week of operation, then follow the regular maintenance schedule for the pump.

CAUTION:

Never tighten a fitting while it is under pressure.

14. Repair or tighten leaking fittings, hoses, etc.

Daily:

1. Check the level of liquid in the sequestrant (MF-600) tank, replenish as necessary.
2. Check that the chemical injection pump is operating.
3. Check the level of the slurry mix. Refill with RO product water, then a 4:l ratio of PZ 75 (sodium carbonatelbicarbonate): MP-07 (passivating phosphate), then agitate as necessary.
4. Read and record the pre-media filter pressure.

NOTE:

If the high pressure system is pumping the original volume, the pre-media filter pressure should not change.

5. Read and record the pre-cartridge filter pressure. A reduction of 5-10 or more psid will require media backwashing.
6. Read and record the pump suction pressure. Exchange or clean filter cartridges when this gauge reads 20 psig (1.4 BAR) or less.
7. Examine the crankcase oil sight glass on the high pressure pump. Look for contamination of the oil or the presence of water. If contaminated change the oil per the manufacturer's instructions. It should always be at the halfway level while the pump is operating.
8. Observe the high pressure pump. Check for excessive leakage of water from the pump packing. A small leak is desirable. If leakage has increased since last inspection, tighten the packing. Tighten the packing only until the leakage has been reduced to a trickle. Over tightening the packing causes excessive friction on the plungers (they may crack) and wear on the packing.
9. Record any maintenance performed in the log book or on the back of the sheet, including tank refills, dampener charges, refill of pump oil, etc.

Weekly:

1. Inspect the V-belts on the high pressure pump drive with the RO system shutdown. With an applied force of 6 to 9 lbs., a belt should not deflect more than 112". Check each belt separately. Should the belts be loose, tighten them by first loosening the motor base bolts then turn the bolt(s) on the motor mount clockwise.

2. Charge the suction accumulator with air to 4-6 psi less than the normal pump suction pressure. Charge the discharge pulsation dampener to 80% of the RO system's operating pressure. All charges are applied while the unit is "OFF".
3. Backwash and fresh flush the media filters singularly and in sequence.
4. Clean the supply pump's suction strainer.

Monthly:

1. Check the tank solution injection rate. It should be five gallons per day. Adjust the strokelfrequency as necessary to obtain the desired flow rate.
2. Clean the small strainer at the ERT bypass/regulating valve piping, located at the ERT.
3. Check or recalibrate control sensors (flow meters, conductivity probe, pressure switches, etc.).

Quarterly:

1. Change the high pressure pump crankcase oil.
2. Check the high pressure pump plungers for scoring or wear.
3. Grease motor bearings on the high pressure pump.
4. Routinely clean or sterilize the RO system
5. Refill the glycerine in any gauge which is not showing only a small bubble of air at the top
6. Backflush the media filter when there is a 10 psid (0.7 BAR), or more, differential between the inlet and outlet of the filter. Sterilize the filter if the unit is not going to be used for two weeks or more. Back flush filter for 30 minutes when returning to service.
7. Change the bag filter when there is a 15 psi or more differential between the inlet and outlet of the filter. Ensure that the filter housing is clean of debris when replacing bag by rinsing the housing and allowing to drain.
8. Change the cartridge elements before the pump suction/fine filter outlet pressure reaches between15 and 20 psi. Ensure housing is free of debris and clean and rinse as is necessary. Flush filters with fresh water before changing, this will prevent salt water from spilling on other components.

NOTE:

Do not operate the system without the filter cartridge elements being installed.

9. Tighten drive belts (if supplied) when the deflection exceeds .5", or if a reduced flow is observed when the high pressure pump is running.

CAUTION:
Tighten belts with the control power off.

Membranes:

General Cleaning Tips

WARNING:
When handling chemicals, always wear safety apron, gloves and glasses.

1. It is strongly recommended to clean the stages of the RO or NF system separately. This is to avoid having the removed foulant from stage pushed into the another stage resulting in minimal performance improvement from the cleaning. Weekly Flush the RO membranes with non-chlorinated product water after shutdowns and under low pressure weekly. Clean the membranes every 4 - 6 months with non-chlorinated cleaners, or as needed. If there is suspected fouling then clean the membranes with the chemical that is best prescribed. Always sterilize the membranes when they will not be used for one week or more to prevent bacteria from growing. Flush the membranes with fresh water after each use.
2. For multi-stage systems, while each stage should be cleaned separately, the flushing and soaking operations may be done simultaneously in all stages.
3. Fresh cleaning solution needs to be prepared when the cleaning solution becomes turbid and/or discolored.
4. Use alkaline cleaning as the first cleaning step. Acid cleaning should only be applied as the first cleaning step if it is known that only calcium carbonate or iron oxide/hydroxide is present on the membrane elements. If the RO system suffers from colloidal, organic fouling or biofouling in combination with calcium carbonate, then a two-step cleaning program will be needed: alkaline cleaning followed by an acid cleaning. The acid cleaning may be performed when the alkaline cleaning has effectively removed the organic fouling, colloidal fouling and biofouling.
5. Always measure the pH during cleaning. If the pH increases more than 0.5 pH units during acid cleaning, more acid needs to be added. If the pH decreases more than 0.5 pH units during alkaline cleaning, more caustic needs to be added.

6. It is recommended to circulate the cleaning solution regularly in order to maintain the temperature (temperature should not drop more than 5°C) and add chemicals if the pH needs to be adjusted.
7. Turbid or strong colored cleaning solutions should be replaced. The cleaning is repeated with a fresh cleaning solution.
8. If the system has to be shutdown for more than 24 hours, the elements should be stored in 1% w/w sodium metabisulfite solution.

(Additional information regarding the reverse osmosis system, including the membranes, used in the sea water treatment system is available in Appendix Section 4.2.3.4.10 of this manual.)

3.3.4.12 Metering

3.3.4.12.1 pH Monitor/Recorder & Meter

Since the pH Monitor/Recorder (Equip. # IT00060) and meter (Equip. # IT0198C)was designed for maximum unattended operation on a continuous basis, the manufacturer did not list any required maintenance.

(Additional information regarding the pH monitor used in the sea water treatment system can be found in Appendix Section 4.2.3.4.11.1 of this manual.)

3.3.4.12.2 Flow Meter & Sensor

The flow meter (Equip. # IT0198A) is a battery-powered instrument capable of providing uninterrupted flow and total volume based on information from the flow sensor.

The only preventive maintenance listed by the manufacturer is to:

1. Check the meter for low battery power and replace the battery if necessary.
2. Inspect the sensor fitting for possible leaks and repair if necessary.

CAUTION:

Do not remove the sensor from pressurized lines.

Do not exceed the maximum temperature/pressure specifications of the sensor.

Do not install/service without following installation instructions.

Wear safety goggles and face shield during installation/service.

Do not alter product construction.

Failure to follow these safety instructions could result in severe personal injury.

(Additional information regarding the flow meter and sensor used in the sea water treatment system can be found in Appendix Section 4.2.3.4.11.2 of this manual.)

3.3.4.13 Mixers

The manufacturer of the large mixer (Equip. # LE0198A) and the small mixer (Equip. # LE0198B) used on the soda ash tank has recommended the following inspections and preventive maintenance:

WARNING:

Before initiating maintenance procedures, disconnect all power sources to the motor and accessories.

For machines equipped with surge capacitors do not handle the capacitor until it is discharged by a conductor simultaneously touching all terminals and leads, including ground. This discharge conductor should be insulated for handling.

Replace all normal grounding connections prior to operating.

Failure to observe these precautions may result in injury to personnel.

1. The interior and exterior of the mixer should be kept free from dirt, oil, grease and conducting dust. Oily vapor, debris or dust may build up and block off ventilation.
2. Screens and covers are provided as necessary for protection of the equipment and personnel. All screens must be kept free of dirt and debris to ensure proper ventilation and kept in place for protection of personnel.
3. The motor should be disassembled and thoroughly cleaned periodically, as needed.

4. Motors should be inspected at regular intervals for dirt, moisture, fiction, and vibration. Keep the insulation and mechanical parts of the motor clean. Dust that is free from oil or grease may be removed by wiping with a clean, dry cloth, or preferably, by suction. Dust may be blown from inaccessible parts with clean, dry air, using not more than (30 psi 207 kPa or less). Cleaning by suction is preferred because of the possibility of water in compressed air lines and the danger of blowing metal chips into the insulation with compressed air.

WARNING:

To prevent injury to eyes and respiratory organs, safety glasses and suitable ventilation or other protective equipment should be used. Operator must not use compressed air to remove dirt or dust from his person or clothing.

5. When grease or oil is present, wipe with a cloth moistened (but not dripping) with a petroleum solvent of a "safety type" such as Stoddard solvent or similar materials. When a material is difficult to remove, carbon tetrachloride is more effective than petroleum solvents. Wear rubber gloves to prevent skin irritation when using either petroleum solvents or carbon tetrachloride. Petroleum solvents are flammable, but comparatively nontoxic.

WARNING:

Carbon tetrachloride is non-flammable, but is highly toxic. Suitable ventilation should be provided to avoid breathing vapors. When ventilation is not sufficient to prevent a distinct odor or carbon tetrachloride, a chemical cartridge respirator or gas mask must be used.

Failure to observe these precautions may result in injury to personnel

6. The motor should not be subjected to extreme moisture conditions such as high humidity during shut down periods, exposure to water under pressure (such as hosing down) or severe weather conditions.
7. During prolonged periods of storage, the motor should be run at least once a week, or should be provided with heaters to guard against moisture condensation.
8. The insulation resistance of motors not in regular use should be checked with a megger, and, if necessary, the windings should be dried by appropriate means before energizing.
9. The mixer should be periodically checked for unusual vibration and noises.

NOTE:

If vibration of 0.005" (0.127mm) or more is experienced under running conditions, then it is highly probable there is some resonance in the system.

10. The condition of non-reverse couplings should be checked periodically by removing the top cap. If dirt has caused the action of the pins or balls to become sluggish, the pin or ball carrier should be removed, disassembled and thoroughly cleaned with a suitable solvent.

NOTE:

Whenever the dismantling of couplings is necessary, the use of witness marks will assure a balanced condition when reassembly is complete.

11. The manufacturer recommends lubrication of the motor anywhere from six (6) months to a year depending on operating conditions, atmosphere, and temperature. When greasing, stop the motor, remove the grease outlet plug and add grease. Run the motor for about 10 minutes before replacing the outlet plug.

CAUTION:

For motors over 1800 RPM or extra severe duty, dusty locations, frequency of lubrication should be more often.

Over greasing is a major cause of bearing and motor failure. Make sure dirt and contaminants are not introduced when adding grease.

12. Maintain proper lubrication of the motor top bearing by checking the oil level periodically and adding oil when necessary. With the motor at standstill, fill the top bearing reservoir with a good grade of lubricating oil having a viscosity equivalent to S.A.E. #l0w; 150 SUS (IS0 32) @ 100° F for ball bearings and S.A.E. #40W, 600 SUS @ 100° F for roller bearings.

CAUTION:

Motors with oil lubricating ball or roller bearings (320-440 frame) that are going to be stored for any period of time should have the oil reservoir filled to the center of the sight gage with a good grade of rust inhibiting oil.

13. Change oil at regular intervals. The time between oil changes depends upon the severity of operating conditions, and hence, must be determined by the motor user.

(Additional information regarding the mixer and motor used in the sea water treatment system can be found in Appendix Section 4.2.3.4.14 of this manual.)

3.3.4.14 Chlorine Analyzer

The manufacturer of the chlorine analyzer (Equip. # IT0198B) recommends the following inspections and preventive maintenance at the intervals indicated:

WARNING:

To familiarize yourself with handling precautions, dangers and emergency procedures, always review the Material Safety Data Sheets prior to handling containers, reservoirs, and delivery systems that contain chemical reagents and standards. Protective eye wear always is recommended when contact with chemicals is possible.

Daily:

1. The potted lamp should be inspected daily and replaced if necessary. A system alarm code of *E03* indicates replacement of the lamp may be required.

CAUTION:

Use care when handling the lamp to avoid burns from a hot lamp or cuts from a broken lamp.

2. The Y strainer should be checked daily and cleaned if necessary. The frequency of strainer cleaning depends largely on the nature of the sample. The strainer is cleaned by removing the retaining cap from the Y Strainer.
3. The photocell should be inspected and replaced if necessary.

NOTE:

Make sure wires are not crimped when fastening the wire guides.

4. The stirring motor should be inspected and replaced if necessary.

NOTE:

Before tightening the screws that secure the colorirneter block, make sure the lamp and photocell cables and the reagent and sample tubes are clear so they are not crimped between the block and mounting studs.

Make sure wires are not crimped when fastening the wire guides.

5. The glass cell should be inspected and replaced if necessary.

Monthly:

1. Check the chlorine residual analyzer buffer solution and refill as necessary. Both reagents should be installed each time and any solution remaining in the old bottles should be discarded.
2. Clean and inspect the chlorine residual analyzer inlet screen, overflow weir, and reagent valve. Repair and replace as needed.
3. Inspect the chlorine residual analyzer meter gears for tooth wear and misalignment. Repair or replace as necessary.
4. Test the chlorine residual analyzer span, gain, feedback, and zero potentiometer setpoints for accuracy. Adjust or replace as necessary.
5. Inspect the chlorine residual analyzer gold electrode assembly and PCV balls. Replace if necessary.
6. The Colorimeter measuring cell should be cleaned with a dilute acid solution and a cotton swab. Depending on sample conditions at individual locations, it may be necessary to clean the cell weekly.

Semi-Annually:

1. Over a period of time, the clamping action of the pump/valve module will soften the tubing to the point that it can collapse and obstruct liquid flow. This breakdown is accelerated at high temperatures. Therefore, the pump tube should be replaced at six-month intervals.

NOTE:

Reagent caps and tubing must be removed from the reagent bottles before the pinch plate is loosened to prevent reagent sample mixture from being drawn back into the bottles and thus contaminating the reagents.

(Additional information regarding the chlorine analyzer used in the sea water treatment system can be found in Appendix Section 4.2.3.4.15 of this manual.)

3.3.4.15 Emergency Pump House

3.3.4.15.1 Electric Boiler (Water Heater)

The manufacturer states a preventive maintenance program should be established to assure a long, trouble-free life of the water heater. Failure to use the correct procedures or parts in these circumstances may make the unit unsafe.

DANGER:

Do not over-drain the tank. Improper thermostatic control could result and lead to damage to the heater.

Electrocution hazard, the heater must be electrically grounded.

WARNING:

Scalding Hazard: If the water temperature is over 120º F, users can suffer serious or fatal scalding and painful and permanent injury. The consumer products safety commission recommends an initial setting of 100º F, but notes a slower response time of infants, aged, disabled and other persons increases the hazard to them and may require lower settings. Always check the water temperature before using, including washing, bathing or showering.

Temperature limiting valves are available from your plumbing supplier.

Scalding Hazard: If the thermostat is not working properly or if this product is not installed in accordance with the manual, water temperature can reach excessive levels that may cause serious scalding, even if the temperature setting is correct. After installation and any servicing of the unit, verify that the thermostat is working and firmly inserted in the thermostat well by the following the thermostat testing instructions in the manual after installation and any servicing of the unit.

Scalding Hazard: A check valve must be installed in the boiler return line to prevent gravity flow through the heat exchanger. This can cause over heating and result in serious scalding.

If not installed by the boiler manufacturer, install a low water cut-off or pressure reducing valves must be installed on your boiler so that leaking from any plumbing fixture will not result in a dry boiler; If the boiler continues to fire, an explosion hazard exists.

Prevent pressure build-up in any existing internal tankless coil. Do not plug incoming or outgoing tappings in the internal tankless coil plate. Leave the coil in the boiler and leave system connections open, to prevent pressure build-up.

Electrocution Hazard: First disconnect all electrical power before doing any electrical work.

Electrocution Hazard: The water heater must be electrically grounded.

Do not over-drain the tank. Improper thermostatic control could result if the tank is over-drained and cause damage to the tank.

Failure to follow this warning can cause serious personal injury, death or major property damage.

WARNING:

Avoid risk of ingesting a toxic fluid. The heat transfer medium should be water. If glycol must be used, it should be used with double walled heat exchangers.

This tank, like most tanks under pressure, will over time corrode or fail and/or may burst and/or leak or flood (and in rare cases explode) which can cause serious or fatal personal injury and property damage. To minimize risk, a licensed professional must install and periodically inspect and service the unit. A drip pan, connected to an adequate drain must be installed if leaking or flooding can cause property damage.

Follow all of the instructions and recommendations contained in this manual, and the following additional specific warnings. Failure to do so is unsafe and can cause serious scalding, explosion, serious or fatal personal injury and property damage.

Do not connect the water heater's domestic supply with baseboard or other space heating units or elements. Any contaminants in the baseboard units will contaminate the potable water in the water heater and also adversely affect its performance.

Electrical supply must come from the boiler side of the boiler's emergency shut-off switch in order to prevent unsafe boiler operation.

Do not drain this appliance before shutting off the supply valve and opening the relief valve or another downstream fixture, as it will damage this unit. A vacuum breaker should be installed to avoid damaging the liner.

In limited circumstances, space heating can be lost when the water heater is used in the priority mode. Any demand for space heating is postponed until the water heater has reached its set temperature. This delay in supplying the space heating zones is usually not noticed by the inhabitants of the living spaces. However, in the event of certain malfunctions such as circulator or thermostat failure, space heating could be delayed indefinitely. If undetected and uncorrected, freezing damage to piping could result.

Explosion Hazard: Do not install to a high pressure steam boiler greater than 15 psig. An explosion could occur.

Explosion Hazard: The pressure of the heat transfer medium must be limited to a maximum of 30 psig by an approved safety or relief valve on your boiler. The tank pressure must be limited to 150 psig maximum by the installation of a temperature and pressure relief valve.

Damage to the unit and leakage can occur if a vacuum breaker is not installed.

Failure to follow this warning can cause serious personal injury, death or major property damage.

WARNING:

This unit must be installed as a separate heating zone. Do not connect this unit to an existing heating zone or feed boiler water directly through the coil as dangerous over-heating will result.

Failure to use the correct replacement parts may make your unit unsafe.

Painful scalding with possible serious and permanent injury can occur if the temperature is set too high or the thermostat is not functioning properly.

Some new boilers contain materials that may adversely affect heat transfer. To avoid causing poor performance, do not make the initial purge of a new boiler through the water heater.

Failure to follow this warning can cause serious personal injury, death or major property damage.

NOTE:

As in all plumbing products and water storage vessels, bacteria can grow in your hot water maker, especially during times of non-use. Consult your local plumbing official regarding any steps you may wish to take to safely disinfect your home's plumbing system.

If a steel hydropneumatic tank is in place, replace it with a properly sized expansion tank. Otherwise, significant heat transfer system has an expansion tank and the boiler temperatures are being changed, resize the expansion tank.

The following inspections and simple maintenance procedures should be completed at the frequencies suggested:

Monthly Visual Inspection Check:

1. Sediment - Depending on water conditions, a varying amount of sediment may collect in the tank. Although this being a normal condition, sediment will greatly reduce the function of the heating element. Levels requiring service are indicated by a small temperature difference in the supply and return lines. (See also "Scale" below.)
2. Repeated flushing usually clears such material. As a preventive measure, each month water should be drawn from the tank at the drain valve until it runs clear.
3. Inspect all switch mechanisms, terminals, and all piping connections for corrosion and tightness.

4. Scale - A small temperature difference between the water entering and leaving the coil may indicate a scale build-up. A water softener will prevent this problem. (See also "Sediment" above.) Repeated flushing should also resolve the problem. If not, proceed as follows:

   A. To avoid water damage to nearby areas in subsequent steps, shut off the cold water supply to the water heater.

   B. Make a note of the temperature control setting on the water heater, then turn the unit off by depressing the power switch.

   C. Relieve the water pressure in the tank by opening a hot water faucet. This will reduce the risk of scalding injury.

   D. Remove the relief valve from the top of the water heater, taking care to avoid contact with the hot water which may drain out of the lines leading to the domestic uses.

   E. Drain the water heater until the water within the tank is even with the top of the heating element - roughly 15 gallons for 41-gallon units and 5 gallons for 26-gallon units. Do not over-drain the tank or improper thermostatic control could result during Step 6, and lead to damage to the water heater.

   F. Using a funnel, pour one gallon of commercial phosphoric acid solution (commercial ice maker cleaning solution) into the water tank through the top opening. Be sure that the manufacturer's directions, cautions, and warning on the container are followed.

   G. Set the temperature control to its highest setting and operate the system until the control is satisfied.

   H. Allow the heated solution to set in tank for 30 minutes, then drain tank completely using fitting and a hose long enough to reach a floor drain.

   I. Fill water tank with fresh, cold, conditioned water and drain completely twice to flush all phosphoric acid mixture from the tank.

   J. Reinstall the temperature pressure relief valve, being sure the temperature pressure relief valve temperature probe reaches into the top portion of the tank and the top half union fitting is firmly in place.

   K. Open the cold water supply and fill the tank with water. Then purge air from lines and tank by operating hot and cold water faucets throughout the facility.

L. Return the to the setting noted in Step 2, flip the power switch on and verify the water heater is functioning properly. As an alternative to the above, the heating element may be removed from the water heater, cleaned, and reinstalled (with a new gasket); or, in some cases, a simple high velocity washing by water from a wand may be used in place of Steps 5-9. The chemical cleaning process, however, is the most effective if done properly.

Yearly Visual Inspection Check:

1. Domestic Water Piping - Check all piping for a signs of leakage at joints, unions and shutoff valves. Remedy as needed.
2. Relief Valve - Inspect and replace if necessary.

CAUTION:

The relief valve is a safety device.

WARNING:

Scalding Hazard: If the water temperature is over 120º F, users can suffer serious or fatal scalding and painful and permanent injury. The consumer products safety commission recommends an initial setting of 100º F, but notes a slower response time of infants, aged, disabled and other persons increases the hazard to them and may require lower settings. Always check the water temperature before using, including washing, bathing or showering.

Scalding Hazard: If the thermostat is not working properly or if this product is not installed in accordance with the manual, water temperature can reach excessive levels that may cause serious scalding, even if the temperature setting is correct. After installation and any servicing of the unit, verify that the thermostat is working and firmly inserted in the thermostat well by the following the thermostat testing instructions in the manual after installation and any servicing of the unit.

Scalding Hazard: A check valve must be installed in the boiler return line to prevent gravity flow through the heat exchanger. This can cause over heating and result in serious scalding.

If not installed by the boiler manufacturer, install a low water cut-off or pressure reducing valves must be installed on your boiler so that leaking from any plumbing fixture will not result in a dry boiler; If the boiler continues to fire, an explosion hazard exists.

Failure to follow this warning can cause serious personal injury, death or major property damage.

WARNING:

Avoid risk of ingesting a toxic fluid. The heat transfer medium should be water. If glycol must be used, it should be used with double walled heat exchangers.

This tank, like most tanks under pressure, will over time corrode or fail and/or may burst and/or leak or flood (and in rare cases explode) which can cause serious or fatal personal injury and property damage. To minimize risk, a licensed professional must install and periodically inspect and service the unit. A drip pan, connected to an adequate drain must be installed if leaking or flooding can cause property damage.

Follow all of the instructions and recommendations contained in this manual, and the following additional specific warnings. Failure to do so is unsafe and can cause serious scalding, explosion, serious or fatal personal injury and property damage.

Do not connect the water heater's domestic supply with baseboard or other space heating units or elements. Any contaminants in the baseboard units will contaminate the potable water in the water heater and also adversely affect its performance.

Electrical supply must come from the boiler side of the boiler's emergency shut-off switch in order to prevent unsafe boiler operation.

Do not drain this appliance before shutting off the supply valve and opening the relief valve or another downstream fixture, as it will damage this unit. A vacuum breaker should be installed to avoid damaging the liner.

In limited circumstances, space heating can be lost when the water heater is used in the priority mode. Any demand for space heating is postponed until the water heater has reached its set temperature. This delay in supplying the space heating zones is usually not noticed by the inhabitants of the living spaces. However, in the event of certain malfunctions such as circulator or thermostat failure, space heating could be delayed indefinitely. If undetected and uncorrected, freezing damage to piping could result.

Explosion Hazard: Do not install to a high pressure steam boiler greater than 15 psig. An explosion could occur.

Explosion Hazard: The pressure of the heat transfer medium must be limited to a maximum of 30 psig by an approved safety or relief valve on your boiler. The tank pressure must be limited to 150 psig maximum by the installation of a temperature and pressure relief valve.

Damage to the unit and leakage can occur if a vacuum breaker is not installed.

Failure to follow this warning can cause serious personal injury, death or major property damage.

WARNING:

This unit must be installed as a separate heating zone. Do not connect this unit to an existing heating zone or feed boiler water directly through the coil as dangerous over-heating will result.

Failure to use the correct replacement parts may make your unit unsafe.

Painful scalding with possible serious and permanent injury can occur if the temperature is set too high or the thermostat is not functioning properly.

Temperature limiting valves are available from your plumbing supplier.

Some new boilers contain materials that may adversely affect heat transfer. To avoid causing poor performance, do not make the initial purge of a new boiler through the water heater.

Prevent pressure build-up in any existing internal tankless coil. Do not plug incoming or outgoing tappings in the internal tankless coil plate. Leave the coil in the boiler and leave system connections open, to prevent pressure build-up.

Electrocution Hazard: First disconnect all electrical power before doing any electrical work.

Electrocution Hazard: The water heater must be electrically grounded.

Do not over-drain the tank. Improper thermostatic control could result if the tank is over-drained and cause damage to the tank.

Failure to follow this warning can cause serious personal injury, death or major property damage.

NOTE:

As in all plumbing products and water storage vessels, bacteria can grow in your hot water maker, especially during times of non-use. Consult your local plumbing official regarding any steps you may wish to take to safely disinfect your home's plumbing system.

If a steel hydropneumatic tank is in place, replace it with a properly sized expansion tank. Otherwise, significant heat transfer system has an expansion tank and the boiler temperatures are being changed, resize the expansion tank.

(Additional information regarding the boiler (water heater) used in the pump house can be found in Appendix Section 4.2.3.4.13.1 of this manual.)

3.3.4.15.2 Electric Unit Heater

Because of the simple design of the unit heaters, they are nearly maintenance free. However, depending on the environment, simple maintenance practices should be adopted.

The manufacturer recommends the following yearly cleaning regimen:

WARNING:

Disconnect all power supplies before installing or servicing the heater. If the power disconnect is out of sight, lock it in the open position and tag it to prevent unexpected application of power. Failure to do so could result in fatal electric shock, or severe personal injury.

Do not depend upon a thermostat or other switch as sole means of disconnecting power when installing or servicing heater. Always disconnect power at main circuit breaker as described above. Failure to do so could result in fatal electric shock.

HAZARDOUS VOLTAGE! DISCONNECT ALL ELECTRIC POWER INCLUDING REMOTE DISCONNECTS BEFORE SERVICING. Failure to disconnect power before servicing can cause severe personal injury or death. This unit contains energy saving controls. The fan will run automatically to dispense warm air. A 30 to 60 second time delay on startup is normal.

Do not use any tools (i.e. screwdriver, pliers, etc.) across the terminals to check for power. Use a voltmeter.

Allow all rotating fans to stop before servicing to avoid serious injury to fingers and hands.

1. Wipe all excess lubricant from the motor, fan and casing. Clean the motor thoroughly. (A dirty motor may run hot and eventually cause internal damage.)
2. Clean the coil.
3. Verify all air passages remain free of dirt and other obstructions that could cause reduced air flow. Clean as necessary.
4. Loosen the dirt with a brush on the fan side of the coil. Operate the motor allowing the fan to blow the loosened dirt through the unit.
5. Use high pressure air, or steam, on the side of the coil away from the fan.

NOTE:

A piece of cheesecloth or burlap bag may be used to collect the large particles during the cleaning process.

6. Clean the casing, fan blades, fan guard and diffuser using a damp cloth.
7. Any rust spots on the casing should be cleaned and repainted.
8. Tighten the fan guard, motor frame and fan bolts. Check the fan for clearance in the panel orifice and free rotation.

NOTE:

For cleaning and maintenance purposes, the fan and motor assembly may be removed easily from the unit heater.

Consult motor manufacturer's service facility for information on type of grease and oil to be used for lubrication purposes.

Motor Lubrication:

The manufacturer states the motor bearings are permanently lubricated.

(Additional information regarding the unit heater used in the pump house can be found in Appendix Section 4.2.3.4.13.2 of this manual.)

3.3.4.15.3 Packaged Booster Pump System

Normal Flow Pumps and Motors:

The manufacturer of the normal flow pumps has recommended the following inspections and preventive maintenance for the pumps, motors, and control unit:

WARNING:

Before installing, using or servicing these products, read the warning notes and instructions in the instruction manuals.

Electrical connections to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices.

When disassembling a gasketed joint, always use a new gasket upon reassembly. NEVER RE-USE OLD GASKETS.

Unexpected startup hazard, disconnect and lockout power before servicing.

Pressurize the pump body slowly while checking for leaks at all joints with gaskets.

Make certain the internal pressure is relieved before servicing.

Open the drain valve, do not proceed until the liquid stops coming out of the drain valve. If liquid does not stop flowing from the drain valve, the isolation valves are not sealing and should be repaired before proceeding. After the liquid stops flowing from the drain valve, leave the drain valve open and continue. Remove the drain plug located on the bottom of the pump volute. Do not plug or close the drain valve until reassembly is completed.

Make sure all flange bolts have been adequately torqued.

Do not run pump dry, seal damage may occur. Inspect pump seal regularly for leaks, replace as required.

Rotating components disconnect and lock out power before servicing. Consult installation and service instruction sheet before operating or servicing.

Failure to follow these warnings could result in serious personal injury, or death and property damage.

1. The pump itself was lubricated at the factory and does not require any further lubrication.
2. The pump should be inspected regularly for leaking seals, worn gaskets and loose or damaged components. Repair, or replace, as required.
3. Drain the pump if there is a chance that the system will freeze by removing the plugs at the top and bottom of the volute shell.
4. If the pump has been used for pumping aggressive, or polluted liquids, it should be flushed through with clean water to avoid corrosion or sediment in cast the pump is not being used for some time.

5. Lubricate motor bearings in accordance with the manufacturer's instructions listed on the nameplate. As a general rule; sleeve bearings are to be lubricated through the motor oil cups per the lubrication decal once every four (4) months, or more often under adverse conditions. Use eight (8) to ten (10) drops in each oil cup. Ball bearings should be lubricated every six (6) months to two (2) years depending on conditions with soda soap or lithium base grease.
6. The pump and motor should be inspected periodically for unusual noises and proper alignment. Repair as necessary.
7. The motor should be inspected regularly loose or damaged components. Repair, or replace, as required.

Controller:

1. The controller should be inspected regularly for loose or damaged components. Repair, or replace, as required.

WARNING:

Installation, start-up and maintenance should be performed only by qualified personnel.

The drive must be disconnected from the AC line before any service work is done.

The "Stop/Off" key on the local control panel of the drive does not disconnect the equipment from the AC line and is not to be used as a safety switch.

While the drive is connected to the AC line, the motor can be brought to a stop by means of external switch closures, serial bus commands or references. If personal safety considerations make it necessary to ensure that no unintended start occurs, these stops are not sufficient.

During programming of parameters, the motor may start. Be certain that no one is in the area of the motor or driven equipment when changing parameters.

A motor that has been stopped may start if faults occur in the electronics of the drive, or if an overload, a fault in the supply AC line or a fault in the motor connection or other fault clears.

If the "Local/Hand" key is activated, the motor can only be brought to a stop by means of the "Stop/Off" key or an external safety interlock.

Touching electrical parts may be fatal, even after equipment has been disconnected from AC line. To be sure that capacitors have fully discharged, wait 14 minutes for 208 V and 460 V units and 30 minutes for 600 V units after power has been removed before touching any internal component.

WARNING:

To avoid getting metal chips into the electronics, do not drill any holes after the unit has been installed in a vertical position.

Motor will start when "HAND START" is activated.

The controller can start at anytime with a start signal through the digital inputs. Digital inputs have higher priority than control keys "HAND START" and "AUTO START".

When in the Run Request mode, the motor may start at any time without warning.

When in the Jog Request mode, the motor may start at any time without warning.

When in the Freeze Request mode, the motor may start at any time without warning.

Booster Pump System and Motors:

The manufacturer of the booster pumps has recommended the following inspections and preventive maintenance for the pumps and motors:

WARNING:

Do not attempt any maintenance, inspection, repair or cleaning in the vicinity of rotating equipment. Such action could result in personal injury to operating personnel.

Before attempting any inspection or repair on the pump, the driver controls must be in the "OFF" position, locked and tagged to prevent injury to personnel performing service on the pump.

Depending on the product being pumped, the pump should be washed down before any work is done on it.

Observe extreme caution when venting and/or draining hazardous liquids. Wear protective clothing in the presence of caustic, corrosive, volatile, flammable, or hot liquids. DO NOT breathe toxic vapors. DO NOT allow sparking, flames, or hot surfaces in vicinity of the equipment.

1. Pumps designed and shipped with "sealed for life" bearings do not require further lubrication.
2. Pumps with greaseable bearings require lubrication yearly or every 2000 hours of operation, which ever occurs first. Do not over-grease. Too much grease can cause over-heating and premature bearing failure.

3. Pumps designed and shipped with oil lubricated bearings require a regular oil maintenance program enforced. Pumps with oil lubricated bearings are fitted with a transparent reservoir (constant level oiler) that maintains the oil level about the centerline of the lower bearing. When necessary, the oil supply in the reservoir of the constant level oiler must be renewed. To refill, remove the reservoir and fill with oil. The oil should be renewed yearly or after every 8000 hours of operation, which ever occurs first.

WARNING:

Operation of the unit without proper lubrication can result in overheating of the bearings, bearing failures, pump seizures and actual breakup of the equipment, exposing operating personnel to personal injury.

Pumps shipped prior to August 1, 1996, refer to factory for bearing lubrication recommendation.

4. The pump should be inspected regularly for leaking seals, worn gaskets and loose or damaged components. Repair, or replace, as required.
5. Drain the pump if there is a chance that the system will freeze by removing the plugs at the top and bottom of the volute shell.
6. If the pump has been used for pumping aggressive, or polluted liquids, it should be flushed through with clean water to avoid corrosion or sediment in cast the pump is not being used for some time.
7. Always follow motor manufacturer's lubrication instructions if available, and periodically check grease fittings and drain plugs for leaks. To lubricate motor while running or at rest, remove grease drain plug (if any) and filler plug on grease fitting. Grease with clean lubricant until grease appears at drain hole or along motor shaft.
8. The pump and motor should be inspected periodically for unusual noises and proper alignment. Repair as necessary.
9. The motor should be inspected regularly loose or damaged components. Repair, or replace, as required.

(Additional information regarding the booster pump system used in the pump house can be found in Appendix Section 4.2.3.4.13.3 of this manual.)

3.3.4.15.4 Circulation Pumps

The manufacturer of the circulation pumps has recommended the following inspections and preventive maintenance for the pumps and motors:

Removal of the pump body from the system is not necessary unless the flange gaskets are leaking or the pump body itself is damaged. In either case, it will not be necessary to remove the flanges.

WARNING:

Before installing, using or servicing these products, read the warning notes and instructions in the instruction manuals.

Electrical connections to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices.

When disassembling a gasketed joint, always use a new gasket upon reassembly. NEVER RE-USE OLD GASKETS.

Single phase motors are equipped with automatic reset overload protectors. Unexpected startup hazard, disconnect and lockout power and close the pump service valves before servicing.

Pressurize the pump body slowly while checking for leaks at all joints with gaskets.

Make certain the internal pressure is relieved before servicing.

The maximum working pressure of the pumps is listed on the nameplate, do not exceed this pressure.

Open the drain valve, do not proceed until the liquid stops coming out of the drain valve. If liquid does not stop flowing from the drain valve, the isolation valves are not sealing and should be repaired before proceeding. After the liquid stops flowing from the drain valve, leave the drain valve open and continue. Remove the drain plug located on the bottom of the pump volute. Do not plug or close the drain valve until reassembly is completed.

Make sure all flange bolts have been adequately torqued.

Do not run pump dry, seal damage may occur. Inspect pump seal regularly for leaks, replace as required.

Rotating components disconnect and lock out power before servicing. Consult installation and service instruction sheet before operating or servicing.

Failure to follow these warnings could result in serious personal injury, or death and property damage.

1. The manufacturer recommends the pump bearings be lubricated with 1/2 teaspoon (20 to 30 drops) of 20# weight non-detergent oil annually. Motor bearings should be lubricated as instructed on the lubrication decal once every four months (more often under adverse conditions). Use eight (8) to ten (10) drops in each oil tube.
2. The pump should be inspected regularly for leaking seals, worn gaskets and loose or damaged components. Repair, or replace, as required.
3. Drain the pump if there is a chance that the system will freeze by removing the plugs at the top and bottom of the volute shell.
4. If the pump has been used for pumping aggressive, or polluted liquids, it should be flushed through with clean water to avoid corrosion or sediment in cast the pump is not being used for some time.
5. Lubricate motor bearings in accordance with the manufacturer's instructions listed on the nameplate. As a general rule; sleeve bearings are to be lubricated through the motor oil cups per the lubrication decal once every four (4) months, or more often under adverse conditions. Use eight (8) to ten (10) drops in each oil cup. Ball bearings should be lubricated every six (6) months to two (2) years depending on conditions with soda soap or lithium base grease.
6. The pump and motor should be inspected periodically for unusual noises and proper alignment. Repair as necessary.
7. The motor should be inspected regularly loose or damaged components. Repair, or replace, as required.

(Additional information regarding the circulation pumps can be found in Appendix Section 4.2.3.4.13.4 of this manual.)

3.3.5 Fire Protection System

Perform maintenance on the Fire Protection System, including all sub components and devices, in accordance with the following PMs:

#6700FM, #6705FM, #6719FQ, #6705FQ, #6705FS, #6705FA, and #6707FA.

3.3.5.1 Carbon Dioxide CO_2 Extinguishing System

In addition to the routine inspections and maintenance listed in the PM's for the CO_2 Extinguishing System (Equip. # SY00198), the National Fire Protection Agency (NFPA) has established the following general inspections for CO_2 fire extinguishing systems. Sections that follow also contain inspection and maintenance procedures for the individual components used in the system.

DANGER:

ASPHYXIANT HAZARD: All personnel must be instructed to evacuate the area at the first alarm.

After a CO_2 discharge, all personnel must stay out of the building until it has been properly ventilated, unless they are equipped with a Self-Contained Breathing Apparatus (SCBA).

CO_2 is colorless, odorless, and tasteless. It is an asphyxiant. A space that has been flooded with CO_2 does not contain enough oxygen to sustain human life.

WARNING:

CO_2 cylinder assemblies must be stored, handled, transported, serviced, maintained, tested, and installed only by trained personnel in accordance with the instructions contained in this manual, NFPA-12, and Compressed Gas Association (CGA) pamphlets C-1, C-6, G-6, G-6.3 and P-1. CGA pamphlets may be obtained from the Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4102.

Before performing maintenance procedures, refer to the material safety data sheets and safety bulletins in the appendix.

All actuation devices (control heads, discharge heads, etc.) must be removed from the system cylinders prior to performing system maintenance. Observe all safety precautions applicable to handling pressurized equipment. Recharge of CO_2 cylinder assemblies must be performed by personnel trained in Kidde CO_2 systems equipment.

CAUTION:

CO_2 cylinder assemblies must be stored, handled, transported, serviced, maintained, tested, and installed only by trained personnel in accordance with the instructions contained in the Operations and Maintenance Manual, NFPA-12, and CGA pamphlets C-1, C-6, G-6, G-6.3 and P-1. CGA pamphlets may be obtained from the Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, VA 22202-4102.

Before performing maintenance procedures, refer to the material safety data sheets and safety bulletins.

All actuation devices (control heads, discharge heads, etc.) must be removed from the system cylinders prior to performing system maintenance. Observe all safety precautions applicable to handling pressurized equipment. Recharge of CO_2 cylinder assemblies must be performed by personnel trained in Kidde CO_2 systems equipment.

Control head(s) must be in the "set" or "closed" position before attaching to the cylinder valve, to prevent accidental discharge of the carbon dioxide system.

CO_2 cylinders must not be recharged without a retest if more than five (5) years have elapsed from the date of the last test. Retest shall be in accordance with the requirements of CFR 49, Section 173.34. After retest, interior of cylinders must be thoroughly dried and free of residue.

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following general inspections for CO_2 fire extinguishing systems. Sections that follow also contain inspection and maintenance procedures for the individual components used in the system.

Monthly:

1. Make a general inspection survey of all cylinders and equipment for damaged or missing parts.
2. Ensure access to hazard areas, remote nitrogen or cable pull stations, discharge nozzles, and cylinders is unobstructed and there are no obstructions to the operation of the equipment or distribution of carbon dioxide.
3. Inspect flexible actuation hoses for loose fittings, damaged threads, cracks, distortion, cuts, dirt and frayed wire braid. Tighten loose fittings. Replace hoses having stripped threads or other damage. If necessary, clean parts. Inspect flexible actuation hose adapters for stripped threads and damage. Replace damaged adapters. Inspect couplings and tees for tightness. Tighten if necessary. Replace damaged parts.

4. Inspect CO_2 cylinder pressure operated control heads for physical damage, deterioration, corrosion, distortion. cracks, dirt, and loose couplings. Tighten loose couplings. Replace damaged caps. Replace control head if damage is found. If necessary, clean parts.
5. Inspect carbon dioxide cylinder and valve assembly for damage, physical damage such as cracks, dents. distortion. and worn parts. Check burst disc for damage, and replace if necessary. If necessary, clean cylinder and associated parts.
6. Inspect cylinder straps, cradles, and attaching hardware for loose, damaged, or broken parts. Check straps and associated parts for corrosion, oil, grease, grime, etc. Tighten loose hardware. Replace damaged parts. If necessary, clean.
7. Inspect flexible discharge hoses for loose fittings, damaged threads, cracks, rust, kinks. distortion, dirt, and frayed / wire braid. Tighten loose fittings, and replace hoses which have stripped threads. If necessary, clean.
8. Inspect discharge manifold for physical damage, corrosion, and dirt. Inspect manifold support brackets and clamps for looseness and damage. Inspect connections to manifold for tightness. Inspect check valves where applicable, for deformation, leakage, cracks, wear, corrosion, and dirt. Secure loose parts. Replace damaged pans. If necessary, clean.
9. Inspect discharge nozzles for dirt and physical damage. Replace damaged nozzles.

CAUTION:

Nozzles must never be painted. The part number of each nozzle is stamped on the nozzle. Nozzles must be replaced by nozzles of the same part number. Nozzles must never be interchanged, since random interchanging of nozzles will adversely affect proper CO_2 distribution within a hazard area.

10. Inspect pressure switches for deformations, cracks, dirt or other damage Replace switch, if damage is found.
11. Check nitrogen cylinder for proper operating pressure. If pressure loss (adjusted for temperature) exceeds 10%, recharge with nitrogen to 1800 PSIG at 70° F.

Semi-annual Weighing of CO_2 Cylinders:

WARNING:

The CO_2 cylinders are equipped with 4 high rate discharge valve, which when actuated, will open, remain open, and cannot be closed. Accidental actuation of the discharge valve on an unsecured, disconnected cylinder will result in a discharge thrust capable of propelling the cylinder to velocities that will cause severe property damage and bodily injury.

It is therefore extremely important that the exact sequence of cylinder removal always be followed.

Further cylinder removal or cylinder replacement must always be supervised.

1. Remove control head at the coupling nut only.
2. Disconnect flexible hose from discharge head.
3. Loosen cylinder framing until cylinders are free.
4. Hook scale on weighing angle, and slip yoke under discharge head.
5. Pull down until cylinder is just clear of floor and lever is horizontal.
6. Read weight directly off scale. The scale is calibrated to compensate for leverage. Empty cylinder weight is stamped on the cylinder valve body; therefore, deduct empty weight from scale reading. Also, deduct 3.75 pounds for weight of discharge head. The result is the amount, known as the charge weight, of carbon dioxide in the cylinder.
7. If charge weight loss exceeds 10%, forward charged cylinder **WITH DISCHARGE AND CONTROL HEADS REMOVED AND SAFETY CAP AND PROTECTION CAP INSTALLED** to a Kidde distributor.
8. After all cylinders have been weighed, reconnect flexible hose from discharge head. Tighten clamps, and reinstall control heads on cylinders. Tighten control head coupling nuts securely.

Every 2 years:

Hydrostatic test all CO_2 system hoses and flexible connectors.

WARNING:

DO NOT USE WATER OR OXYGEN TO BLOW OUT PIPE LINES. The use of oxygen is especially dangerous as the possible presence of even a minute quantity of oil may cause an explosion.

Do not disconnect discharge head fr0m flexible hose. Accidental discharge of CO_2 system will cause flexible hose without discharge head attached to flail violently, resulting in possible equipment damage and severe bodily injury to personnel.

When disconnecting control heads (tandem mounted), do not let the heads turn. if interconnecting cable housing is a loose fit, this will prevent accidental discharge.

CAUTION:

Before conducting any tests, remove the pneumatic control heads from the cylinders.

Every 5 years:

1. Hydrostatic test all CO_2 system hoses and flexible connectors.

Cleaning:

1. Remove dirt from metallic parts using a lint-free cloth moistened with dry cleaning solvent.
2. Dry pans with clean, dry, lint-free cloth or air blow dry.
3. Wipe nonmetallic parts with clean, dry lint-free cloth. Remove corrosion with crocus cloth.

Every 12 years:

Hydrostatic test all CO_2 cylinders.

Post-Discharge:

After a CO_2 system discharge, perform the following post-discharge maintenance procedures:

1. Install and retest unused CO_2 storage cylinders.
2. Reset all control heads on cylinders and stop (directional) valves on multi-hazard systems. (Replace any control head that fails to reset properly.)
3. Reinstall locking pins.
4. Replace seal wires.

3.3.5.1.1 Storage Cylinders

The National Fire Protection Agency (NFPA) has established the following inspections and warnings for CO_2 storage cylinders.

WARNING:

Ensure that all personnel have evacuated the building before actuating the manual CO_2 release valve(s) located at the cylinder bank. In a restricted space, CO_2 displaces the oxygen required to sustain human life.

Actuating the manual CO_2 release valve at the cylinder bank discharges CO_2 into the protected space immediately and without warning. Direct skin contact with super-cooled CO_2 gas can cause immediate and severe tissue damage due to frostbite.

Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of violent discharge.

UNDER NO CIRCUMSTANCES is the discharge head to remain attached to the cylinder valve after removal from service, during shipment, handling, storage, or during filling.

Discharge hose must be connected to system piping and to the discharge head before attaching to cylinder valve to prevent injury in the event of discharge.

Control heads must be in SET position before attaching to the cylinder valve to prevent accidental discharge.

DO NOT remove the cylinder from the bracketing if the valve protection cap is missing or not installed. Each cylinder is factory equipped with a valve protection cap threaded securely over the valve assembly. This device is a safety feature and provides protection during handling. This protection cap must be installed at all times, except when the cylinder is connected into the system piping, being filled, or leak tested.

The valve protection cap must be stored in a secure place and made readily available for use. Do not move or handle cylinders without the cap installed.

CAUTION:

CO_2 cylinders must not be recharged without a retest if more than five (5) years have elapsed from the date of the last test. Retest shall be in accordance with the requirements of CFR 49, Section 173.34. After retest, interior of cylinders must be thoroughly dried and free of residue.

NOTE:
Spent cylinders will be shipped to an authorized refill station.

Monthly:

1. Make a general inspection survey of all cylinders and equipment for damaged or missing parts.
2. Inspect CO_2 cylinder pressure operated control heads for physical damage, deterioration, corrosion, distortion. cracks, dirt, and loose couplings. Tighten loose couplings. Replace damaged caps. Replace control head if damage is found. If necessary, clean parts.
3. Inspect carbon dioxide cylinder and valve assembly for damage, physical damage such as cracks, dents. distortion. and worn parts. Check burst disc for damage, and replace if necessary. If necessary, clean cylinder and associated parts.
4. Inspect cylinder straps, cradles, and attaching hardware for loose, damaged, or broken parts. Check straps and associated parts for corrosion, oil, grease, grime, etc. Tighten loose hardware. Replace damaged parts. If necessary, clean.
5. Inspect flexible discharge hoses for loose fittings, damaged threads, cracks, rust, kinks. distortion, dirt, and frayed / wire braid. Tighten loose fittings, and replace hoses which have stripped threads. If necessary, clean.
6. Inspect discharge manifold for physical damage, corrosion, and dirt. Inspect manifold support brackets and clamps for looseness and damage. Inspect connections to manifold for tightness. Inspect check valves where applicable, for deformation, leakage, cracks, wear, corrosion, and dirt. Secure loose parts. Replace damaged pans. If necessary, clean.
7. Check nitrogen cylinder for proper operating pressure. If pressure loss (adjusted for temperature) exceeds 10%, recharge with nitrogen to 1800 PSIG at 70° F.

Semi-annual Weighing of CO_2 Cylinders:

WARNING:

The CO_2 cylinders are equipped with 4 high rate discharge valve, which when actuated, will open, remain open, and cannot be closed. Accidental actuation of the discharge valve on an unsecured, disconnected cylinder will result in a discharge thrust capable of propelling the cylinder to velocities that will cause severe property damage and bodily injury.

It is therefore extremely important that the exact sequence of cylinder removal always be followed.

Further cylinder removal or cylinder replacement must always be supervised.

1. Remove control head at the coupling nut only.
2. Disconnect flexible hose from discharge head.
3. Loosen cylinder framing until cylinders are free.
4. Hook scale on weighing angle, and slip yoke under discharge head.
5. Pull down until cylinder is just clear of floor and lever is horizontal.
6. Read weight directly off scale. The scale is calibrated to compensate for leverage. Empty cylinder weight is stamped on the cylinder valve body; therefore, deduct empty weight from scale reading. Also, deduct 3.75 pounds for weight of discharge head. The result is the amount, known as the charge weight, of carbon dioxide in the cylinder.
7. If charge weight loss exceeds 10%, forward charged cylinder **WITH DISCHARGE AND CONTROL HEADS REMOVED AND SAFETY CAP AND PROTECTION CAP INSTALLED** to a Kidde distributor.
8. After all cylinders have been weighed, reconnect flexible hose from discharge head. Tighten clamps, and reinstall control heads on cylinders. Tighten control head coupling nuts securely.

Every 12 years:

1. Hydrostatic test all CO_2 cylinders.

Post-Discharge:

After a CO_2 system discharge, perform the following post-discharge maintenance procedures:

1. Install and retest unused CO_2 storage cylinders.
2. Reset all control heads on cylinders and stop (directional) valves on multi-hazard systems. (Replace any control head that fails to reset properly.)
3. Reinstall locking pins.
4. Replace seal wires.

(For additional information regarding CO_2 cylinders, refer to Appendix Section 4.2.3.5.1.2 of this manual.)

3.3.5.1.2 Discharge Nozzles

In addition to routine inspections and maintenance, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria.

Discharge nozzles damaged by dropping, striking, wrench twist/slippage, or the like must be replaced. Discharge nozzles that have been exposed to corrosive products of combustion, but have not operated, should be replaced if they cannot be completely cleaned by wiping the sprinkler with a cloth or by brushing it with a soft bristle brush. To function properly, the discharge nozzles must be clean and unobstructed.

Nozzle sizing and location have been calculated to produce the best possible CO_2 dispersion pattern. If a discharge nozzle requires replacement, it must be replaced with an identical unit.

WARNING:

The CO_2 cylinders are equipped with a high rate discharge valve, which when actuated, will open, remain open, and cannot be closed. Accidental actuation of the discharge valve on an unsecured, disconnected cylinder will result in a discharge thrust capable of propelling the cylinder to velocities that will cause severe property damage and bodily injury.

It is therefore extremely important that the exact sequence of cylinder removal always be followed.

Further cylinder removal or cylinder replacement must always be supervised.

NOTE:

Do not clean discharge nozzles with soap and water, ammonia or any other cleaning fluids.

A supply of at least six spare discharge nozzles shall be stored in a cabinet on the premises for replacement purposes. The stock of spare discharge nozzles shall be proportionally representative of the types and temperature ratings of the system discharge nozzles.

A minimum of two discharge nozzles of each type and temperature rating installed shall be provided. The cabinet shall be so located that it will not be exposed to moisture, dust, corrosion, or a temperature exceeding 100º F (38º C).

A special discharge nozzle wrench shall be provided and kept in the cabinet to be used in the removal and installation of discharge nozzles. One wrench shall be provided for each type of discharge nozzle installed.

Discharge nozzles shall not be altered in any respect or have any type of ornamentation, paint, or coatings applied after shipment from the place of manufacture.

Inspection of discharge nozzles is covered in NFPA 25.

Annually:

Inspect discharge nozzles from the floor level to ensure they are free of corrosion, foreign materials, paint, and physical damage and are installed in the proper orientation (for example, upright, pendant, or sidewall). Discharge nozzles should also be inspected for proper installation, that they are not obstructed, and proper clearances from structural members are maintained. Any discharge nozzle that is painted, corroded, damaged, loaded, or in the improper orientation shall be replaced.

NOTE:

Discharge nozzles installed in concealed spaces such as above suspended ceilings shall not require inspection.

Unacceptable obstructions to spray patterns shall be corrected.

Inspect the supply of spare discharge nozzles for the following:

- The proper number and type of discharge nozzles;
- A sprinkler wrench for each type of discharge nozzles.

Testing of discharge nozzles is covered in NFPA 25.

Discharge nozzles that have been in service for 10 years shall be tested or replaced. If maintained and serviced, they shall be retested at 10-year intervals.

Maintenance of discharge nozzles is covered in NFPA 25.

Replacement discharge nozzles shall have the proper characteristics for the application intended. These include the following:

- Style
- Orifice size and *K*-factor
- Temperature rating
- Coating, if any
- Deflector type (e.g., upright, pendant, sidewall)
- Design requirements

(For additional information regarding discharge nozzles, refer to Appendix Section 4.2.3.5.1.3 of this manual.)

3.3.5.1.3 Initiating Devices

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria.

Routinely, insure that nothing has been placed in a way that obscures or blocks access to the manual pull stations.

The manual pull stations are tested during the semi-annual inspection of the CO_2 releasing panel, performed in accordance with PM #0132FS.

3.3.5.1.4 Zone Valves / Control Heads

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria. The CO_2 cylinder banks are each equipped with actuating valves (control heads) that initiate the release of CO_2 gas.

WARNING:

UNDER NO CIRCUMSTANCES is the discharge head to remain attached to the cylinder valve after removal from service, during shipment, handling, storage, or during filling. Failure to follow this instruction could cause serious bodily injury, death, and property damage.

Never connect the discharge head to the cylinder valve without the flex loop attached to the discharge outlet and connected to system piping with the cylinder properly secured.

Discharge hose must be connected to system piping and to the discharge head before attaching to cylinder valve to prevent injury in the event of discharge.

Control heads must be in SET position before attaching to the cylinder valve to prevent accidental discharge.

(For additional information regarding Zone Valves and Control Heads, refer to Appendix Section 4.2.3.5.1.4 of this manual.)

3.3.5.2 Fire Sprinkler System

The pre-action fire protection system in the Water Plant operates in conjunction with the fire detection and alarm system. Maintenance is the work necessary to keep the system operable or make repairs. Repairs must be made immediately to assure that the system will operate when needed.

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria. The sprinkler system shall be inspected, tested, and maintained in accordance with National Fire Protection Association (NFPA) Fire Protection Systems, "*Inspection, Test & Maintenance Manual.*

This section details maintenance procedures to be completed on the mechanical components of the system.

Records should be kept of all inspections, tests and maintenance conducted on the mechanical components of the system. The sample forms contained in Appendix Section 4.2.3.5.2.10 have spaces for recording the necessary information.

If any components of the system are repaired, replaced, or if new components are added, the system should be immediately inspected and tested in accordance with National Fire Protection Association (NFPA) Fire Protection Systems, "*Inspection, Test & Maintenance Manual"*.

NOTE:

Any system maintenance or inspection that involves placing a component of the system "out-of-order" will eliminate the fire protection normally provided by the fire protection system. Before performing any maintenance work on the fire protection system or any component thereof, permission to shut down the affected fire protection system must be obtained from the Environmental Health and Safety coordinator, and all personnel who may be affected by this action must be notified.

***Before* performing any maintenance on the fire protection system which may result in an alarm actuation, notify the Communication Center that system maintenance is being performed.**

***After* maintenance is performed, notify the Communication Center that maintenance is complete and confirm that alarm system indications are normal.**

3.3.5.2.1 Sprinklers

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria. Sprinklers damaged by dropping, striking, wrench twist/slippage, or the like must be replaced. Sprinklers that have been exposed to corrosive products of combustion, but have not operated, should be replaced if they cannot be completely cleaned by wiping the sprinkler with a cloth or by brushing it with a soft bristle brush. Replacements must be made with the same model sprinkler.

NOTE:

Before **performing any maintenance on the fire protection system which may result in an alarm actuation, notify the Communication Center that system maintenance is being performed.**

After **maintenance is performed, notify the Communication Center that maintenance is complete and confirm that alarm system indications are normal.**

Before performing any maintenance work on the fire protection system or any component thereof, permission to shut down the affected fire protection system must be obtained from the Environmental Health and Safety coordinator, and all personnel who may be affected by this action must be notified.

Do not clean sprinklers with soap and water, ammonia or any other cleaning fluids.

Absence of an escutcheon, which is used to cover a clearance hole, may delay the time to sprinkler operation in a fire situation.

Inspection of sprinklers is covered in NFPA 25.

Quarterly:

1. The sprinklers should first be inspected from the floor level, then conduct a ransom sampling of close-up visual inspections to better determine the exact sprinkler condition and the long term integrity of the corrosion resistant coating.
2. Ensure the sprinklers are free of corrosion, foreign materials, paint, and physical damage and are installed in the proper orientation (for example, upright, pendant, or sidewall).
3. Sprinklers shall not be altered in any respect, have any type of ornamentation, paint, coatings applied after shipment from the place of manufacture, leak, a cracked bulb, lost liquid from its bulb, or exhibit visible signs of corrosion must be replaced.
4. Sprinklers should also be inspected for proper installation, that they are not obstructed, and proper clearances from structural members are maintained. Any sprinkler that is painted, corroded, damaged, loaded, or in the improper orientation shall be replaced.
5. Sprinklers damaged by striking, wrench twist/slippage, or the like, must also be replaced.

NOTE:

Sprinklers installed in concealed spaces such as above suspended ceilings shall not require inspection.

Unacceptable obstructions to spray patterns shall be corrected.

1. Inspect the supply of spare sprinklers for the following:

   A. The proper number and type of sprinklers;

   B. A sprinkler wrench for each type of sprinkler.

Testing of sprinklers is covered in NFPA 25.

Dry sprinklers that have been in service for 10 years shall be tested or replaced. If maintained and serviced, they shall be retested at 10-year intervals.

Maintenance of Sprinklers is covered in NFPA 25.

Replacement sprinklers shall have the proper characteristics for the application intended. These include the following:

- Style,
- Orifice size and *K*-factor,
- Temperature rating,
- Coating, if any,
- Deflector type (e.g., upright, pendant, sidewall), and
- Design requirements.

(For additional information regarding the fire sprinklers, refer to Appendix Section 4.2.3.5.2.2 of this manual.)

3.3.5.2.2 Fire Sprinkler Air Compressor

A regulated, scheduled preventive maintenance program is the best way to keep the compressor running at peak efficiency. The manufacturer recommends the following inspections and checks:

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria. This maintenance schedule was developed for typical applications. Maintenance intervals should be shortened in harsher environments.

WARNING:

Compressed air has great force. Always release pressure from the compressor and all associated tubing and components before servicing the compressor. Failure to do so can result in severe injury or death.

HAZARDOUS VOLTAGE. Always disconnect the power supply to disable reset devices before performing any maintenance or repair work on the compressor. Always tag and lock out before attempting to service this device. Failure to do so can result in severe injury or death.

MOVING PARTS: Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing.

HOT SURFACES: Can cause serious injury. Do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

HIGH PRESSURE AIR: Bypassing, modifying or removing safety/relief valves can cause serious injury or death. Do not bypass, modify or remove safety/relief valves. Do not direct air stream at body. Rusted tanks can cause explosion and severe injury or death.

RISK OF BURSTING: Use only suitable air handling parts acceptable for pressure of not less than the maximum allowable working pressure of the machine.

Motors, electrical equipment and controls can cause electrical arcs that will ignite a flammable gas or vapor. Never operate or repair in or near a flammable gas or vapor. Never store flammable liquids or gases near the compressor.

Failure to follow this warning can cause serious personal injury, death or major property damage.

NOTE:

This compressor is designed for non-lubricated service. Bearings are permanently lubricated. Do not lubricate any part of the compressor or motor.

Before performing maintenance, release air pressure from the system and disconnect lock and tag the main power supply, or disconnect the wire from the engine spark plug.

Weekly or Before Each Operation:

1. Check for oil leaks.
2. Drain receiver tank condensate (if automatic draining device was not provided). Open manual drain valve and collect and dispose of condensate accordingly.

3. Check for unusual noise and vibration.
4. Ensure belt guards and covers are securely in place.
5. Ensure area around compressor is free from rags, tools, debris, and flammable or explosive materials.
6. Clean air filter elements.
7. Clean all external parts of the compressor and motor.

Monthly:

1. Inspect for air system for leaks. Repair as necessary.
2. Check air system for tightness of screws and bolts. Tighten as needed.
3. Manually test the safety relief valve.

Quarterly:

1. Change filters.

(Additional information, including removal/replacement of parts and troubleshooting techniques, on the compressor is available in Appendix Section 4.2.3.5.2.3 of this manual.)

3.3.5.2.3 Air Maintenance Device

The air maintenance device does not require any regularly scheduled maintenance. it is recommended, however, that its proper operation and condition be periodically verified in accordance with the following described inspection procedure. Any impairment must be immediately corrected.

NOTE:

***After* maintenance is performed, notify the Communication Center that maintenance is complete and confirm that alarm system indications are normal.**

Before performing any maintenance work on the fire protection system or any component thereof, permission to shut down the affected fire protection system must be obtained from the Environmental Health and Safety coordinator, and all personnel who may be affected by this action must be notified.

Inspection Procedure:

It is recommended the following inspection procedure for the air maintenance device be performed quarterly.

1. Verify that the By-Pass Valve is closed.
2. Close the air maintenance device's Air Supply Control Valve and clean out the 1/4 inch Strainer located at the inlet to the Restrictor Check Valve. Be sure to reinstall the strainer screen and tighten the cap securely.
3. Open the air maintenance device's Air Supply Valve and verify that the control valve in the air supply trim to the system being pressurized is open.
4. Verify that the system pressure is essentially the same as the previously established requirement. If not, adjust the system pressure as follows:

   A. Close the system's main control valve and open the main drain valve. Close the Accelerator Control Valve, if the system is so equipped.

   B. Close the control valve in the air supply trim of the system to be pressured. Remove the system pressure gauge from its connection and install it in the side gauge port on the pressure regulator. Open the air supply control valve in the air maintenance device. Adjust the output pressure of the pressure regulator. Turn the adjusting stem clockwise, as viewed from the stem end of the pressure regulator, to increase pressure and counter-clockwise to decrease pressure.
   One-half turn of the stem will change the outlet pressure by approximately 5 psi (0.4 bar). Close the Air Supply Control Valve in the air maintenance device. Return the system air pressure gauge to its normal location. Reinstall the 1/4 inch pipe plug in the gauge port of the pressure regulator. Apply pipe thread sealant sparingly to the plug threads only. Open the control valve in the air supply trim to the system being pressurized. Open the air supply control valve in the air maintenance device. After the system pressure has stabilized, note the value and compare with the requirement. Re-adjust the pressure regulator as required using part of this procedure.

   C. Slowly open the Accelerator Control Valve, as applicable.

D. Slowly open the main control valve and after water begins to flow, slowly close the main drain valve and then completely open the main control valve. The air maintenance device is now ready for service.

It is also recommended that accumulated moisture be removed from the air supply moisture filtration equipment, at least quarterly. More frequent inspections may be necessary in particularly humid environments.

(Additional information, including removal/replacement of parts and troubleshooting techniques, on the air maintenance device is available in Appendix Section 4.2.3.5.2.4 of this manual.)

3.3.5.2.4 Backflow Preventer

The backflow prevention assembly can be serviced with commonly available tools and are designed for ease of maintenance. The assemblies are designed to be serviced in line, so the unit should not need to be removed from the line during servicing.

CAUTION:

The use of pliers or other tools may damage the guiding surfaces and require unnecessary replacement. Do not scratch or mark sealing or guiding surfaces.

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria.

1. Double check valves should be inspected and tested annually.
2. The most common cause of check fouling and relief valve discharge is dirt and debris in the seating areas. The line should be flushed clean of debris before installation of the assembly. To flush the line after installation of the assembly, slowly close the inlet shut-off valve, remove the covers and spring assemblies of both check valves and open the inlet shut-off valve to allow sufficient flow of water through the assembly to clear all sand, debris, etc. from the line.
3. Rinse all parts with clean water before reassembly.

4. Carefully inspect diaphragms, seals and seating surfaces for damage or debris. If the check valve seat disc has been severely cut at the seat ring diameter, the assembly has been subjected to extremely high and repeated back pressure. Either thermal water expansion or water hammer are the most likely causes. If back pressure persists, consider installation of a pressure relief valve downstream of the assembly.
5. Use caution to avoid damaging any guiding surfaces while handling parts. Do not force parts together. The o-ring seals used in the assemblies require only a small tightening force to ensure a positive seal.
6. Test unit after servicing in accordance with the locally approved test method to ensure proper operation.

(Additional information on the backflow preventer can be found in Appendix Section 4.2.3.5.2.5 of this manual.)

3.3.5.2.5 Pre-Action Valve and Trim

The Pre-Action Valve & Trim uses automatic sprinklers and a supplemental detection system. The supplemental detection system is typically comprised of 24 VDC heat detectors, smoke detectors, manual pull stations, etc.

Actuation of the detection system automatically operates (releases) the deluge valve, allowing water to flow into the sprinkler piping system and to be discharged from any sprinklers that may be open.

WARNING:

The Pre-Action Valve & Trim must be installed and maintained in compliance with manufacturer's documentation as well as with the applicable standards of the National Fire Protection Association, in addition to the standards of any other authorities having jurisdiction.

The following procedures, inspections, and maintenance must be performed as indicated, in addition to any specific requirements of the NFPA, and any impairment must be immediately corrected.

The manufacturer recommends additional preventive maintenance as follows:

NOTE:

It is recommended that automatic sprinkler systems be inspected, tested, and maintained by a qualified Inspection Service in accordance with local requirements and/or national codes.

Some of the procedures outlined in this section will result in operation of the associated alarms. Consequently, notification must first be given to the owner and the fire department, central station, or other signal station to which the alarms are connected.

Before closing a fire protection system main control valve for maintenance work on the fire protection system that it controls, permission to shut down the affected fire protection systems must first be obtained from the proper authorities and all personnel who may be affected by this action must be notified.

Quarterly:

1. Test the system waterflow alarms.
2. Verify operation of the solenoid valve for electric actuation.

NOTE:

When the main control valve is opened, the pressure on the diaphragm chamber may increase. This increase in pressure is normal. If the pressure is greater than 250 psi (17,2 bar), the pressure is to be relieved by partially and temporarily opening the manual control station. However, do not allow the pressure indicated on the diaphragm chamber pressure gauge to drop below the supply pressure shown on the water supply pressure gauge, since this action may result in tripping of the deluge valve.

3. Verify operation of the supervisory low pressure alarm switch.

Annually:

1. Test the deluge valve for proper operation.

(Additional information on the backflow preventer can be found in Appendix Section 4.2.3.5.2.6 of this manual.)

3.3.5.2.6 OS&Y Valve

The OS&Y valve and its associated supervisory switch should be inspected and tested in accordance with applicable NFPA codes and standards and/or the authority having jurisdiction.

In addition to the routine inspections and maintenance listed in the PM's, the National Fire Protection Agency (NFPA) and the manufacturer has established the following inspections and maintenance criteria.

Quarterly:

1. All valves, and connections, should be inspected weekly for leakage, damage, and corrosion. All leaks should be repaired and defective valves replaced.
2. Carefully inspect diaphragms, seals and seating surfaces for damage or debris.
3. Lubricate all valve stems.
4. Exercise outside screw and yoke (OS&Y) valves. Operate each valve through its full range and return to its normal position. The handle should be backed off one-quarter (1/4) turn from the fully opened position to prevent jamming. Reseal or re-lock if appropriate.

(Additional information for the OS&Y valve can be found in Appendix Section 4.2.3.5.2.7 of this manual.)

3.3.5.2.7 Valves

Annually, all valves used in the fire protection system should have the following preventive maintenance conducted:

1. Lubricate all valve stems.
2. Periodically inspect all valves for leaks, corrosion, and damage. Replace defective valves.
3. Each control valve have a tag attached which records the date the valve was sealed or locked.
4. Each alarm, dry pipe, pre-action and deluge valve should have a tag attached which records the date and information on any maintenance performed on the valve.

5. Over pressurization of the system piping with air may result in the opening of the pressure relief valves. If this has occurred and if the relief valve continues to bleed air after the system pressure has been reduced to its normal pressure range of 10 +/-2 psi (0.69 +/-0.14 bar), most likely debris has become lodged in the seating area. To help clean the seating area, slowly pull up on the ring at the top of the relief valve to allow a full flow of air through the relief valve, and then release the ring to allow the relief valve to snap closed. Repeat the cleaning procedure as necessary.

3.3.5.2.8 Deluge Valve

The deluge valve requires regularly scheduled maintenance and service. In addition, it is recommended that the proper operation of the system and condition of the system, in which it is used, be periodically verified in accordance with the procedures in this section. It is also recommended that any part of an automatic sprinkler system be inspected, tested, and maintained by a qualified inspection service in accordance with local requirements and/or national codes. Any impairment to the system must be promptly corrected in order to maintain the integrity of the system.

WARNING:

The deluge valve must be installed and maintained in compliance with manufacturer's documentation, as well as with the applicable standards of the National Fire Protection Association, in addition to the standards of any other authorities having jurisdiction. Failure to do so may impair the performance of the valve.

NOTE:

It is recommended that individuals responsible for care and maintenance of the deluge valve develop an overall understanding of the system prior to performing inspection and/or maintenance procedures. These instructions, as well as individual instructions for the solenoid valve, manual control station, dry pilot actuator, switches, and pressure maintenance device should be reviewed.

Before performing the inspection procedures, which will result in operation of alarms, notify the proper authorities and all personnel who may be affected.

Before performing any maintenance work on the fire protection system or any component thereof, permission to shut down the affected fire protection system must be obtained from the Environmental Health and Safety coordinator, and all personnel who may be affected by this action must be notified.

Before closing a fire protection system main control valve for maintenance work on the fire protection system which it controls, permission to shut down the affected fire protection system must be obtained from the proper authorizes and all personnel who may be affected by this action must be notified.

***Before* performing any maintenance on the fire protection system which may result in an alarm actuation, notify the Communication Center that system maintenance is being performed.**

***After* maintenance is performed, notify the Communication Center that maintenance is complete and confirm that alarm system indications are normal.**

The maintenance and inspection procedures in this section apply only to the deluge valve. Refer to the manufacturer's instructions and NFPA 25 for care and maintenance procedures for all other devices such as electric detection, main control valve, supervisory devices, pilot sprinklers, etc.

Fire protection systems subject to an emergency impairment caused by an interrupted water supply condition, it is recommended that consideration be given to installing a low water supply pressure switch, with the appropriate alarm/indications, to monitor the water supply pressure.

Before operating a manual control station for inspection purposes, close the main control valve and relieve the supply pressure to the deluge system if the deluge valve is not to be tripped.

Weekly Inspections & Testing:

1. All gauges shall be inspected. The gauge on the deluge valve shall indicate the normal supply water pressure is being maintained.

Monthly Inspections & Testing:

1. The deluge valve shall be externally inspected to verify the following:
   A. The valve is free from physical damage.
   B. All trim valves are in the appropriate opened or closed position.
   C. There is no leakage from the valve seat.
   D. Electrical components are in service.
   E. The gauge monitoring the pre-action system supervisory pressure shall be inspected to verify that it indicates that normal pressure is being maintained.
   F. The gauge monitoring the detection system pressure shall be tested to verify that it indicates that normal pressure is being maintained.

Quarterly Inspections & Testing:

1. Every quarter, verify that the air supply control valve is open. Drain the drip leg in the air supply line.Verify that the system pressure gauge is indicating the proper pressure.

Testing of the system waterflow alarms should be performed quarterly. To test the waterflow alarm, open the alarm test valve which will allow a flow of water to the pressure alarm switch and/or water motor alarm. Upon satisfactory completion of the test, close the alarm test valve. For dry pilot release, testing of the low pressure alarm switch and drainage of the pilot line condensate should be performed quarterly as follows:

1. Close the differential chamber supply control valve.
2. Close the main control valve.
3. Open the main drain valve.
4. Drain the dry pilot line condensate as follows:
   A. Close the gauge test valve located below the dry pilot line pressure gauge.
   B. Remove the 1/4 inch plug from the gauge test valve.
   C. Crack open the gauge test valve and allow all condensate, if any, to drain out.
   D. Close the gauge test valve, replace the plug, and then open the gauge test valve.

E. Open the inspector's test connection, and slowly relieve pneumatic pressure. Verify that the low pressure alarm switch is operational and that the low pressure set points are as follows:

F. Low pressure alarm setting at approximately 6 psi (0.4 bar) below the minimum pilot line service pressure requirement.

G. Fire alarm setting at approximately 15 psi (1.0 bar) below the minimum pilot line service pressure requirement.

H. Close the inspector's test connection, and allow the dry pilot line to automatically repressurize.

I. Open the differential chamber supply control valve.

J. Slowly open the main control valve. Close the main drain valve as soon as water discharges from the drain connection. Observe the automatic drain valve for leaks. If there are leaks, determine and correct the cause of the leakage problem. If there are no leaks, fully open main control valve.

Annual Inspections & Testing:

1. The interior of the deluge valve shall be cleaned thoroughly and the parts replaced or repaired as necessary.
2. Verify proper operation of the deluge valve.

Trip Test:

1. The interior of the deluge valve and the condition of the detection devices shall be inspected when the trip test is conducted. Grease, or other sealing materials, shall not be applied to the seating surfaces of the deluge valves.

NOTE:

Internal inspection of valves that can be reset without removal of a faceplate shall be permitted to be conducted every 5 years.

2. Manual activation devices shall be operated. Each deluge valve shall be trip tested at full flow in warm weather and in accordance with the manufacturer's instructions.

NOTE:

Where the nature of protected property is such that water cannot be discharged for test purposes, the trip test shall be conducted in a manner that does not necessitate discharge in the protected area.

In the case of performing a full flow trip test, perform steps 4 through 7; however, if water must be prevented from flowing beyond the riser, perform steps 1 through 7 and be prepared to perform step 6 as soon as the items outlined in step 5 are verified.

Records indicating the date the deluge valve was last tripped and the tripping time as well as the individual and organization conducting the test shall be maintained at a location or in a manner readily available for review by the authority having jurisdiction.

NOTE:

Automatic air pressure maintenance devices, if provided, shall be tested at the time of the annual deluge trip test, in accordance with the manufacturer's instructions.

Every 5 years:

Strainers, filters, restricted orifices, and diaphragm chambers shall be inspected internally (unless tests indicate a greater frequency is necessary).

The valve should be disassembled and all internal components inspected. Replace any defective components.

Upon Discovery:

Leaks causing drops in supervisory pressure sufficient to sound warning alarms and electrical malfunctions causing alarms to sound shall be located and repaired.

Water Pressure Drop:

Water pressure suddenly restored after a significant pressure drop could trip the deluge valve.

NOTE:

If the water supply pressure is significantly reduced below the normal expected static pressure range (as could occur in the case of a water main break or repair), and there is a subsequent drop in the differential chamber water pressure below its normal range (due, for example, to a leak in a piping connection to or from the differential chamber or, a leaking the differential chamber check valve caused by dirt or debris in the check valve seal area), the deluge valve could inadvertently trip, if its water supply pressure is quickly restored.

A drop in water supply pressure to below its normal range constitutes an emergency impairment as defined by NFPA 25. Should this condition occur, immediately close the main control valve and use the steps below to reset the system:

1. Prior to the water supply pressure being restored to the closed main control valve, note the pressure indicated by the differential chamber pressure gauge and, whether the pressure is within the normally expected range.
2. If the differential chamber pressure is below the normal range, check for and correct any source of leakage from the differential chamber, prior to resetting the system.
3. After the water supply pressure is restored to the main control valve, reset the deluge valve.

(Additional maintenance information for the deluge valve is available in Appendix Section 4.2.3.5.2.8 of this manual.

3.3.6 Compressed Air Systems

Compressed air is used in the Water Plant for general shop air and blowdown of the generators exhaust gas waste heat exchangers. A second compressed air system is located in the sea-water intake structure is used to assist in cleaning the water intake filter.

3.3.6.1 Air Compressors

The electric-driven two stage compressor (Equip. # AC00060) located just outside the Generator Room and the compressor (Equip. # CA0010) in the Sea-water Intake Structure were designed for 100% continuous duty operation.

General Safety Warnings:

Do not directly inhale compressed air.

Do not over-pressure the receiver tank or similar vessels beyond design limits.

Do not use a receiver tank, or similar vessels, that fail to meet the design requirements of the compressor.

Do not drill into, weld or otherwise alter the receiver tank or similar vessels.

Do not remove, adjust, bypass, change, modify or make substitutions for safety/ relief valves, pressure switches or other pressure control related devices.

Do not use air tools or attachments without first determining the maximum pressure recommended for that equipment.

Do not point air nozzles or sprayers toward anyone.

Do not touch the compressor pump, motor or engine or discharge tubing during or shortly after operation. These parts become hot.

Do not operate where flammable or explosive liquids or vapors such gasoline, natural gas and solvents are present.

Do not operate with guards or shields removed, damaged or broken.

Do not remove, paint over or deface decals. Replace any missing decals.

Air compressors are not designed, intended, or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

The manufacturers recommend the following inspections and preventive maintenance requirements:

DANGER:

Intake air can contain carbon monoxide or other contaminants. Which can cause serious injury or death. The air compressor is not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

WARNING:

Hazardous voltage can cause serious injury or death. Disconnect power and bleed pressure from the tank before servicing. Lockout and Tagout machine. Compressor must be connected to properly grounded circuit. See grounding instructions in manual. Do not operate compressor In wet conditions. Store Indoors.

Moving parts can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing. Lockout and tagout machine.

Hot surfaces can cause serious injury, do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

Bypassing, modifying or removing safety relief valves can cause serious injury or death. Do not bypass, modify or remove safety relief valves.

Do not direct air stream at body.

Rusted tanks can cause explosion and severe injury or death. Drain tank daily or after each use. Drain valve located at bottom of tank.

Before performing maintenance, release air pressure from the system and disconnect, lockout and tagout the main power supply, or disconnect the wire from the engine spark plug.

CAUTION:

RISK OF BURSTING Use only suitable air handling parts acceptable for pressure of not less than the maximum allowable working pressure of the machine.

NOTE:

New or rebuilt compressor pumps will discharge higher than normal amounts of all until the piston rings are seated (approximately 100 operating hours).

All compressed air systems contain maintenance parts (e.g. lubricating oil, filters, separators) which are periodically replaced. These used parts may be, or may contain, substances that are regulated and must be disposed of in accordance with local, state, and federal laws and regulations.

Take note of the positions and locations of parts during disassembly to make reassembly easier. The assembly sequences and parts illustrated may differ for your particular unit.

Any service operations not explained in this manual should be performed by an authorized service representative.

Reference the engine owner's manual for engine care information.

The following maintenance schedule has been developed for typical applications. Maintenance intervals should be shortened in harsher environments.

Daily Inspections:

1. Check for oil leaks.
2. Check lubricant level. Fill as needed.
3. Drain receiver tank condensate. Open the manual drain valve and collect and dispose of condensate accordingly.
4. Check for unusual noise and vibration.
5. Ensure the belt guards and covers are securely in place.
6. Ensure engine (if supplied) is filled with fuel and lubricant according to the manufacturer's recommendations.
7. Check system oil pressure on pressure lubricated models while compressor is hot.
8. Ensure the area surrounding the compressor is free from rags, tools, debris, and flammable or explosive materials.

Weekly Inspections:

1. Observe operation of the safety relief valves while the compressor is running. Replace any safety relief valves that do not operate freely.
2. Inspect the air filter element(s). Replace as necessary.

Monthly Inspections:

1. Inspect for air leaks. Squirt soapy water around joints during compressor operation and watch for bubbles.
2. Check tightness of screws and bolts. Tighten as needed.
3. Inspect tension of drive belts. Adjust if necessary.
4. Clean the exterior.

3/500:*

1. Change the petroleum lubricant while the crankcase is warm.
2. Drain compressor oil and clean oil sight glass.

*Indicates months / operating hours, whichever occurs first.

6/1000:*

1. Replace oil filter and change lubricant (if necessary) on pressure lubricated models.

*Indicates months / operating hours, whichever occurs first.

12/2000:*

1. Change synthetic lubricant while the crankcase is warm.
2. Replace the filter element.

*Indicates months / operating hours, whichever occurs first.

Lubrication:

Synthetic lubricant is recommended from start-up.

Petroleum-based lubricant that is of premium quality, does not contain detergents, contains only anti-rust, anti-oxidation, and anti-foam agents as additives, has a flashpoint of 440° F (227° C) or higher, and has an auto-ignition point of 650° F (343° C) or higher can be used.

CAUTION:

Do not operate without lubricant or with inadequate lubricant.

Failure to adhere to this warning will or can cause minor injury or property damage.

(For additional information regarding the air compressor, refer to Appendix Section 4.2.3.6.1 of this manual.)

3.3.6.2 Air Receiver

The life of an air receiver tank is dependent upon several factors including, but not limited to, operating conditions, ambient environments, and the level of maintenance. The exact effect of these factors on tank life is difficult to predict; therefore, the manufacturer recommends that you schedule a certified tank inspection within the first five years of compressor service. If the tank has not been inspected within the first 10 years of compressor service, the receiver must be taken out of service until it has passed inspection. Tanks that fail to meet requirements must be replaced.

WARNING:

Failure to replace a rusted air receiver tank could result in air receiver tank rupture or explosion, which could cause substantial property damage, severe personal injury, or death. Never modify or repair tank. Obtain replacement from the service center.

The manufacturer recommends the following preventive maintenance at intervals indicated:

1. The tank should have a complete external inspection for erosion or corrosion.
2. All fittings, valves, and piping should be inspected monthly for damage, leaks, and corrosion.
3. All safety valves shall be tested frequently and at regular intervals to determine whether they are in good operating condition.

(For additional information regarding the air receiver tank, refer to Appendix Section 4.2.3.6.2 of this manual.)

3.3.6.3 Air Outlet Accessories

No routine maintenance is assigned for the gauges used in the compressed air system at this time.

However, the gauges should be inspected annually for damage, leaks, obstructions, and breakage. Repair as necessary.

General maintenance for ball valves consists of operating the valve periodically to ensure that it is functioning properly.

Routine maintenance consists of tightening the packing to compensate for wear. The handle nut also provides the packing preload on the ball valve. When leakage occurs, the packing/handle nut should be tightened in 1/8 to 1/4 turn increments just enough to stop leakage.

WARNING:

DO NOT under any circumstances, solder the downstream end of this valve while there is upstream pressure/or with fluid trapped in the cavity around the ball. Thermal expansion of this fluid could produce excessive internal pressure which could damage seat or body materials. Always drain down the system and cycle the valve two to three times after drain down is complete before applying heat. Steam created from trapped fluid in the cavity around the ball could cause the valve to BURST if valve is heated excessively.

NOTE:

The manufacturer does not recommend disassembly of this valve to attempt internal repairs.

(For additional information regarding the accessories used on the compressed air system, refer to Appendix Section 4.2.3.6.3 of this manual.)

3.3.7 Fuel Oil System

3.3.7.1 Fuel Meters

No routine maintenance, cleaning or lubrication is required on the flowmeter. The user should establish a schedule for periodic checking and cleaning of the strainer.

The manufacturer has issued the following recommendations for the flowmeter:

1. No attempt should be made by the user to alter any physical dimension of the flowmeter or component part.
2. Do not use force to assemble or disassembly any component of the flowmeter. All components are manufactured to exact tolerances.
3. When an unserviceable flow meter has been returned to the factory for rework, it must be understood that in extreme cases it may be economically impractical to repair the flowmeter.
4. No attempt should be made by the user to replace the rotor bearings. Rotors and bearings are manufactured as a subassembly and are available as replacement or spare parts.

(For additional information regarding the flowmeter used in the fuel oil system, refer to Appendix Section 4.2.3.7.1 of this manual.)

3.3.7.2 Day Tanks / Gauges

The fuel storage day tank was designed to require minimum maintenance. All components have been chosen for a long, reliable life. The manufacturer also recommends the following maintenance be carried out:

Each Year:

1. Water and sediment should be drained from the tank each year. If normal engine / generator testing does not consume one tank full of fuel each year the tank should be drained and refilled with fresh fuel.
2. Remove the inspection port from the tank and examine the interior of the tank. Using an inspection lamp examine all internal components. With the tank drained test sending unit operation. Install a new inspection port gasket and replace the inspection cover.
3. Depress the Press-To-Test button and observe pump and motor performance.
4. Inspect pump to motor alignment and wear. Inspect the pump for leaks.
5. Re-tighten hose clamps at all pump hose connections. Re-tighten the pump bracket, motor bracket, and pump motor coupler hardware.
6. Inspect all plumbing connections for leaks. Test all options and fuel level alarms for proper operation.
7. Re-tighten all electrical connections.

After Three Years:

1. After three years of normal use re-oil the tank motor with 10 drops of 5W30 or 10W oil. Do Not Over Oil The Motor.

(For additional information regarding the fuel oil day tank, refer to Appendix Section 4.2.3.7.2 of this manual.)

3.3.7.3 Fuel Oil Strainer

The manufacturer has recommended the following preventive maintenance steps:

1. The strainer installed on the fuel oil supply line has a special yoke screw and swinging yoke for quick cleaning without the use of a wrench or other tools.
2. Inspect the basket at each cleaning for holes or tears, repair or replace as required.
3. Inspect all connections for leaks or damage during cleaning, repair as necessary.

CAUTION:

To prevent damage to the basket, DO NOT permit strainer pressure differential between the inlet and outlet connections to exceed 20 psi.

Follow the manufacturer's instructions when using a solvent to clean the basket.

NOTE:

Do not allow basket contents to dry as this will make cleaning most difficult.

4. The basket should be cleaned when there is a 5 psi increase in pressure loss across the strainer. Invert the basket and wash out debris by directing a stream of air or water against the basket exterior. Use solvent if strained fluid is fuel or a chemical. Follow the manufacturer's instructions when using a solvent to clean the basket.

(For additional information regarding the strainer used in the fuel oil system, refer to Appendix Section 4.2.3.7.3 of this manual.)

3.3.7.4 Valves and Fittings

The valves and fittings in the fuel oil system require periodic inspections and preventive maintenance.

1. Inspect all valve and fitting connections for leaks and corrosion. Repair as necessary. Leakage through the bonnet joint would require valve repair or replacement. Leakage through the valve seat is generally due to foreign matter lodged in the seat. Such foreign material can be washed away through the valve.
2. Periodic adjustment of the stem packing and cycling of the valve from open to close may be required.
3. If the valve develops a packing leak, adjust the packing nut to increase pressure on the packing stem.

(For additional information regarding valves and fittings used in the fuel oil system, refer to Appendix Section 4.2.3.7.4 of this manual.)

3.3.8 Engine and Generator Systems

This section details the manufacturer's recommended maintenance requirements needed to maintain the two diesel engine generator sets.

Maintenance records are a key element of a well managed maintenance program. With accurate maintenance records, the manufacturer can help fine tune the recommended maintenance intervals to meet specific situations. Regular inspections and preventive maintenance will help in determining equipment condition and reveal future problems. This should result in a lower engine operating cost.

Maintenance personnel should keep these general safety warnings in mind while performing any inspections, preventive maintenance, or maintenance on the components in the following sub-sections:

WARNING:

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance, or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

The stop-manual-automatic switch on the cranking panel must be set to the "stop" position when performing maintenance or repair work on a standby generator set. This prevents the unit from starting if a power failure or voltage drop should occur while working on the unit.

To prevent personal injury due to accidental starting of the engine, disconnect the batteries or disable the starting system before doing maintenance or repair work.

Lock out all switch gear and automatic transfer switches associated with the generator while performing any generator maintenance or repairs. Ensure no shock hazard exists.

Personal injury or death can result from high voltage.

When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present.

Improper test equipment can fail and present a high voltage shock hazard to its user.

Make sure the testing equipment is designed for and correctly operated for high voltage and current tests being made.

Failure to do so could result in personal injury or death. Make sure residual voltage in the rotor, stator and the generator is discharged.

WARNING:

When servicing or repairing electric power generation equipment:

1. **Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked-out or tagged DO NOT OPERATE.**
2. **Remove all fuses.**
3. **Make sure the generator engine is stopped.**
4. **Make sure all batteries are disconnected.**
5. **Make sure all capacitors are discharged.**

Failure to do so could result in personal injury or death. Make sure residual voltage in the rotor, stator and the generator is discharged.

3.3.8.1 Diesel Engines and Generator Systems

3.3.8.1.1 Diesel Engine and Generator Sets

The manufacturer recommends when required, weekly, monthly, yearly, every 3 years and when doing a major overhaul inspections and maintenance to be completed while in standby mode, before starting the engine, while the engine is running, and after stopping the engine. These maintenance procedures are particularly important if the engine has not been used for any length of time. Inspections and preventive maintenance should be completed whether the engine generator is in *standby* mode or is running.

The manufacturer recommends the following inspections and preventive maintenance at a minimum:

WARNING:

Personal injury or death can result from improper troubleshooting and repair procedures.

The following repair procedures should only be performed by qualified personnel familiar with this equipment.

When Required: Perform

1. Generator Load Check.
2. Generator Set Test.

WARNING:

Dangerous voltages are present at both the generator and the system bus.

Under no circumstances should any attempt be made to connect instrumentation to these points until you are certain all power is off.

All instruments must be connected to the generator and the system bus through potential transformers, which provide a maximum of 600 volts to the instruments.

Dangerous voltages are present at the generator's output terminals. Until the power is verified to be OFF, there should not be any device that is connected to the following terminals: (TI), (TZ), and (T3). The voltmeter must be connected to the generator through potential transformers. Potential transformers provide a maximum of 600 volts to the voltmeter.

Failure to follow instructions will result in death or serious injury.

3. Rotating Rectifier Test.
4. Varistor Test.
5. Winding Test.

Every Week: Perform

1. Air Inlet Filter - Check.
2. Bearing Temperature - Measure and Record.
3. Electrical Connections - Check.
4. Generator - Inspect.
5. Power Factor - Check.
6. Space Heater - Check.
7. Stator Winding Temperature - Measure/Record.
8. Voltage and Frequency - Check.
9. Walk-Around Inspection.

WARNING:

Personal injury or death can result from improper troubleshooting and repair procedures.

The following troubleshooting and repair procedures for the Walk-Around Inspection should only be performed by qualified personnel familiar with this equipment

Every 100 Service Hours or 3 Months: Perform

1. Insulation Test.

WARNING:

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

Personal injury or death can result from electrocution.

The megohmmeter is applying a high voltage to the circuit.

To avoid electrocution, do not touch the instrument leads without first discharging them. When finished testing also discharge the generator windings.

Every 1000 Service Hours: Perform

1. Bearing - Lubricate.

Every 2000 Service Hours or 6 Months: Perform

1. Generator - Dry.
2. Generator Set Vibration - Inspect.
3. Stator Lead - Check.

Every Year:

1. Bearing - Lubricate.
2. Generator - Dry.
3. Generator Set Vibration - Inspect.
4. Insulation - Test.

WARNING:

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

Personal injury or death can result from electrocution.

The megohmmeter is applying a high voltage to the circuit.

To avoid electrocution, do not touch the instrument leads without first discharging them. When finished testing also discharge the generator windings.

5. Stator Lead - Check.

Every 10,000 Service Hours: Perform

1. Bearing - Lubricate.

Every 3 Years: Perform

1. Rotating Rectifier - Check.

Overhaul: Perform

1. Bearing - Inspect.

Because the actual inspection and maintenance steps are so extensive, they are not listed in this manual. Refer to Appendix Section 4.2.3.8.1.1, page 86 and Appendix Section 4.2.4.3.3, page 111.

3.3.8.1.2 Engine Pre-Heat System

Tubular electric circulation heaters are used to pre-heat the engine coolant. This is necessary during extreme cold conditions to keep from shocking the engines. The heaters are especially critical during periods when the engines has not been ran for a while or at the beginning of each season.

In order to extend the life of your heater, the manufacturer has recommended the following maintenance steps should be performed:

CAUTION:

When performing any maintenance on the heater, all safety regulations must be followed. Approved safety lockout procedures must be followed before opening the heater or heater electrical housing.

Monthly:

1. Inspect equipment for leaks or visible damage

Semi-Annually:

1. Open terminal housing and ensure it is dry and clean.
2. Check the resistance between each circuit leg and ground.
3. Check all terminals for damage and to ensure that all terminals are tight and secure. Care should be taken not to over-tighten terminals.
4. Check resistance between circuit legs.
5. Check enclosure gasket if provided and replace if damaged.

Annually:

1. Open terminal housing to ensure it is clean and dry.
2. Remove bolts from heater and pull heater bundle. Care must be taken in removing the bundle not to damage the elements. Check heater elements for any sign of buildup of foreign materials such as scale, coking or sludge. If buildup is noted, clean elements. Check over-temp thermocouple to ensure it is properly secured to the element. If the thermocouple is removed for any reason, it must be re-attached to the same element in the same location. Reinstall heater bundle using a new gasket and taking care not to damage the element. When bolting the heater into place, proper tightening procedures and torque must be used to ensure proper seating of the gasket.

CAUTION:
Always use a new gasket, NEVER USE THE OLD GASKET.

3. Reconnect conduit and wires using care to reconnect to the proper terminals. Close housing cover using new gasket if necessary.
4. Check the resistance between each circuit leg and ground.
5. Check all terminals for damage and to ensure that all terminals are tight and secure. Care should be taken not to over-tighten terminals.
6. Check resistance between circuit legs.
7. When restarting the heater, monitor for leaks.

3.3.8.2 Engine Cooling System

The diesel engines used in the Water Plant have a pressure type jacket-water cooling system. A pressure type cooling system has two advantages. The first advantage is that the cooling system can safely operate at a temperature higher than the normal boiling (steam) point of water. The second advantage is that this type system prevents cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) in the water pump. With this type system, it is more difficult for an air or steam pocket to develop in the cooling system. The cause for increased engine temperature is generally because regular inspections of the cooling system are not made.

The engine water cooling system consists of two major components; the first major component is the jacket water cooling cavities within the engine and the exterior piping, pumps, valves, and fittings. The second major component is the remote radiators, fans, and motors. Heat exchangers and expansion tanks are covered in other sections of this manual.

3.3.8.2.1 Jacket Water Components

The manufacturer recommends the following maintenance be completed on the engine cooling system at the time intervals indicated:

Daily:

1. Check coolant level. Maintain level within 13 mm (1/2 inch) to bottom of filler neck or proper level on sight gauge (if equipped).
2. Verify there are no leaks in the cooling system.

NOTE:

Water pump seals. A small amount of coolant leakage across the surface of the "face-type" seals is normal, and required, to provide lubrication for this type of seal. A hole is provided in the water pump housing to allow this coolant/seal lubricant to drain from the pump housing. Intermittent leakage of small amount of coolant from this hole is not an indication of water pump seal failure. Replace the water pump seals only if a large amount of leakage, or a constant flow of coolant is observed draining from the water pump housing.

Weekly:

1. Check all connections in the cooling system for tightness and leaks. Make repairs as necessary.
2. Check for leaks around the coolant level meter. Verify the coolant level meter is operational. Replace if necessary.

3. Look for air or combustion gas in the cooling system.

Yearly:

1. Replace coolant element (if equipped), or add liquid coolant conditioner.
2. Check coolant level. Maintain level within 13 mm (1/2 inch) to bottom of filler neck or proper level on sight gauge (if equipped).
3. All valves should be checked for corrosion and leaks. Replace or repair as necessary.
4. All valves should be checked for operation by exercising the valves from one limit to the other. Replace or repair as necessary.

(For additional maintenance information on the jacket water cooling system, see Appendix Sections 4.2.3.8.1.1 of this manual.)

3.3.8.2.2 Remote Radiators, Fans & Motors

This section provides preventive maintenance recommended by the manufacturer for the remote radiators, fans, and motors.

Daily:

1. Check the cooling fan for clearance, excessive vibration and noise.
2. Check for worn cooling belts, replace if necessary.
3. Verify the cooling radiator shows no signs of leakage or corrosion.

Weekly:

1. Check the fan belts for proper tension (DO NOT OVER TIGHTEN BELTS).
2. Check for proper fan belt sheave alignment.
3. Verify there is no foreign matter loose in the airstream or in the fan itself.
4. Check all connections for tightness and leaks. Make repairs as necessary.
5. Check the fan for rotational freedom.
6. Verify the cooling fan shroud opening is in place and functional.
7. Look for bent radiator fins. Be sure that air flow through the radiator does not have a restriction.
8. Inspect the pressure cap and/or filler cap and the surface that seals the cap. This surface must be clean. Replace the radiator cap is necessary.

Lubrication of Fan Motor:

Frequency of lubrication for the electric fan cooling motor will vary depending on the hours of operation, temperature & surrounding conditions. The manufacturer recommends the following schedule:

HOURS OF SERVICE PER YEAR	SUGGESTED RELUBE INTERVAL
5000	**Every 5 Years**
Continuous Normal Application	Once a Year
Continuous in high ambient, or dirty or moist location. Where the motor is idle for six months or more. In applications with high vibration, or where shaft end is hot (Pump-Fan).	Every 6 Months

CAUTION:

Keep grease clean! Do not mix petroleum grease and silicone grease in motor bearings.

Use high grade ball bearing grease. Use consistency of grease suitable for class of insulation stamped on the nameplate. The manufacturer recommends a lithium grease.

(For additional maintenance information on the remote radiators, fans and motors, see Appendix Sections 4.2.3.8.2.1 of this manual.)

3.3.8.3 Stack Gas

3.3.8.3.1 Non-Heat Recovery Silencers

The manufacturer of the non-heat recovery silencers states these silencers are designed to be maintenance free. However, like the heat recovery silencers, a build-up of soot will cause increased back pressure into the generator engines which can result in poor running performance. Therefore, it is important the sootblowing system is activated at regular intervals to keep these silencers soot free.

These silencers should also be inspected at regular intervals for leaks or damage. Repair as necessary.

(For additional maintenance information on the non-heat recovery silencers, see Appendix Sections 4.2.3.8.3.2 of this manual.)

3.3.8.3.2 Heat Recovery Silencers

The Heat Recovery Silencers consist of a basic heat exchanger with an exhaust bypass damper (diverter control dampers) mounted on top. Besides providing heat recovery, the heat exchangers are designed to provide a significant reduction in exhaust noise. Because of their function, it is critical these heat exchangers (EHX-1 & EHX-2) receive regular inspections and maintenance. A soot blowing system was included with these heat exchangers to help keep the exhaust side from fouling. A build-up of soot will cause increased back pressure into the generator engines which can result in poor running performance. Enough back pressure could chock the engines, preventing them from running. The other side of the heat exchanger is of the water based design tied to the Glycol waste heat recovery system. Like other water based heat exchangers, scale or sediment can become a problem.

The manufacturer recommends the following preventive maintenance procedures:

Exhaust Side:

The sootblowers can minimize the need for manual cleaning. However, for fuel oil type atmospheres, regular periodic manual inspection and cleaning of the heat exchanger surface is mandatory to insure maximum efficiency and equipment longevity.

Oil fired applications require more frequent inspection of the heat transfer core area because of the greater potential for soot loading and particulate buildup on the finned tube surface.

The manufacturer recommends a routine physical inspection of the heat transfer core area. Frequency of inspections will be dependent on the performance conditions and the quality of combustion. The inspection and maintenance procedure can be performed without dismantling any of the piping or the exhaust stack connections. The access door(s) should be opened for inspection and cleaning when it has been determined the fins are fouled and need cleaning (i.e. 1/16" thickness build up or greater on the fins). The fouled finned tube area can be manually cleaned by blowing high pressure steam or air with a lance assembly across the fins.

NOTE:

Ensure that the combustion source is off and is cool, and the exchanger is cool before attempting to inspect or clean the fin coil(s).

The exhaust bypass must be adjusted to the 100% 'normal operating' position in order to allow the soot to leave the exchanger after being blown off.

Water (Glycol) Side:

The heat exchanger should be inspected periodically for internal build-up of scale or sediment. If found, scale or sediment should be removed either chemically or mechanically. Cleaning the unit may be accomplished by either back flushing, circulating cleaning agents in unit (cleaning-in-place) or, by disassembling the unit and performing a manual cleaning. If the water contains suspended foreign material, deposits can accumulate in the flow passages. Under these circumstances, back flushing may be adequate to clean unit. If this method is ineffective for the removal of hard scale, you may want to circulate buffered cleaning agents as recommended by the manufacturer of the agents in unit to remove scale or disassemble unit for manual cleaning. Plates can be cleaned while hanging on frame or removed depending on how much work is required. **Cleaning-in-place is the preferred cleaning method**.

TYPE OF FOULING	SUGGESTED CLEANERS
Calcium Sulphate, Silicates	Citric, Nitric, Phosphoric or Sulfamic Acid
Calcium Carbonate	10% Nitric Acid (1 volume concentrated Nitric Acid with specific gravity 1.41 to 9 volumes of water), Oakite 131
Alumina, Metal Oxides, Silt	Citric, Nitric, Phosphoric or Sulfamic Acid
Barnacles, Mussels, Seaweed, Wood Chips	Back flush per cleaning-in-place procedure
Bilogical Growth	Sodium carbonate or sodium hydroxide

Because of their importance, general guidelines for cleaning listed in the manufacturer's manual are repeated below:

NOTE:

Always add concentrated cleaning solutions to water before circulating through the unit, Never inject these solutions while the water is circulating, Remove rusted or pitted areas that appear on the plates with commercial scouring powder. Follow this by flushing with clean water.

Cleaning solutions should always be circulated with a centrifugal pump.

Do not use hydrochloric (muriatic) acid for cleaning plates.

Thoroughly rinse the plates with clean water following any type of chemical cleaning.

Never open the unit when hot, under pressure, holding liquid or operating.

Do not use brushes with carbon steel bristles or steel wool. A fiber type brush is recommended, but as a last resort use a brush of similar material to the thermal plates Be careful not to scratch plates or damage gaskets if they are to be reused. After brushing rinse each plate with water.

Limit cleaning solution concentration to 4% in strength, with temperatures not exceeding 140° F unless otherwise specified.

The following solvents should not be used in contact with gaskets: Ketones (e.g. Acetone, Methylethylketone, Methylisobutylketone) Esters (e.g. Ethylacetate, Butylacetate) Halogenated hydrocarbons (e.g. Chlorothene, Carbon tetrachloride, Freons).

NOTE:

If chlorinated solutions are used as the cleaning media, use a minimum concentration at the lowest temperature possible. Minimize the plate exposure time. The chlorine concentration must be less than 100 PPM and temperatures must be under 100° F with a maximum plate exposure time of 10 minutes. Follow the cleaning recommendations of suppliers, relative to concentration, temperature and treatment time.

Care must be exercised when handling certain fluids. Follow manufacturers instructions. Use eye and skin protection. Wear a respirator when required.

Never clean the plates with a steel brush or steel wool.

Always wipe the gaskets clean before closing the unit to prevent damage resulting from adhering particulate matter.

Under no circumstances should phosphoric or sulfamic acid be used with titanium plates. Do not use hydrochloric acids, or water containing in excess of 300 ppm chlorides with stainless steel.

Cleaning-In-Place (CIP) Procedure:

In applications where extremely corrosive fluids are being used, a clean-in-place system is recommended to lengthen the life of the thermal plates. Because the CIP is the preferred method of cleaning, the manual process is not discussed here but the procedure is available in the manufacturer's manual.

1. Drain both sides of the unit. If it is not possible to drain, force liquids out of the unit with flush water.
2. Flush the unit on both sides with warm water at approximately 110º F until the effluent water is clear and free of the process fluid.
3. Drain the flush water from the unit and connect the CIP pump.
4. For through cleaning it is necessary to flow CIP solution bottom to top to insure wetting of all surfaces with cleaning solution. When cleaning multiple pass units it will be necessary to reverse flow for at least half the cleaning time to wet all surfaces.
5. For optimum cleaning, use the maximum flow rate of water, rinse or CIP solution that the CIP nozzle size will allow. A CIP operation will be most effective if performed on a regularly scheduled basis and before the unit is completely fouled.

NOTE:

If brine is used as a cooling medium, completely drain the fluid from the unit and flush the unit with cold water prior to any cleaning operation. Corrosion will be kept at a minimum if all traces of brine are eliminated before using hot CIP solutions on either side of the heat exchanger.

Back flushing:

1. Many applications use fluids that may contain solids and sediments that can be trapped and plug up a plate heat exchanger, If this problem is anticipated it is very beneficial to make provisions in your piping for back flushing the unit.
2. Back flushing should be done with water at 11/2 times the process flow rate.
3. It is recommended that fluids containing particulate enter at the bottom of the unit and exit at the top. This will cause some solids to collect in bottom of inlet nozzle instead of going into plate pack and clogging.
4. Another alternative to back flushing is to arrange piping so both fluids can be periodically reversed.

The following solvents should not be used in contact with gaskets

- Ketones (e.g. Acetone, Methylethylketone, Methylisobutylketone),
- Esters (e.g. Ethylacetate, Butylacetate),
- Halogenated hydrocarbons (e.g. Chlorothene, Carbon tetrachloride, Freons), and
- Aromatics (e.g Benzene, Toluene).

WARNING:

Care must be exercised when handling certain fluids. Follow manufacturer's instructions. Use eye and skin protection. Wear a respirator when required.

CAUTION:

The gasket may have to be stretched prior to installation to fit the gasket groove. Avoid excess stretching as damage to gasket can result.

(For additional maintenance information on the heat recovery silencers, see Appendix Sections 4.2.3.8.3.3 of this manual.)

3.3.8.3.3 Diverter Control Dampers

The purpose of the actuator controlled diverter control dampers (exhaust bypass damper) mounted on top of heat exchangers (EHX-1 & EHX-2) is to control the amount of exhaust routed into the heat exchangers.

The manufacturer advises there is little or no maintenance required except for the following:

1. The gear train has been permanently lubricated at the factory. In the event it becomes necessary to perform maintenance on the actuator, upon reassembling Lubriplate EMB grease should be used.
2. Check the entire motor and control hookup. Proper checkout ensures that the motor operates the load (valve) properly.
3. Verify the motor responds properly to the controller as the input varies.
4. Verify the auxiliary switch, if used, operates at the desired point of motor rotation.
5. Inspect motor, linkage, and valve or damper to ensure all mechanical connections are correct and secure.
6. Ensure that there is adequate clearance for the linkage throughout the entire motor stroke without binding or striking other objects.
7. Drive the motor fully open and fully closed.
8. For spring return motors, ensure that the valve returns to normal position upon power interruption.
9. Return the controller to the desired setting before leaving the job.
10. The exterior case on the damper actuators should be kept clean.
11. Verify there is no debris around the actuators to interfere with their operation.
12. No maintenance is required for the time delay module other then verifying the module is operating within the selected delay time.

(For additional maintenance information on the exhaust diverter control dampers, see Appendix Sections 4.2.3.8.3.4 of this manual.)

3.3.8.4 Lubricating Oil System

The lubricating oil system is critical for continued operation of the engine generator. Therefore, inspections and maintenance of this system needs to be completed on a regular basis.

If one of the following problems in the list is present, it generally indicates a problem in the lubrication system for the engine:

- Too Much Oil Consumption (oil leakage or consumption),
- Oil Pressure is Low,
- Oil Pressure is High,
- Too Much Bearing Wear, and
- Increased Oil Temperature.

Unusual oil consumption can be attributed to oil leakage of some kind. Oil leakage can occur on the outside of the engine, leaving visible marks. Oil leakage can also be internal, as into the combustion area as indicated by blue exhaust smoke.

Too much oil consumption can also be the result if oil with the wrong viscosity is used. Oil with a thin viscosity can be caused by fuel leakage into the crankcase, or by increased engine temperature.

Low oil pressure can be caused by the level of the oil in the crankcase. Add oil if needed. It is possible for the oil level to be too far below the oil pump supply tube. This will cause the oil pump to not have the ability to supply enough lubrication to the engine components.

Another cause of low oil pressure can result from the inlet screen of the supply tube for the oil pump being restricted. This will cause cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) and a loss of oil pressure.

Air leakage in the supply side of the oil pump will also cause cavitation and loss of oil pressure. If the bypass valve for the oil pump is held in the open (unseated) position, the lubrication system cannot get to a maximum pressure. Oil pump gears that have too much wear will cause a reduction in oil pressure.

Components that are worn and have too much bearing clearance can cause oil pressure to be low. Low oil pressure can also be caused by an oil line or oil passage that is open, broken or disconnected.

Oil pressure will be high if the bypass valve for the oil pump cannot move from the closed position.

If the oil cooler has a restriction, the oil temperature will be higher than normal when the engine is operated. The oil pressure of the engine will not get low just because the oil cooler has a restriction. Also check the oil cooler bypass valve to see if it is held in the open position (unseated). This condition will let the oil through the valve instead of the oil cooler, and oil temperature will increase.

Because of the importance the lubricating oil system plays in the performance of the generator engine, the manufacturer recommends the following inspections and maintenance be performed to keep the engine's lubricating oil system in operating condition:

Daily:

1. Check and verify engine oil pressure and temperature is within specifications while the engine is running. Run the engine to get the engine oil temperature at 210° F (99° C). A 5° F increases in temperature gives approximately 7 kPa (1 psi) decrease in engine oil pressure. Make sure engine oil temperature does not go above 239° F (115° C).
2. Check the oil pump's bypass valve. If the bypass valve is being held in the open position, remove and clean the bypass valve and bypass valve bore. Install a new oil filter to be sure that no more debris makes the bypass valve stay open.
3. Visually inspect the engine for oil leaks.
4. Check oil level while the engine is warm, but not running. Add oil if necessary to bring the oil level up to the correct level.

Recommended lubrication types and frequency of changing these lubrication types, including the oil filter, can be found in the Appendix Sections indicated below.

(For additional maintenance information on the engine lubricating oil system, see Appendix Sections 4.2.3.8.1.1 and 4.2.3.8.4.1 of this manual.)

3.3.8.5 Engine Fuel Oil System

This section presents general instructions for maintaining components associated with the engine fuel oil system.

The tables located at the end of this section indicate items which must be performed to maintain systems and equipment at a minimum level of operational readiness. The listed minimum action items should be supplemented by manufacturer-recommended maintenance activities and procedures for specific pieces of equipment. Maintenance actions included in this chapter for various modes of operation, subsystems, or components are summarized in the tables.

Inspect fuel oil system. Start at the outdoor fuel oil storage tank and follow the fuel oil system piping all the way to the diesel engine-generators.

Inspect for the following:

1. Leaking pipe joints and/or corrosion.
2. Sagging or misalignment of piping.
3. Fuel oil leaks or spills. Inspect containment area for the storage tanks for cracks or any other inconsistencies.
4. Exercise all valves in the fuel oil system. Inspect packing gland and tighten if necessary. Check for correct positioning and operation. Check for leaking seals.
5. Adjust operator linkages and limit switches on control valves.
6. Clean any strainers present. Change strainer basket by turning change valve handle to isolate one of the baskets from service. Remove cover and basket screen. Clean and reinstall screen in strainer in same position as before and tighten cap. Place cleaned basket in service by turning the change valve handle. Clean the other basket screen.
7. Replace filter elements. Replace coalescing filter elements when differential pressure has increased above design standard. Follow manufacturer's instructions for filter element replacement.
8. Check fuel levels. Fill the storage tank as required.
9. Check level controls. Verify all level controls are operational.
10. Test alarms. Verify that the horns sound and all annunciator lights illuminate by pressing the appropriate test push buttons.
11. Check tank heaters. Verify that all fuel oil heaters are operating correctly.
12. Dewater day tanks. Drain water and sediment from day tanks by momentarily opening drain valve to flush out these contaminants.
13. Lubricate rotating equipment. Grease all zerks at the manufacturer-recommended service interval. Grease gently with a handgun to avoid damage to grease seals. Do not over grease.
14. Examine internal engine pump parts. Periodically, remove the head and examine idler bushing and head and pin for wear. Replacing a relatively inexpensive idler bushing and idler pin after only moderate wear will eliminate the need to replace more expensive parts at a later date.
15. Clean all equipment regularly. Clean equipment is easier to inspect, lubricate, and adjust. Clean equipment also runs cooler and looks better.
16. Inspect engine fuel oil components. Inspect diesel engine mounted fuel oil system components **DAILY**. Check for leaks or any inconsistencies.

17. Dewater fuel filters/separators. Drain water from secondary fuel oil filter/ separators **DAILY** by momentarily opening drain valves to flush out sediment and water. prime the unit by removing the lid and filling the unit with clean fuel. Replace the lid and snugly tighten the T-handle by hand ONLY.
18. Inspect fuel oil cooler. Clean coils and check proper setting and operation **DAILY** of thermostats.

Day Tanks / Gauges

The fuel storage tank was designed to require minimum maintenance. All components have been chosen for a long, reliable life. The following maintenance should be carried out:

Each Year:

1. Water and sediment should be drained from the tank each year. If normal engine / generator testing does not consume one tank full of fuel each year the tank should be drained and refilled with fresh fuel.
2. Remove the inspection port from the tank and examine the interior of the tank. Using an inspection lamp examine all internal components. With the tank drained test sending unit operation. Install a new inspection port gasket and replace the inspection cover.
3. Depress the Press-To-Test button and observe pump and motor performance.
4. Inspect pump to motor alignment and wear. Inspect the pump for leaks.
5. Re-tighten hose clamps at all pump hose connections. Re-tighten the pump bracket, motor bracket, and pump motor coupler hardware.
6. Inspect all plumbing connections for leaks. Test all options and fuel level alarms for proper operation.
7. Re-tighten all electrical connections.

After Three Years:

1. After three years of normal use re-oil the tank motor with 10 drops of 5W30 or 10W oil. Do Not Over Oil The Motor.

FUEL OIL SYSTEM

Action	Frequency
Check fuel level gauges.	Daily
Inspect engine fuel oil components.	Daily
Dewater strainers and filters.	Daily
Manually check fuel level.	Weekly

FUEL OIL SYSTEM

Action	Frequency
Inspect fuel oil system.	Monthly
Exercise valves	Monthly
Exercise fuel circulation system.	Monthly
Replace filter elements.	Monthly
Clean strainers.	Monthly
Check level controls.	Monthly
Test alarms.	Monthly
Check tank heaters.	Monthly
Dewater fuel tanks.	Monthly
Clean all pumps.	Monthly
Inspect fuel oil coolers.	Monthly
Examine internal pump parts.	Yearly
Pressure gauges.	Yearly
Temperature indicators.	Yearly
Lubricate transfer pumps.	6/yrs.

3.3.8.5.1 Fuel Oil Filters

Frequency of water draining or element replacement is determined by the contamination level of the fuel. The manufacturer recommends the following:

Weekly:

1. Drain water separator (if equipped).

> **NOTE:**
> **The fuel oil filters can be isolated one filter at a time for servicing even while the engine is running.**

Every 250 operating hours:

1. Clean the PRIMARY fuel filter (if equipped).
2. Replace the FINAL fuel filter.

> **CAUTION:**
> **DO NOT fill the fuel filters with fuel before installing them. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to the fuel system.**

> **NOTE:**
> **DO NOT remove the plug in the fuel filter base (for the fuel pressure sending unit [if equipped] to purge air from the fuel system. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base and lead to fuel leakage.**

(For additional maintenance information on the fuel oil filter, see Appendix Sections 4.2.3.8.1.1 and 4.2.3.8.5.1 of this manual.)

3.3.8.5.2 Fuel Oil Coolers

Temperature, turbulence, velocity, flow distribution, surface finish and water quality all effect fouling in a cooler.

Measuring of inlet and outlet temperatures of the cooler indicates if fouling has occurred. Fouling of the heat transfer surface decreases the heat transfer, resulting in temperature differences lower than specified. Another way to determine fouling is by measuring pressure drop over the cooler.

Since fouling restricts the passages and thus increasing the velocity, this will be shown as increased pressure drop. When using these methods make sure that the water flow rate is as specified as changes in flow rate, of course, also effect temperature and pressure drop.

Periodically perform the following inspections and preventive maintenance:

1. Leaking pipe joints and/or corrosion. Repair as necessary.
2. Sagging or misalignment of piping. Repair as necessary.
3. Fuel oil leaks or spills. Clean as necessary.
4. Inspect the unit regularly for loose bolts and connections, rust, corrosion, dirty or clogged cooling element.
5. Check for correct positioning and operation. Vee belts, sheave alignment, and correct belt tension must be maintained.
6. Check for leaking seals. Repair as necessary.
7. If cleaning of the cooler core is required, back-flush with water will remove most soft deposit. If fouling appears in shape of hard deposit, circulate a weak acid through the cooler in reverse direction to the normal water flow. Use 5% phosphoric acid or, for frequent cleaning, 5% oxalic acid or similar weak acid. Afterwards rinse with a large quantity of water to flush all acid from the cooler before starting up the system again. Never wait until the cooler is completely clogged before cleaning.
8. Clean any strainers present.
9. Sheaves and taper lock bushings require clean surfaces.
10. Lubricate rotating equipment. Grease all zerks at the manufacturer-recommended service interval. Grease gently with a handgun to avoid damage to grease seals. Do not over grease.
11. Clean all equipment regularly. Clean equipment is easier to inspect, lubricate, and adjust. Clean equipment also runs cooler and looks better. The manufacturer recommends cleaning all external surfaces and disconnecting the system for internal cleaning yearly.
12. Clean core coils and check for proper setting and operation.

Valves, thermometers, and fittings associated with the fuel oil cooler should be inspected and maintenance performed per their respective sections of this manual.

(For additional maintenance information on the fuel oil cooler, see Appendix Section 4.2.3.8.5.2 of this manual.)

3.3.8.5.3 Fuel Oil Shut-Off Valves and Piping

All piping, valves, and connections should be inspected weekly for leakage, damage, and corrosion. All leaks should be repaired and defective valves replaced.

Normal stem packing wear can be compensated for by tightening the packing gland nut clockwise. If all the adjustment to the packing gland nut has been made, remove the lever and packing gland nut and add one or two replacement bearings on top of the old packing. Reassemble the packing gland nut and lever.

The manufacturer states the following valve parts require periodic lubrication:

- Stem,
- Disc,
- All gaskets,
- Surface of piston assembly which contacts the lip seal,
- upper stem pin, and
- Stem end.

IMPORTANT:

In the event the valve is disassembled, assembled, or rebuilt, adhere to the manufacturer's torque and lubrication requirements.

If general repair of the valve is required, it is recommended that the entire body center section be replaced as a unit. This reduced down-time and permits the old unit to be rebuilt when more time is available. The rebuilt unit can then be retained for future use.

CAUTION:

DO NOT loosen or disassemble valves while under pressure.

Failure to follow this caution can cause serious personal injury, death or major property damage.

(For additional maintenance information on the fuel oil shut-off valves, see Appendix Section 4.2.3.8.5.3 of this manual.)

3.3.9 Control Systems

3.3.9.1 Direct Digital Control and Monitoring Equipment

3.3.9.1.1 Controllers

Per manufacturer, this equipment does not require routine maintenance.

If the controller is inoperative, replace the controller.

After replacing the controller, check operation according to the installation information furnished with the assembly. Operate the system through one (1) complete cycle to make certain that the controller is operating properly.

(For additional maintenance information on the controllers, see Appendix Section 4.2.3.9.1.1 of this manual.)

3.3.9.1.2 Control Valves

3-Way Control Valves:

Per the manufacturer, this equipment does not require routine maintenance other than monthly checking for leaks and the case exterior should be kept clean.

If the valve does not close off tightly, check the system pressure.

If the valve is inoperative, replace the complete unit.

After replacing the valve, check operation according to the installation information furnished with the assembly. Operate the system through one (1) complete cycle to make certain that the valve is operating properly.

Solenoid Valves:

The manufacturer has recommended the following preventive maintenance:

WARNING:

Turn off all electrical and depressurize the valve before making repairs.

It is not necessary to remove the valve from the pipe line for repairs.

1. Keep the medium flowing through the valve to help keep the valve free from dirt and foreign material as much as possible.
2. While in service, operate the valve at least once a month to insure proper opening and closing.

3. Periodic inspection (depending on media and service conditions) of internal valve parts for damage of excessive wear is recommended.
4. A periodic cleaning of all solenoid valves is desirable. The time between cleanings will vary, depending on media and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive leakage or noise indicates that a cleaning is required.

Butterfly Control Valves:

Weekly:

The valves should be inspected on a weekly basis for proper position setting, signs of leakage, corrosion, and damage. Replace if necessary.

Monthly:

Externally inspect valves to verify:

1. The gauges indicate normal supply water pressure is being maintained.
2. The valve is free of physical damage.
3. All valves are in the appropriate open or closed position.
4. There is no leakage or corrosion present.

Every 5 years:

1. Valves and any associated strainers, filters, or restriction orifices shall be inspected internally (unless tests indicate a greater frequency is necessary) to verify that all components operate properly, move freely, and are in good condition.
2. Internal components shall be cleaned, repaired, or replaced as necessary in accordance with the manufacturer's instructions.
3. Any sign of leakage from the gland should be addressed immediately by tightening the gland nuts gradually and evenly in a clockwise direction 1/4 turn, or until the leakage stops. If no further adjustment is possible the packing should be replaced.

NOTE:

Whenever a stem is replaced, the packing should be changed also.

Do not over-tighten packing box gland nuts. Over-tightening will increase the torque required to operate the valve. When tightening the gland nuts, use half-turn increments until leakage has stopped.

If the valve has to be disassembled and re-assembled, the manufacturer recommends closely observing all the notes, cautions, and warnings listed in the manufacturer's manual beginning on page 45 contained in Appendix Section 4.2.3.9.1.2 of this manual.

Globe and Ball Valves:

Although the manufacturer did not list any maintenance, the valves should be inspected on a weekly basis for proper position setting, signs of leakage, corrosion, and damage. Replace if necessary.

WARNING:

Turn off all electrical and depressurize the valve before making repairs.

Quarterly:

1. Verify the tightness of bolts, drain, vent.

Every Five (5) Years:

1. Disassemble the critical service valves and/or actuated valves, verifying the sealing surface and lapping them again if necessary.
2. Change all the gaskets.

(For additional maintenance information on the control valves described above, see Appendix Section 4.2.3.9.1.2 of this manual.)

3.3.9.1.3 Damper Operators

No lubrication or periodic servicing of the damper operators is required. The case exterior and cover should be kept clean.

If the operator is inoperative, replace the operator. After replacing the operator, check operation according to the installation information furnished with the assembly. Operate the system through one (1) complete cycle to make certain that the operator is functioning properly.

(For additional maintenance information on the damper operators described above, see Appendix Section 4.2.3.9.1.3 of this manual.)

3.3.9.1.4 Input / Output Sensors

Per manufacturer, this equipment does not require routine maintenance.

If the sensor is inoperative, replace the sensor.

After replacing the sensor, check operation according to the installation information furnished with the assembly. Operate the system through one (1) complete cycle to make certain that the sensor is operating properly.

(For additional maintenance information on the input/output sensors described above, see Appendix Section 4.2.3.9.1.4 of this manual.)

3.3.9.1.5 Transmitters

Per manufacturer, this equipment does not require routine maintenance except cleaning as required. The appropriate maintenance schedule should be based on the specific characteristics of the application liquids. Specific cleaning instructions can be found in Appendix Section 4.2.3.9.1.5 of this manual.

If the transmitter is inoperative, replace the sensor.

After replacing the transmitter, check operation according to the installation information furnished with the assembly. Operate the system through one (1) complete cycle to make certain that the transmitter is operating properly.

(For additional maintenance information on the transmitters described above, see Appendix Section 4.2.3.9.1.5 of this manual.)

3.3.9.1.6 Transducers

Per manufacturer, this equipment does not require routine maintenance.

If the transmitter is inoperative, replace the sensor.

After replacing the transmitter, check operation according to the installation information furnished with the assembly. Operate the system through one (1) complete cycle to make certain that the transmitter is operating properly.

(For additional maintenance information on the transducers described above, see Appendix Section 4.2.3.9.1.6 of this manual.)

3.3.9.1.7 Actuators

Rotary actuators require little maintenance other than refilling the gear case section with lubrication. If it becomes necessary to perform maintenance on the actuator, the manufacturer recommends using Lubriplate EMB grease.

A variety of maintenance methods may apply for each type of acturator, controller, and the gear box with its associated motor. You should choose the best methods for your facility and then determine how best to apply those methods. For example, consider whether you should just check for possible bearing trouble on a motor by feeling components for high temperature and listening for unusual sounds.

The following presents basic guidelines to follow when implementing an effective actuator and motor maintenance program.

WARNING:

Before doing any maintenance or disassembly/assembly, shut off the medium to the actuator. Remove the conduit wiring to prevent personal injury or equipment damage.

1. Check the acturator/linkage for binding and unusual noises.
2. Inspect, clean, and check the linkage between the acturator and the damper. Check operation of the linkage by hand, feeling for any binding or sticking. Moving parts should operate without excessive friction. Look for loose pins, bolts, or bearings.
3. Typically, greased lubrication is preferred for lower speed or intermittent duty applications. Oil lubrication will extend the life of the actuator and improve its efficiency. More importantly, oil lubrication is required in order to maintain the case temperature below its maximum allowable operating temperature.

Motor maintenance:

1. Lubricate regularly according to manufacturer's instructions. On sleeve bearings and other oil-lubricated machines, check oil reservoirs on a regular basis. For example, in poor environments, change oil at least once a month. Never over-lubricate; excess grease or oil can damage the motor. Be sure to use only the lubricant specified for the machine in question. However, check into the possibility of using modern lubricants, which have excellent life and lubricating qualities.

2. Check mounting of motors regularly. Inspect mounting bolts and steel base plates for possible warping and concrete base plates for cracking or spalling. Annually, perform vibration analysis tests. Excessive vibration may be hard to detect by hand; but it could be enough to shorten motor life significantly. You can accomplish field vibration analysis with portable instruments that identify vibrations and display their amplitudes and frequencies. Then, you can identify and correct the source of the problem.
3. Keep the motor clean and cool. In dirty operating environments, blow out dirt with dry compressed air (no more than 50 lb.) as often as needed. In high-temperature locations where high reliability is a priority, consider the use of oversized motors. Excessive ambient temperatures will shorten motor life.
4. Trunnion pins, spade/clevis bushings and any other mounting components should be inspected periodically. Scored trunnion pins should be replaced.

(For additional maintenance information on the actuators described above, see Appendix Section 4.2.3.9.1.7 of this manual.)

3.4 ELECTRICAL SYSTEMS

There are several different systems which make up the electrical systems for the Water Plant that require maintenance. These include:

The 120 / 208-volt, 3-Phase Interior / Exterior Electrical Distribution Systems - the interior electrical distribution system provides power to all equipment, lighting, receptacles, and fire protection equipment within the water plant. The exterior electrical distribution system supplies Station power in the event the Power Plant cannot.

The Engine Generator Systems - provide back-up Station power in the event the generator systems in the Power Plant are non-operational.

The Power Distribution System - uses automatic paralleling switchgear to automatically control the start-up, synchronizing and control of generator power to the Station.

The Lighting System - which includes fluorescent lamp fixtures for interior area and egress illumination, incandescent lamp fixtures for the area lighting, and self-luminous egress fixtures and emergency fixtures.

The Heat Trace System - which is used to provide warmth to prevent vent-thru-roof piping, fresh incoming fresh water piping, and waste water piping from freezing.

The Signaling Systems - which consists of telephone, a local area land (LAN) system, and a fire alarm system signals. The fire detection and alarm system provides mechanical fan shutdown, smoke / fire damper closure, fire door closure, alarm signaling, area detection using heat detectors, and a mechanical air duct detection using smoke detectors.

A well planned and executed maintenance schedule is essential for satisfactory operation of electrical equipment. The type and frequency of maintenance should be based on the operating and service conditions, application of the equipment, and finally the manufacturer's maintenance instructions and recommendations.

Before performing maintenance on any electrical systems or equipment, some basic safety rules must be followed such as:

DANGER:

HAZARD OF ELECTRIC SHOCK, BURN, OR EXPLOSION

Electrical equipment must be serviced only by qualified electrical personnel.

Turn off all power supplying equipment before working on or inside equipment.

Always use a properly rated voltage sensing device to confirm power is off.

Replace all devices, doors, and covers before turning on power to equipment.

Ground equipment per the National Electric Code.

Replacement parts must comply with the equipment manufacturer's requirements (refer to the equipment nameplate, placard, and documentation).

Do not use an air hose or compressed air gun to blow air into equipment.

Failure to follow these instructions will result in death or serious injury, or equipment damage.

3.4.1 Interior Electrical Distribution System

The interior power distribution system for the Water Plant and Pump House consists of the following major components:

- power and light distributing panelboards with breakers,
- motor control centers,
- enclosed combination motor controllers,
- variable frequency drives (VFD),
- enclosed disconnect switches, and
- other miscellaneous electrical components.

3.4.1.1 Panelboards

Panelboards for the facility provide a means of controlling general electrical lighting and power distribution. The following table identifies panelboards by designation, voltage, phase, wire, and breaker-space counts:

WATER PLANT/PUMP HOUSE PANELBOARDS			
DESIGNATION	**VOLTAGE**	**MODEL**	**PHASES (P) / WIRES(W) / SPACES)**
LP-2	120/208	NQOD	3P / 4W / 41S
WPH	270/480	NQOD I-Line	3P / 4W / 41S
WP-1	120/208	NQOD	3P / 4W / 41S
WP-2	120/208	NQOD	3P / 4W / 41S
PHH	270/480	NF	3P / 4W / 41S
PHL	120/208	NQOD	3P / 4W / 41S

WARNING:

277 / 480 volts or 120 / 208 volts present within branch electrical distribution panelboards. Do not touch electrical connections before ensuring the power has been disconnected using an approved lockout/ tagout and / or using insulated tools and proper personal protective equipment (PPE). Failure to do so can result in serious injury or death. Only qualified personnel should attempt the operation and maintenance of this equipment.

All panelboards (Equip. numbers PP00206, PP00207, PP00208, PP00209, PP00210, and PP00211) should be inspected annually per PM #6216FA. Besides the annual inspection, the manufacturer has recommended the following preventive maintenance be performed at the intervals indicated.

A panelboard, which has been carrying its regular load for at least 3 hours just prior to inspection, should be field tested by feeling the dead front surfaces of circuit breakers, switches, interior trims, doors, and enclosure sides with the palm of the hand. If the temperature of these surfaces does not permit you to maintain contact for at least 3 seconds, this may be an indication of trouble and investigation is necessary.

WARNING:

Hazardous voltages in electrical equipment can cause severe personal injury or death. Energizing busway for the first time after initial installation or maintenance is potentially dangerous. Unless otherwise specified, inspect and perform preventive maintenance only on busway and equipment to which power has been turned off, disconnected, and electrically isolated so that no accidental contact can be made with energized parts. Follow all manufacturer's warnings and instructions.

Unless otherwise specified, inspection and maintenance should only be performed on panelboards to which power has been turned off, disconnected, and electrically isolated so that no accidental contact can be made with energized parts. Follow all manufacturer's warnings and instructions. Besides the maintenance performed during PM0396FA, the manufacturer has recommended the following maintenance:

CAUTION:

Hydrocarbon spray propellants and hydrocarbon based sprays or compounds will cause degradation of certain plastics. Contact the panelboard manufacturer before using these products to clean, dry, or lubricate panelboard components during installation or maintenance.

Inspect Panelboard Once Each Year:

1. Inspect the panelboard once each year or after any severe short circuit.
2. If there is an accumulation of dust and dirt, clean out the panelboard by using a brush, vacuum cleaner, or clean lint-free rags. Avoid blowing dust into circuit breakers or other components. A moderate amount of dry nonconductive dust is not harmful. **Do not use a blower or compressed air.**
3. Carefully inspect all visible electrical joints and terminals in the bus and wiring system.
4. Visually check all conductors and connections to be certain that they are clean and secure. Loose and / or contaminated connections increase electrical resistance which can cause overheating. Such overheating is indicated by discoloration or flaking of insulation and / or metal parts. Pitting or melting of connecting surfaces is a sign of arcing due to a loose, or otherwise poor connection. Parts which show evidence of overheating or looseness should be cleaned and re-torqued or replaced if damaged, Tighten bolts and nuts at bus joints to manufacturer's torque specifications.

CAUTION:

Do not remove plating from aluminum parts in joints or terminations. Damage to plating can result in overheating. Replace damaged aluminum parts.

5. Examine fuse clip contact pressure and contact means. If there is any sign of overheating or looseness;, follow the manufacturer's maintenance instructions or replace the fuse clips. Loose fuse clips can result in overheating.
6. Re-tighten plug fuses.
7. Be sure that all conditions which caused the overheating have been corrected.
8. Check circuit breakers, switches, and fuses to ensure they have the proper ampere, voltage, and interrupting ratings. Ensure that non-current-limiting devices are not used as replacements for current-limiting devices.

NOTE:

Never attempt to defeat rejection mechanisms which are provided to prevent the installation of the incorrect class of fuse.

9. Operate each switch or circuit breaker several times to ensure that all mechanisms are free and in proper working order. Replace as required. See "*NEMAAB-4*" for maintenance of molded case circuit breakers.
10. Check the operation of all mechanical components. Replace as required.
11. Exercise switch operating mechanisms and external operators for circuit breakers to determine that they operate freely to their full on and off positions.
12. Check the integrity (functionally test) of all electrical and mechanical interlocks, safety devices, and padlocking mechanisms.
13. Whenever practical, check all devices for missing or broken parts, proper spring tension, free movement, corrosion, dirt, and excessive wear.
14. Adjust, clean, and lubricate or replace parts according to the manufacturer's instructions. Use clean nonmetallic light grease or oil as instructed.

NOTE:

Do not oil or grease parts of molded case circuit breakers

15. If no instructions are given on the devices, sliding copper contacts, operating mechanisms, and interlocks may be lubricated with clean, light grease.

16. Wipe off excess lubrication to avoid contamination.

CAUTION:

Hydrocarbon spray propellants and hydrocarbon based sprays or compounds will cause degradation of certain plastics. Contact the panelboard manufacturer before using these products to clean, dry, or lubricate panelboard components during installation or maintenance.

17. Clean and dress readily accessible copper electrical contacts, blades, and jaws according to the manufacturer's instructions when inspection indicates the need.
18. Look for and replace damaged insulating material and assemblies where sealing compounds have deteriorated.
19. Look for any moisture or signs of previous wetness or dripping inside the cabinet.

NOTE:

Condensation in conduits, or dripping from outside sources, is one known cause of panelboard malfunction

20. Seal off any conduits which have dripped condensate, and provide means for further condensate to drain away from the panelboard.
21. Seal off any cracks or openings which have allowed moisture to enter the enclosure. Eliminate the source of any dripping on the enclosure and any other source of moisture.
22. Replace or thoroughly dry and clean any insulating material, which is damp or wet or shows an accumulation of deposited material from previous wettings.
23. Inspect all component devices. Replace any component device which shows evidence of moisture damage or has been subjected to water damage or flooding. Additional information may be found in the NEMA document "*Guidelines for Handling Water Damaged Electrical Products,*" National Electrical Manufacturers Association.
24. In the event of water damage, e.g., flooding or sprinkler discharge, the manufacturer should be consulted before clean up and corrective action is attempted.

25. If a severe electrical short circuit has occurred, the excessive currents may have resulted in structural component and / or bus and conductor damage due to mechanical distortion, thermal damage, metal deposits, or smoke. Examine all devices and bus supports for cracks or breakage. The manufacturer should be consulted before cleanup and correction is attempted.
26. Test the ground fault protection system (if furnished) in accordance with the manufacturer's instructions.
27. Check insulation resistance under any of the following conditions:
    A. Severe Short Circuit,
    B. Parts Replaced,
    C. If it has been necessary to replace parts or clean insulating surfaces, and
    D. If the panelboard has been exposed to high humidity, condensation, or dripping moisture.

Restoring Power

If power to the panelboard was turned off prior to performing maintenance, the following steps should be completed before restoring power:

1. Tighten all accessible electrical connections to the manufacturer's torque specifications, If such information is not provided with the equipment, consult the manufacturer.
2. Make certain that all blocks and packing materials used for shipment have been removed from all component devices and the panelboard.
3. Manually exercise all switches, circuit breakers, and other operating mechanisms to make certain they operate freely.
4. To make sure that the system is free from short circuits and ground faults, conduct an insulation resistance test phase to ground and phase to phase with the switches or circuit breakers in both the open and closed positions. If the resistance reads less than one (1) megohm while testing with the branch circuit devices in the open position, the system may be unsafe and should be investigated. If after investigation and possible correction, low readings are still observed, the manufacturer should be contacted. Some electronic equipment may be damaged by this testing. Refer to the manufacturers equipment markings for guidelines.
5. Test the ground fault protection system (if furnished) in accordance with the manufacturer's instructions.
6. Set any adjustable time current trip device settings to the proper values.

NOTE:

Experience has indicated that damage from over current can be reduced if the devices used for overload and short-circuit protection are set to operate instantaneously (that is, without intentional time delay) at 115% of the highest value of phase current which is likely to occur as the result of any anticipated motor starting or welding currents.

7. Check to determine that all grounding connections are properly made. If the panelboard is used as service equipment, make certain that the neutral, if present, is properly bonded to the cabinet.
8. Remove all foreign material from the panelboard and cabinet before installing the cabinet front, Make certain that all dead front shields are properly aligned and tightened.

WARNING:

Hazardous voltages in electrical equipment can cause severe personal injury or death. Energizing a panelboard for the first time, after initial installation, or maintenance is potentially dangerous.

9. There should be no load on the panelboard when it is energized. Turn off all of the downstream loads.
10. The equipment should be energized in sequence by starting at the source end of the system and working towards the load end. In other words, energize the main devices, then the feeder devices, and then the branch-circuit devices. Turn the devices on with a firm positive motion.

After all main, feeder, and branch circuit devices have been closed, loads such as lighting circuits. contactors, heaters, and motors may be turned on.

Lugs & Breaker Switches

The maintenance of circuit breakers deserves special consideration because of their importance for routine switching and for protection of other equipment. Electric transmission system breakups and equipment destruction can occur if a circuit breaker fails to operate because of a lack of preventive maintenance. The need for maintenance of circuit breakers is often not obvious as circuit breakers may remain idle, either open or closed, for long periods of time.

Breakers that remain idle for 6 months or more should be made to open and close several times in succession to verify proper operation and remove any accumulation of dust or foreign material on moving parts and contacts.

Routine maintenance tests enable personnel to determine if breakers are able to perform their basic circuit protective functions. The tests performed during routine maintenance are aimed at assuring that the breakers are functionally operable. The type of tests performed, and frequency of these tests, largely depend on the type of breaker, the service it performs, and the operating conditions. Conditions that make frequency maintenance and inspections necessary are:

- High humidity and high ambient temperature,
- Dusty or dirty atmosphere,
- Corrosive atmosphere,
- Frequent switching operations,
- Frequent fault operations, and
- Older equipment.

The tests performed and frequency is different for low-voltage breakers from medium, which differs from high voltage breakers. Testing and the frequency is also based on the type and construction of the breaker (i.e. molded case breakers vs. oil circuit breakers vs. vacuum circuit breakers, etc.).

WARNING:

120 / 208 volts present within the electrical disconnect switches. Do not touch electrical connections before ensuring the power has been disconnected using an approved lockout / tagout and / or using insulated tools and proper personal protective equipment (PPE).

Only qualified personnel should attempt the operation and maintenance of this equipment.

The following minimal inspections and checks should be completed on a routine basis. A specific checklist should be developed in the field for each type of inspection for each circuit breaker maintained:

1. Verify on / off operation of the disconnect. Check terminations for secureness or signs of overheating.
2. Exercise switch operating mechanisms and external operators for circuit breakers to determine that they operate freely to their full on and off positions.
3. Check for missing or broken parts, proper spring tension, free movement, rusting or corrosion, dirt, and excessive wear.
4. Replace the device if appreciable material has burned away or if parts are charred or cracked.

5. Check the main contacts for pitting, spring pressure, signs of overheating, alignment, overtravel, or wipe.
6. Retighten all wire connections according to the manufacturer's instructions.
7. Check circuit breakers and fuses to ensure they have the proper ampere, voltage, and interrupting ratings.
8. Ensure that non-current-limiting devices are not used as replacements for current-limiting devices. Never attempt to defeat rejection mechanisms, which are provided to prevent the installation of the incorrect class of fuse.
9. Perform an insulation resistance test.
10. Conduct a millivolt drop test to check for abnormal conditions inside the breaker.
11. Perform an overload tripping test.

(For additional information about the panelboards, see drawing sheets E0.1 to E6.4 in Appendix Section 4.1.2 of this manual. Manufacturer's data in can be found in Appendix section 4.2.4.1.1.)

3.4.1.2 Motor Control Centers

Preventive maintenance for the motor control center (Equip. # PD00024) should be at regular intervals, as frequently as the severity of duty justifies. Time intervals of one week, one month, or one year may be appropriate, depending on the duty. It is also desirable to establish specific check lists for each control, as well as a logbook to record the history of incidents. Many of the maintenance steps used for panelboards and breaker switches can also be used for the motor control centers.

WARNING:

This control equipment is designed to be installed, operated, and maintained by adequately trained workmen.

Authorized personnel may open a unit door of a motor control center (MCC) while the starter unit is energized.

When servicing and adjusting the electrical equipment, refer to the applicable drawings covering the specific motor control center (MCC) and any other related interconnection drawings.

Follow any instructions, which may be given for each device.

If fully inserted, the power and control circuits will be energized.

Separate control sources of power must also be disconnected. If control power is used during maintenance, take steps to prevent feedback of a hazardous voltage through a control transformer. Be alert to power factor correction capacitors that may be charged. Discharge them before working on any part of the associated power circuit.

CAUTION:

Maintenance of control components requires that all power to these components be turned OFF by opening the branch circuit disconnect means and withdrawing the unit to the detent position, or removing the unit entirely from the MCC. When units are fully inserted into the MCC, the line side of each disconnect is energized. Do not work on fixed units unless the main disconnect for the MCC is OFF.

Good conduction requires clean, tight joints, free of contaminants such as dirt and oxides. Good insulation requires the absence of carbon tracking and the absence of contaminants such as salt and dust that become hydroscopic and provide an unintended circuit between points of opposite polarity.

NOTE:

When working on portions of a branch circuit remote from the MCC, lock the disconnect means for that circuit in the *OFF* position. To positively lock the operating mechanism in the *OFF* position, a metal locking bar recessed in the handle may be extended and padlocked with from one to three padlocks.

Cleaning:

1. Soot, smoke, or stained areas (other than inside arc chutes), or other unusual deposits, should be investigated and the source determined before cleaning is undertaken.
2. Vacuum or wipe clean all exposed surfaces of the control component and the inside of its enclosure.
3. Equipment may be blown clean with compressed air that is dry and free from oil. (Be alert to built-in oilers in factory compressed air lines!) If air blowing techniques are used, remove arc covers from contactors and seal openings to control circuit contacts that are present.
4. It is essential that the foreign debris be removed from the control center, not merely rearranged. Control equipment should be clean and dry. Remove foreign material from the outside top and inside bottom of the enclosure, including hardware and debris, so that future examination will reveal any parts that have fallen off or dropped onto the equipment.
5. Remove dust and dirt inside and outside the cabinet without using liquid cleaner.

Mechanical Checks:

1. Determine the cause of any loose connections and correct. When screw type lugs (marked CUIAL) are used with aluminum wire, joint should be checked for tightness every 200 operations of the device. Tighten all electrical connections.
2. Look for signs of overheated joints, charred insulation, discolored terminals, etc.
3. Mechanically clean to a bright finish (don't use emery paper) or replace those terminations that have become discolored.
4. Wires and cables should be examined to eliminate any chafing against metal edges caused by vibration, that could progress to an insulation failure.
5. The intended movement of mechanical parts, such as the armature and contacts of electromechanical contactors, and mechanical interlocks should be checked for freedom of motion and functional operation.
6. Check all indicating lamps, mechanical flags, doors, latches, and similar auxiliaries and repair, if required.

(For additional information about the motor control centers, see manufacturer's data in Appendix section 4.2.4.1.2.)

3.4.1.3 Enclosed Motor Controllers and Contactors

Motor controllers and contactors are typically used to provide overload protection and manual and / or automatic control on motor driven equipment.

WARNING:

Read and understand maintenance procedures before maintaining or servicing the controller. Only qualified personnel should install, adjust, service, and maintain the controllers.

Many parts in this controller, including printed circuit boards, operate at line voltage. DO NOT TOUCH. Use personal protective equipment and follow precautions and measurement procedures referenced in the User's Manual when making any measurements on energized equipment. Use instruments and insulated tools approved for the job.

Observe and follow all applicable lock-out and tag-out procedures for specific installation.

Confirm that the controller has been correctly selected, installed, and applied before performing any service or maintenance.

Install all covers before applying power or starting and stopping controller.

1. Check equipment for proper operation.
2. Inspect wiring connections for secureness and for signs of overheating.
3. Verify proper overload sizing in accordance with motor nameplate specifications. Clean cabinet spaces.
4. Check contacts for signs of excessive wear.

NOTE:

Contacts are not harmed by discoloration and slight pitting. DO NOT FILE THEM as dressing wastes contact material. Replacement is necessary only when contact has worn thin.

5. Do not oil or grease parts of molded case circuit breakers.

The manufacturer recommends cleaning the motor periodically to prevent the possibility of overheating due to an accumulation of dust and dirt on the windings or on the motor exterior.

CAUTION:

Always disconnect the power source before working on or near a motor or its connected load.

If the motor gets wet, allow it to dry thoroughly before using.

Consult a qualified electrican if in doubt how to ground or connect the motor.

Any of the following could result in motor damage or failure and could be interpreted as abuse, misuse or misapplication of the motor:

- **Connection to a power source other than the voltage and frequency specified on the nameplate.**
- **Incorrect connection.**
- **Excessive or improper lubrication.**
- **Dropping, carrying by the leads or otherwise mishandling the motor.**
- **Insertion of an object into the motor.**
- **Misapplication or improper use.**
- **Failure to insulate unused motor leads.**
- **Use of a capacitor different than the rating specified.**

Sleeve bearing motors should be re-oiled annually. More frequent oilings may be needed for continuous or severe duty operation. Add up to 30 drops of electric motor oil or an SE grade of SAE 10 motor oil to each bearing.

Ball bearing motors are factory lubricated and under normal operating conditions require no additional lubrication for ten years.

(Additional information for enclosed motor controllers and contactors is available in Appendix Section 4.2.4.1.3 of this manual.)

3.4.1.4 Variable Frequency Drives (VFD)

The variable frequency drives are used to control the circulation pumps and the pumps used for the remote radiators. Along with the quarterly PM 0436FQ (Equip. # CL00057, # CL00058, # CL00059, # CL00060, # CL00063, # CL00090, and # CL00098), the manufacturer recommends the following preventive maintenance:

DANGER:

Turn off all power supplying this equipment before working on it.

Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.

This equipment must only be installed and serviced by qualified electrical personnel.

Turn off all power supplying this equipment before working on or inside equipment.

Always use a properly rated voltage sensing device to confirm power is off.

Replace all devices, doors, and covers before turning on power to this equipment.

Read and understand all manufacturer's documentation entirely before installing or operating Class 8839 58M drive controllers. Installation, adjustment, repair, and maintenance of the drive controllers must be performed by qualified personnel.

DO NOT short across DC bus capacitors or touch unshielded components or terminal strip screw connections with voltage present.

Before servicing the drive controller:

- **Disconnect all power including external control power that may be present before servicing the drive controller.**
- **Place a "DO NOT TURN ON" label on the drive controller disconnect. Lock the disconnect in open position.**
- **WAIT TEN MINUTES for the DC bus capacitors to discharge. Then follow the DC bus voltage measurement procedure on page 42 to verify that the DC voltage is less than 45 V. The drive controller LEDs are not accurate indicators of the absence of DC bus voltage.**

Install and close all covers before applying power or starting and stopping the drive controller.

Failure to follow these instructions will result in death or serious injury.

A number of diagnostic and status codes are included on the power converter. The keypad display provides visual indication of controller operation and protective circuit functions using indicator lights to assist in maintenance and troubleshooting of the electronic components.

NOTE:

For controllers equipped with optional line contactor the power is removed by the line contactor upon power converter fault trips.

The equipment should be checked periodically for:

- Signs of external damage. Repair or replace as necessary:

DANGER:

Read and understand the bus voltage measurement procedure before performing the procedure. Measurement of bus capacitor voltage must be performed by qualified personnel.

Many parts in the drive controller, including printed wiring boards, operate at line voltage. DO NOT TOUCH. Use only electrically insulated tools.

Failure to follow these instructions will result in death or serious injury.

CAUTION:

ELECTROSTATIC DISCHARGE

Do not subject this device to electrostatic discharge. This controller contains electronic components that are very susceptible to damage from electrostatic discharge.

Failure to follow these instructions can result in injury or equipment damage.

- Cracked, charred, or damaged covers or enclosure parts.
- Damage to the keypad such as scratches, punctures, burn marks, chemical burns, or moisture in the screen.
- Oil or electrolyte on the bottom of the drive controller which might have leaked from the capacitors inside.
- Excessive surface temperatures of enclosures and conduits.
- Damage to power or control conductors.
- Unusual noise or odors from any of the equipment.
- Abnormal temperature, humidity, or vibration.
- Periodically inspect the enclosure gaskets for damage.

- The manufacturer also recommends cleaning the filters monthly.

The manufacturer of the drive controllers keypad display recommends the following preventive maintenance:

DANGER:

HAZARDOUS VOLTAGE

Read and understand all procedures before servicing the drive controllers. Installation, adjustment, and maintenance of these drive controllers must be performed by qualified personnel.

Electronic shock will result in death or serious injury.

At regular intervals, perform the following preventive maintenance on the drive controllers:

1. Check the condition and tightness of the connections.
2. Make sure ventilation if effective and the temperature around the drive controller remains within specified levels.
3. Remove dust and debris from the drive controller.
4. Complete a bus voltage measurement.

DANGER:

HAZARDOUS VOLTAGE

Read and understand the bus voltage measurement procedure before performing the procedure. Measurement of bus capacitor voltage must be performed by qualified personnel.

DO NOT short across DC bus capacitors or touch unshielded components or terminal strip screw connections with voltage present.

Many parts in this drive controller, including printed wiring boards, operate at line voltage. DO NOT TOUCH. Use only electrically insulated tools.

Electronic shock will result in death or serious injury.

5. Verify and measure the input line voltage to determine if it is within the drive controller's tolerance.
6. Perform operational checks on all peripheral equipment.

CAUTION:

DIELECTRIC TESTS WHILE CONNECTED

Can Cause Equipment Damage

Do not perform high potential dielectric tests on circuits while the circuits are connected to the drive controller.

Any circuit requiring high potential dielectric tests must be disconnected from the drive controller prior to performing the test.

Failure to follow these instructions can result in injury or equipment damage.

(Additional information for the variable frequency drives is available in Appendix Section 4.2.4.1.4 of this manual.)

3.4.1.5 Enclosed Disconnect Switches

Verify on / off operation of the disconnect. Check terminations for secureness or signs of overheating.

WARNING:

120 / 208 volts present within the electrical disconnect switches. Do not touch electrical connections before ensuring the power has been disconnected using an approved lockout / tagout and / or using insulated tools and proper personal protective equipment (PPE).

Only qualified personnel should attempt the operation and maintenance of this equipment.

Failure to follow this warning can cause serious personal injury, death or major property damage.

Exercise switch operating mechanisms and external operators for circuit breakers to determine that they operate freely to their full on and off positions.

Check for missing or broken parts, proper spring tension, free movement, rusting or corrosion, dirt, and excessive wear.

Replace the device if appreciable material has burned away or if parts are charred or cracked.

Retighten all wire connections according to the manufacturer's instructions.

Check circuit breakers and fuses to ensure they have the proper ampere, voltage, and interrupting ratings. Ensure that non-current-limiting devices are not used as replacements for current-limiting devices. Never attempt to defeat rejection mechanisms, which are provided to prevent the installation of the incorrect class of fuse.

(Additional information for disconnect switches is available in Appendix Section 4.2.4.1.5 of this manual.)

3.4.2 Exterior Electrical Distribution System

The exterior electrical distribution system is a network outside the Water Plant consisting of pad-mounted medium voltage switches, transformers, and load banks. Because of the harsh environment these components exist in, regular inspections and maintenance is required, sometimes even immediate attention.

3.4.2.1 Pad-Mounted Medium-Voltage Switches

The manufacturer has recommended the following yearly inspections and preventive maintenance for the switches and their cabinets:

CAUTION:

HAZARD OR PERSONAL INJURY OR EQUIPMENT DAMAGE.

Inspection, maintenance, and parts replacement must be performed only with the primary source(s) of power disconnected and locked open. Be absolutely sure there is no backfeed through any feeder circuit.

Disconnect all sources of electric power. Assume all circuits are live until they are completely de-energized, tested, grounded, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.

Use a properly rated voltage sensing device to confirm the power is OFF.

Be aware of potential hazards; wear personal protective equipment, and take adequate safety precautions. Ensure compliance with NFPA 70E - Standard for Electrical Safety Requirements for Employee Workplaces and OSHA Standards - 29 CFR Part 1910 Subpart S - Electrical.

Failure to follow these instructions will result in death, serious injury, or equipment damage.

Yearly:

1. Always, after a fault current or stressful condition on a circuit, inspect the switch immediately. Otherwise, inspect the switch yearly.
2. Perform a standard 60-cycle hi-pot test to measure insulation integrity.
3. Inspect all connections for symptoms which indicate overheating or weakened insulation. If necessary, re-tighten hardware.
4. Remove dust from busses, connections, supports, and enclosure surfaces.
5. Wipe all supports and enclosure surfaces with a solvent such denatured alcohol.
6. Inspect the switch interrupter blades. When one-third of the arcing tip is burned away, replace the blade assembly.
7. Clean the main blade and jaw contact areas with an electrical contact cleaner and then lubricate these areas with a light film of Mobilgrease 28.

NOTE:
Do not lubricate the interrupter blades or arcing tips.

8. Inspect all connections for tightness. Tighten if necessary.
9. Manually operate mechanical moving parts such as switch assemblies, interlocks, doors, etc.
10. The main shaft bearings do not require additional lubrication.

(Additional information for the medium-voltage switches is available in Appendix Section 4.2.4.2.1 of this manual.)

3.4.2.2 Dry-Type Transformers

Like other electrical equipment, dry-type transformers (equipment #PD00190 and PD00179 for the sea-water intake structure) require periodic maintenance to assure successful operation. In addition to performing inspection and maintenance semi-annually in accordance with PM #0311FS, the manufacturer also recommends the following inspections:

Inspections should be made at regular intervals. The frequency of these inspections will depend on the site and operating conditions.

Clean, dry installations should be inspected at least twice annually. Transformers exposed to poor conditions such as air contaminated by dust or chemical fumes, dampness and temperature variances should be inspected more frequently.

DANGER:

Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high voltage lines and equipment.

Before servicing the transformer, ensure all static charge has been discharged by grounding the coils with an appropriate grounding device.

Do not re-energize the transformer if the transformer has been damaged.

Failure to follow these instructions will result in death or serious injury.

WARNING:

Power distribution equipment must be selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install or maintain this equipment can result in death, severe personal injury, and equipment damage.

Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of the manufacturer's manual. Improper operation, handling or maintenance can result in death, severe personal injury, and equipment damage.

Before servicing, lock the line switches on both the high and low voltage in the OPEN position.

NOTE:

Experience indicates that if a shutdown exceeding 12 hours occurs, and especially if high humidity conditions exist, then small strip heaters may be placed in the bottom of the unit shortly after shutdown to maintain the temperature of the unit a few degrees above that of the outside air.

Before returning to service, the unit should be inspected for evidence of moisture, and insulation resistance should be checked. If there is evidence of moisture, or if the insulation resistance is low, the transformer should be dried out.

A clean contact surface area is necessary Therefore, terminals must be clean. If transformers are installed outdoors or in a harsh environment, seal the connections with approved electrical joint compound. Apply the compound to exposed connections and the surface area before a bolted connection is made.

The following inspection and maintenance should be performed periodically throughout the year on all larger pad-mounted transformers:

Cabinet Exterior:

1. Annually, inspect all exposed surfaces for evidence of tampering, battered metal, and gouges. Dents, or deformities should be repaired.
2. Look for signs of overheating and of voltage creepage over insulating surfaces. Signs of voltage creepage include tracing or carbonization on the insulating surface.
3. Lead supports, tap changers, terminal boards, bushings and other major insulating surfaces should be brushed or wiped with a dry cloth.
4. Check for evidence of rusting, corrosion, and deterioration of the paint.
5. Keep the area around the transformer clean.
6. Cleanliness of screens located over or behind ventilation louvers should be checked and cleaned weekly to monthly.

Cabinet Interior:

WARNING:

Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet (removing covers and side panels) and doing cabinet interior inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.

1. Inspect for damage that reduces electrical clearances.
2. Inspect for dirt, especially accumulations on insulating surfaces, or those which tend to restrict air flow. Pay particular attention to the top and bottom ends of winding assemblies and ventilating ducts.
3. Inspect for signs of internal condensation, corrosion or deterioration of the paint on the enclosure.
4. Check all gauges and controls for proper operation. Repair or replace as required.
5. Inspect drain cocks, plugs, fuse mountings and switches. Repair as required.
6. Check for loose connections, for the condition of tap changers or terminal boards, and for the general condition of the transformer.
7. Lead supports, switches, terminals boards, bushings and other insulating surfaces can be cleaned using a brush or dry cloth.

8. Check operation of ventilation fans with control switch in "Manual" mode weekly to monthly.

CAUTION:

Enclosure covers and side panels should not be removed while the transformer is energized.

Before servicing a transformer that has been in operation, be sure to lock the line switches on both the high and low voltage in the open position. A ground cable should be connected to the transformer line terminals to discharge any energy that may be stored in the windings and to prevent accidentally re-energizing the transformer.

Tank Interior:

Service to bushings or equipment inside the transformer tank will require that the tank be opened and the insulating liquid lowered to the appropriate level.

WARNING:

Hazardous Voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet and doing internal tank inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.

CAUTION:

Elevated Pressure. Can cause personal injury or damage to transformer. Release internal pressure with pressure relief device before removing tank cover, manhole cover, or handhole cover.

Before performing any maintenance on the tank interior, consult the manufacturer's maintenance information in Appendix Section 4.2.4.2.2.

The following inspection and maintenance should be performed periodically throughout the year on smaller dry transformers:

1. Clean the windings with a vacuum, blower, or compressed air. Vacuum cleaning is the preferred first step of cleaning, followed by the use of compressed air. The compressed air should be clean and dry, and should be applied at relatively low pressure (not over 25 psi).

2. The preferred method of cleaning the windings is vacuuming followed by the use of compressed air. The compressed air or nitrogen should be clean and dry, with a low application pressure, not over 25 psi.
3. Check tap connections for tightness and ability to provide correct voltage.
4. Check the core assembly for loose and/or discolored laminations.

CAUTION:

Do not use liquid cleaners or solvents. These materials can cause deterioration of insulating materials.

Do not push or pull a cloth through the coils.

Putting Transformers Back Into Service:
Before returning any transformer to service, the unit should be inspected for evidence of moisture, and insulation resistance should be checked. If there is evidence of moisture, or if the insulation resistance is low, the transformer should be dried out by one of the methods described below.

Three dry out methods are presently used.

1. External heating. (Preferred method),
2. Internal heating, and
3. External and Internal heating.

In all cases, the free moisture visible on the unit should be blown or wiped off to reduce drying time.

CAUTION:

The transformer dry out processes should be constantly supervised with suitable fire extinguishing equipment readily available.

External Heat Drying:

External heating is the preferred method of dry out. The heat can be applied to the transformer using one of the three processes listed below:

1. Directing heated air into the bottom air inlets of the transformer enclosure.
2. Placing the core and coil assembly into a non-flammable enclosure with openings in the top and bottom through which heated air can be circulated.
3. Placing the core and coil assembly in a suitable, ventilated oven.

NOTE:

When directing heated air into the transformer enclosure as required by either of the first two methods, it is important that the air passes through the windings and not around the sides.

Good ventilation will ensure that condensation does not occur in the core and coil assembly or the enclosure. The air flow through the enclosure should result in equal inlet and outlet temperatures.

The heat source can be space heaters or resistance grids placed inside the enclosure, or placed outside the enclosure with the heated air blown into the bottom of the enclosure.

Protect the core and coil assembly from direct radiation from the heaters.

The maximum safe air temperature for any of the methods described above is 110° C.

Drying By Internal Heat:

Drying by internal heat is fast and safe. An adequate source of impedance voltage is required.

Heat is generated by shorting one winding and applying sufficient voltage to the other winding to circulate 50 to 100% of normal current. Generally, the voltage required will be the rated voltage times the per unit impedance.

NOTE:

Provision should be made to control the rate of temperature rise and limit the maximum temperature. The winding temperature must not exceed 100°C as measured by resistance or thermometers placed in the duct between the windings. Thermometers used for this purpose should be the spirit type, not the mercury type as eddy currents can heat the mercury and produce unreliable readings. A broken mercury thermometer can also contaminate the windings and cause a health hazard. The thermometer should be in physical contact with the winding insulation.

Use the line end terminals of the windings, not the tap terminals, to circulate current through the entire winding.

Protect operators from dangerous voltage levels.

Drying by Internal & External Heat:

This method is a combination of the two methods previously described. It is also the quickest method of drying.

NOTE:

Heat is applied as described in External Heat Drying.

The applied current is less than that required when external heat is not used. It will vary with the unit size and site conditions and will be determined by temperature observation.

The winding temperature must not exceed 100°C.

The use of Winding Insulation Resistance to Determine Drying Time:

The drying time will vary with each transformer, factoring in size, voltage, moisture content and the drying method used.

The measurement of insulation resistance is an indication of the status of the dry out procedure. Measurements are taken before starting dry out and at two hour intervals during the process. The initial reading may be high even though the insulation is not dry. Insulation resistance varies inversely with temperature. To ensure readings are comparative, the transformer temperature must be maintained as constant as possible during the dry out period.

- As the transformer is heated, the presence of moisture is indicated by a rapid drop in resistance.
- Resistance should increase gradually as the dry out continues and climb rapidly near the end of the process.
- Readings may rise and fall for a short time before stabilizing, caused by moisture being wicked out through previously dried portions of insulation.
- A time-resistance curve should be plotted to determine when the resistance levels off and remains constant for 3 to 4 hours - indicating completion.
- Insulation resistance measurements must be taken for each winding to ground. Ground all windings except the winding being tested.
- Before measuring resistance, interrupt the current supply and short and ground the windings for at least one minute to drain off any static charge.
- All readings should be for the same time of application of the test voltage preferably one minute.

(For additional information regarding the dry-type transformers, refer to Appendix Section 4.2.4.2.2 of this manual.)

3.4.2.3 Load Banks

To provide long equipment life and to reduce the chance of electric shock, fires, and personal injury, the manufacturer recommends regular inspections and maintenance. All maintenance work must be done by qualified personnel only.

WARNING:

Personal injury from electrical shock or from the moving fan blade may result if ALL sources of power are not disconnected.

Maintenance personnel must always exercise caution when access panels are removed.

Daily:

1. Remove any restriction to airflow thru the load bank.
2. Check the screens t o make sure that no objects have blocked or entered the openings.
3. Verify that the airflow is in the proper direction.
4. Assure that there is no recirculation of the exhaust air thru the load bank.

Three Months:

1. Remove access panels and screens.
2. Inspect the load resistors for mechanical breakdown which is demonstrated by excessive sagging of the elements. Replace with new resistors as required.
3. Inspect for broken ceramic insulators. Replace as necessary.
4. Inspect for loose hardware or loose connections. Tighten where required.
5. Inspect all connections for oxidation or corrosion. Clean the connection or replace the hardware where required.
6. Verify the airflow switch works properly.
7. Inspect all magnetic contactors t o make sure that the contacts are not severely pitted or corroded. The contacts must move freely and be properly seated.
8. Clean all dirt and debris out of the load bank.
9. Inspect all the wiring for any sign of insulation failure.
10. Replace all access panels and screens. Tighten all the fastening hardware securely.
11. Check the indicator lamps on the control panel.

Annually:

1. The blower motor should be lubricated per the motor manufacturer's requirements and specifications on the motor nameplate.

(For additional information regarding the load bank, refer to Appendix Section 4.2.4.2.3 of this manual.)

3.4.3 Engine and Generator Systems

3.4.3.1 Digital Voltage Regulator

The voltage regulator keeps the generator's output voltage constant with changing loads. The voltage regulator controls the DC voltage and current that is supplied to the exciter stator.

The manufacturer states the only preventive maintenance required for the voltage regulator is to periodically check that the connections between the regulator and the system are clean and tight. The manufacturer recommends that no repair procedure be attempted by anyone other than the manufacturer.

DANGER:

The digital voltage regulator presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

WARNING:

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

When replacement parts are required for this product, the manufacturer recommends using replacement parts from the manufacturer. Replacement parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed these warnings can lead to premature failures, product damage, personal injury or death.

The manufacturer recommends the following inspections and preventive maintenance be performed periodically, especially before each season:

1. Inspect the components on the voltage regulator board to verify they are not burned, damaged, or loose. Repair as necessary.
2. Check for loose connections. Tighten all loose connections.
3. Check for corroded terminals. Replace any corroded terminals.
4. Check for proper connections between the voltage regulator and the generator.

(For additional information regarding the voltage regulator, refer to Appendix Section 4.2.4.3.1 of this manual.)

3.4.3.2 Engine / Generator System Controls

3.4.3.2.1 Engine Modular Control Panels

The manufacturer does not list any specific preventative maintenance required by the engine control panels. The controllers have built-in diagnostics tests designed to detect problems and malfunctions, and report error codes to the liquid crystal display (LCD) panel.

These error codes can then be used to troubleshoot, repair, or replace defective components. The meaning for these error codes can be found in the manufacturer's documentation found in the section mentioned below.

DANGER:

The digital voltage regulator presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

WARNING:

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

When replacement parts are required for this product, the manufacturer recommends using replacement parts from the manufacturer. Replacement parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Do not connect generator to a utility electrical distribution system unless it is isolated from the system. Electrical feedback into the distribution system can occur and could cause personal injury or death.

Open and secure main distribution system switch, or if the connection is permanent, install a double throw transfer switch to prevent electrical feedback. Some generators are specifically approved by a utility to run in parallel with the distribution system and isolation may not be required. Always check with your utility as to the applicable circumstances.

When the engine generator, or any source to which the engine-generator is synchronized to, is operating, voltages up to 600V are present in the control panel.

Do not short these terminal with line voltage to ground with any part of the body or any conductive material. Loss of life or injury could result from electrical shock or injury from molten metal.

When servicing or repairing electric power generation equipment:

- **Make sure the unit is either locked out or tagged DO NOT OPERATE.**
- **Remove all fuses.**
- **Make sure the generator engine is stopped.**
- **Make sure all batteries are disconnected.**
- **Make sure all capacitors are discharged.**
- **Make sure residual voltage in the rotor, stator and the generator is discharged.**

Failure to heed these warnings can lead to premature failures, product damage, personal injury or death.

(For additional information regarding the engine control panels, refer to Appendix Section 4.2.4.3.2 of this manual.)

3.4.3.2.2 Generator Control Panel

The manufacturer does not list any routine preventive maintenance for the generator control panel.

(For additional information regarding the generator control panel, refer to Appendix Section 4.2.4.3.3 of this manual.)

3.4.3.3 Start Batteries and Charger

Start Batteries

Although the engine start batteries are of a maintenance-free design, they will last longer if properly maintained. The following paragraphs detail some simple inspections, preventive maintenance, charging recommendations, and storage techniques.

CAUTION:

Adhere to the following personal safety precautions when installing or working on the charger:

Someone should be within voice range or close enough to come to your aid when you work near a lead acid battery.

Have plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, or eyes.

Wear complete eye protection, face shield, and clothing protection. Avoid touching eyes while working near a battery.

Sulfuric Acid can cause blindness or severe burns. If battery acid contacts skin or clothing, wash them immediately with soap and water. If acid enters the eye, flood the eye with cold, running water for at least ten minutes and get medical attention immediately.

Never smoke or allow a spark or flame in the vicinity of the battery or engine.

Do not drop a metal tool onto the battery. It might spark or short circuit the battery or other electrical parts that may cause an explosion.

Remove all personal metal items such as rings, bracelets, necklace, and watches when working near a lead acid battery. A battery can produce short circuit currents high enough to weld a ring or the like to metal, causing a severe burn.

Do not use the charger for charging dry cell batteries that are commonly used with home appliances. These batteries may burst and cause personal injury and property damage.

NEVER charge a frozen battery.

A dead battery means downtime, and that means decreased productivity and profits. The batteries won't last forever, but using a few simple management techniques, battery life can be maximized.

To reduce the risk of electrical shock, disconnect the charger from the AC power source and the batteries before attempting any maintenance or cleaning. The batteries should be inspected periodically for damage, leaks, and loose cables. The batteries will become useless, or their life will be drastically reduced, if they are allowed to freeze. Therefore, the battery heaters should be checked frequently for operation.

Proper Storage

Using the right storage techniques can help extend the life of the batteries. For storage periods of a few weeks or more, you should disconnect the battery cables. If they are left connected in cold weather, the batteries may discharge and freeze. If the batteries are stored in an unheated area during winter, make sure to remove the batteries and store them in a room with a constant 40-50° F (51° C) temperature.

Recommended Charges

lf the batteries should require charging, the manufacturer recommends a slow charge. A slow charge reduces the risk of overheating the battery, which can boil out the water and buckle the plates.

Overcharging causes a loss of water (which accounts for over 50% of failures) and accelerates positive grid corrosion or grid growth causing plate to strap shorts. Once the full charge condition has been reached, additional current through the battery causes excessive gassing and deterioration of the lead grid and internal paths.

Overcharging batteries on a regular basis causes water to be boiled out of the electrolyte and will eventually warp the plates from overheating and corrode away the positive plates. Overcharging is dependant on the voltage regulator setting. The correct voltage regulator setting is described as one that will keep the battery fully charged with minimum water usage under a wide variety of operating conditions.

High operating temperatures affects battery life as well. Batteries exposed to extreme heat will lose performance and experience a shorter service life. For every 15° F (9.4° C) degree over 77° F (25° C), battery life is cut in half. This holds true for any type of lead acid battery, whether sealed, gelled, AGM, or industrial. Battery temperature should not exceed 126° F (52° C) during normal use.

Ideally, store batteries in a cool, dry place with temperatures not below 32° F (0° C) or above 80° F (27° C). Typically batteries will self-discharge at faster rates at higher temperatures.

Consistent undercharging will decrease useful battery life. Operating a battery with a consistent charge deficit will lead to permanent plate sulfating and/or acid stratification, which causes the storage capacity of the battery to fall off.

Cycling the batteries deeply (80 to 100%) on a daily basis shortens their life. Using only 25 to 50% of the storage capacity of the batteries will put less strain on them and increase their useful life.

A deep cycle is when you start with a fully charged battery, use 80% of its rated capacity, and then fully recharge it. Depending on the type, all batteries have a certain amount of deep cycles they can withstand before they need to be replaced.

Excessive vibration loosens active material, separates active material from the plates, breaks grid wire structure, and separates individual plates from an element. Batteries designed for maximum vibration resistance should have a heavy-duty case with internal element anchoring at both the top and bottom of the element.

Using tap water causes calcium sulfating.

As the battery discharges its freezing point rises. Thus, a discharged battery can freeze and/or sustain damage before it can be recharged.

Lead acid batteries will last a long time if they are operated within the proper charge and discharge voltages. A charge control circuit is necessary for preventing battery overcharge. Conversely, a Low Voltage Disconnect (LVD) circuit prevents excessive battery discharge. By using a combination of both circuits it is possible to keep the battery operating at the proper range.

Charger

The manufacturer recommends the following inspections or maintenance for the battery charger:

WARNING:

There is a risk of explosive gasses, working in the vicinity of a battery is dangerous. Some batteries generate explosive gases during normal battery operation. For this reason, it is of utmost importance that each time before using this unit, you read the manufacturer's manual and follow the instructions exactly.

CAUTION:

To reduce risk of injury and/or damage to the batteries, use only the type of batteries specified on the charger.

1. Clean the outside cabinet of the charger with a dry cloth.

2. Periodically check all connections and tighten if necessary.
3. Check D.C. output cables, connections, battery type, and number of battery cells with charger.
4. Check unit specifications with customer order.
5. Check input connections, input voltage, and line breaker size.
6. Check for shipping damage, loose connections, broken wires, etc.
7. Certain failures can be caused by defective batteries and customer loads, make sure batteries and loads are free from defects.

(For additional information regarding the engine start batteries and charger, refer to Appendix Section 4.2.4.3.5 of this manual.)

3.4.4 Power Distribution System

3.4.4.1 Automatic Paralleling Switchgear

Inspections and maintenance intervals on the switchgear should be scheduled on the basis of operating conditions and experience. Abnormal operation or conditions may require more frequent inspections and more maintenance.

DANGER:

HAZARD OF BODILY INJURY OR EQUIPMENT DAMAGE

Perform inspection and maintenance only with the main sources of power disconnected and locked open with a "work" lock.

Be sure there is no backfeed through any feeder circuit.

Ground the main and feeder circuits before touching the main bus, bus pads, or primary contacts.

Failure to observe these precautions will result in death, severe personal injury, or equipment damage.

The manufacturer recommends the following inspections and preventive maintenance on a periodic bases:

1. Check all busbar connections, and torque all 1/2 inch bolts to 55 lb-ft (74.28 N-m).
2. Inspect the busbars, primary contact supports, and insulating barrier(s).
3. Clean the discoloration from the contact surfaces of the busbar and primary contact. Use an abrasive pad such as Scotch Brite.

4. Inspect the load connectors, stand-off insulators, primary contact supports, and all accessible cable terminations for indications of insulation deterioration.
5. Withdraw each circuit breaker from its compartment, and thoroughly inspect each of the moving mechanisms in the compartment.
6. The shutters should raise and lower smoothly with no indication of binding, twisting, hesitation, or hang-up. Inspect the shutter hardware. Tighten if necessary.
7. Clean the contact surfaces of the ground contact bar, removing grease and dirt buildup. Inspect and tighten the hardware and re-grease.
8. Inspect the stationary control power receptacle, ensuring that the molding is free of cracks, the female contacts are clean, and the assembly is free to move. Clean the front and back surfaces of the receptacle to remove any contamination buildup.
9. Lightly lubricate the primary contacts and the ground contacts with Mobilux EP 1. Lubricate all moving joints (shutters, MOC, TOC, and so forth), rollers, and sliding parts with Mobilgrease 28.
10. Check all terminal block connections for loose hardware and crimp-on terminal conditions.
11. Make certain that the hinge wiring to the door is not frayed and has no insulation damage.
12. Inspect the moving and stationary primary and secondary contacts and the static ground contacts. Clean the contact surfaces, removing any burn or pit marks if required. Use an abrasive pad such as Scotch Brite.
13. Remove the current limiting fuses, and inspect the fuse clip and fuse contact surfaces.
14. Inspect circuits and devices for indication of insulation deterioration.
15. Tighten all hardware, including the secondary contact wiring terminals.
16. Inspect the interlock mechanism for proper operation.
17. Vacuum all compartments and wipe off all insulation using a clean dry cloth. Replace removable back covers.
18. Check ventilation louvers every (3) three to (6) six months. Replace ventilation filters as necessary.
19. Check for evidence of condensation or water leaks.

Manual Ground and Test Device

Proper maintenance of the ground and test device is necessary for satisfactory operation. Perform the following checks, each time, before the device is used:

> **WARNING:**
>
> **HAZARD OF PERSONAL INJURY OR EQUIPMENT DAMAGE**
>
> **Before performing any maintenance or repair work always remove the ground and test device completely from the circuit breaker compartment.**
>
> **Failure to follow this instruction can result in death or serious injury.**

1. Visually inspect the entire ground and test device for loose parts or connections.
2. Lightly coat the contact surfaces and primary contact fingers with grease (MobiP 28 red grease or approved equivalent).
3. Use a clean dry cloth to ensure that the insulation is free from dust and contaminants.
4. Inspect insulated parts if the device has been stored for a prolonged period, or has been exposed to high humidity.
5. Ensure that the insulation is intact.
6. Verify that the ground and test device sustains the specified voltage without flashover for one minute.
7. If necessary, clean the surface of each insulator.
8. Discharge the primary terminals to ground after each test.

(For additional information regarding the switchgear and test devices, refer to Appendix Section 4.2.4.4.1 of this manual.)

3.4.4.2 Medium-Voltage Distribution Switchboards

The manufacturer recommends the switchboard be inspected at least once each year and after any severe short circuit. If the switchboard is used in a corrosive, dusty, or damp environment, inspections and maintenance should be conducted more frequently. The most common indicators of an impending malfunction are moisture, accumulation of dust and dirt, and overheating.

The following inspections and maintenance should be completed yearly:

1. Inspect for moisture or signs of wetness.
2. Remove any signs of dust, dirt by using a brush, vacuum cleaner, or clean lint-free rags.

3. Check for signs of overheating by feeling the dead front surfaces of circuit breakers, switches, interior trims, doors, and enclosure sides.
4. Check the operation of all mechanical components.
5. Clean and lubricate all circuit breakers according the manufacturer's instructions.
6. Check insulation resistance if a severe short circuit has occurred.
7. The battery powering the switchboard has a life expectancy of 3 to 5 years. The battery should be checked monthly for the following:
    - Appearance and cleanliness,
    - Charger output current,
    - Electrolyte level,
    - Evidence of corrosion on terminals,
    - Battery terminal voltage under load, and
    - Tightness of bolted connections.

(For additional information regarding the switchboard, refer to Appendix Section 4.2.4.4.1 of this manual.)

3.4.4.3 Vacuum Circuit Breakers

The manufacturer recommends inspections and preventive maintenance intervals should be based on the application and environment. As a minimum, the manufacturer recommends:

Periodically:

WARNING:

HAZARD OF PERSONAL INJURY OR EQUIPMENT DAMAGE I

Before performing any maintenance or repair work:

- **Always remove the circuit breaker completely from the cell.**
- **Press *OPEN, CLOSE*, and *OPEN* pushbuttons to discharge all springs.**

Disassembly and reassembly of this circuit breaker without following proper procedures can cause improper operation, resulting in damage to the circuit breaker and injury to the operator.

Failure to observe these precautions can cause death or severe personal injury.

1. Inspect circuit breakers after three years or every 3,000 operations, whichever occurs first.
2. Inspect circuit breakers after severe fault operations and record any contact erosion. When contact erosion exceeds 0.12 inch (3.1 rnm), the vacuum interrupter may need to be replaced.
3. Visually inspect the entire circuit breaker and operating mechanism for obvious loose parts or connections.
4. Examine the circuit breaker for evidence of overheating or excessive dirt or moisture.
5. Use a clean, dry cloth, to remove all dirt and moisture from the outside of the vacuum interrupters and from the insulating parts.
6. Perform a hi-pot test on the circuit breaker. Consistent unacceptable test results may indicate a loss of vacuum and the vacuum interrupter may need to be replaced.
7. Measure the resistance measurement from the upper conductor to the lower conductor on each phase of the circuit breaker when it is closed. A reading exceeding 50 micro ohms indicates that either a poor connection exists or that the vacuum interrupter has reached the end of its life cycle. The vacuum interrupter may need to be replaced.
8. Lubricate gear teeth, contact surfaces on guide cams and the trip latch, the MOC linkage, and the primary contacts after 3,000 operations or three years, whichever occurs first.

(For additional information regarding the vacuum circuit breakers used in the switchgear, refer to Appendix Section 4.2.4.4.5 of this manual.)

Circuit Monitor

The circuit monitor does not require regular maintenance, nor does it contain any user-serviceable parts. Do not open the circuit monitor. Opening the circuit monitor voids the warranty.

DANGER:

HAZARD OF ELECTRIC SHOCK, BURN, OR EXPLOSION

Do not attempt to service the circuit monitor. CT and PT inputs may contain hazardous currents and voltages. Only authorized service personnel from the manufacturer should service the circuit monitor.

Turn off all power supplying this equipment before working on or inside.

Always use a properly rated voltage sensing device to confirm that all power is off.

Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume that all circuits are live until they have been completely de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.

Beware of potential hazards, wear personal protective equipment, carefully inspect the work area for tools and objects that may have been left inside the equipment.

Use caution while removing or installing panels so that they do not extend into the energized bus; avoid handling the panels, which could cause personal injury.

Before performing Dielectric (Hi-Pot) or Megger testing on any equipment in which the circuit monitor is installed, disconnect all input and output wires to the circuit monitor. High voltage testing may damage electronic components contained in the circuit monitor.

Failure to follow these instructions will result in death or serious injury.

CAUTION:

HAZARD OF EQUIPMENT DAMAGE

Do not perform a Dielectric (Hi-Pot) or Megger test on the circuit monitor.

High voltage testing of the circuit monitor may damage the unit. Before performing Hi-Pot or Megger testing on any equipment in which the circuit monitor is installed, disconnect all input and output wires to the circuit monitor.

Failure to follow this instruction can result in injury or equipment damage.

(For additional information regarding the circuit monitor used in the switchgear, refer to Appendix Section 4.2.4.4.8 of this manual.)

3.4.4.4 LCD Touch Monitor

The only preventive maintenance required for the touch monitor used on the switchgear is a periodic cleaning of the screen and the cabinet.

CAUTION:

To avoid risk of electric shock, do not disassemble the brick supply or display unit cabinet.

The unit is not user serviceable.

Remember to unplug the display unit from the power outlet before cleaning.

Do not wipe the screen with a cloth or sponge that could scratch the surface. To clean the touchscreen, use window or glass cleaner. Put the cleaner on the rag and wipe the touchscreen. Never apply the cleaner directly on the touchscreen. To clean the display unit cabinet, use a cloth lightly dampened with a mild detergent.

(For additional information regarding the touch monitor used in the switchgear, refer to Appendix Section 4.2.4.4.9 of this manual.)

3.4.4.5 Switchgear Backup Power Systems

The backup power systems for the switchgear consists of a bank of lead selenium batteries used to provide 125 VDC for charging the switchgear breakers, two 12 VDC batteries for the 24 VDC control logic, NEMA rated enclosures, and circuit breakers. Although all the batteries are of a maintenance-free design, they will last longer if properly maintained. The following paragraphs detail some simple inspections and preventive maintenance recommended by the manufacturers. Additional general battery information contained in Section 3.4.3.3 of this manual can also apply to these batteries. Since this information is lengthily, it is not repeated here.

Breaker Lead Selenium Cells

The manufacturer recommends carrying out an inspection of the system once per year, or at the recommended topping-up interval period, to ensure that the batteries, the charging system, and the ancillary electronics are all functioning correctly.

WARNING:

Gases given off by batteries on charge are explosive! Do not smoke or permit open flames near batteries or do anything to cause sparks.

1. All the connectors must be tight. The connectors and terminal bolts should be corrosion-protected by coating with a thin layer of anti-corrosion oil.
2. Cell electrolyte levels should be checked visually to ensure that the level is above the minimum, and if necessary the cells should be topped-up. Use only distilled or deionized water. Never allow the electrolyte level to fall below the "MIN" line. Do not overfill the cells.
3. The batteries, and surrounding area, should also be checked for cleanliness, and if necessary cleaned with a damp soft cloth using clean water. A small amount o detergent may be added to the cleaning water to remove any greasy film. Do not use a wire brush or solvents of any kind. Vent plugs can be rinsed in clean water if necessary.
4. Maintain the battery at the correct float voltage.
5. Whenever the battery is subjected to a discharge of more than 5 to 10 percent of its rated capacity, it should be recharged as soon as possible.
6. Keep the surrounding temperature at a level so the temperature of the electrolyte never exceeds 100° F (38° C).
7. Examine all cells periodically.

Charger for Lead Selenium Cells

Since the charger used for the lead selenium cells in the switchgear does not employ any moving parts other than the adjusting potentiometers, meters and relays used for the alarms batteries, no maintenance other than periodical electrical checks and adjustments should be required during the life of the unit.

The manufacturer of the charger recommends the following inspections and preventive maintenance:

CAUTION:

Do not touch any uninsulated parts of the battery charger, especially the input and output connections, as there is the possibility of electrical shock.

When replacing batteries, use the same number and type of batteries.

Proper disposal of batteries is required. Refer to your local codes for disposal requirements.

Connect or disconnect the battery only when the battery charger is off to prevent arcing or burning.

De-energize all AC and DC inputs to the battery charger before servicing.

Do not operate battery charger if it has been damaged in any way. Refer to qualified service personnel.

Do not disassemble battery charger. Only qualified service personnel should attempt repairs. Incorrect reassembly may result in explosion, electrical shock, or fire.

Gases given off by batteries on charge are explosive! Do not smoke or permit open flames near batteries or do anything to cause sparks.

1. Periodically blow dust off the charger.
2. The approximate state of charge of the battery should be regularly checked.
3. The battery should be regularly maintained as outlined by the battery manufacturer. Special attention should be given to the electrolyte level of the vented cells.
4. Semi-annually, the “Float” and “High Rate” voltages should be checked for compliance to the settings.

Logic Lead Acid Batteries

The two12 VDC lead-acid batteries (series wired for 24 VDC total) are used to maintain the control logic in the switchgear in the event of a power failure.

A dead battery means downtime, and that means decreased productivity and profits. The batteries won't last forever, but using a few simple management techniques, battery life can be maximized.

To reduce the risk of electrical shock, disconnect the charger from the AC power source and the batteries before attempting any maintenance or cleaning. The batteries should be inspected periodically for damage, leaks, and loose cables.

The batteries will become useless, or their life will be drastically reduced, if they are allowed to freeze. Therefore, the battery heaters should be checked frequently for operation.

Proper Storage

Using the right storage techniques can help extend the life of the batteries. For storage periods of a few weeks or more, you should disconnect the battery cables. If they are left connected in cold weather, the batteries may discharge and freeze. If the batteries are stored in an unheated area during winter, make sure to remove the batteries and store them in a room with a constant 40-50° F (51° C) temperature.

Recommended Charges

lf the batteries should require charging, the manufacturer recommends a slow charge. A slow charge reduces the risk of overheating the battery, which can boil out the water and buckle the plates.

Overcharging causes a loss of water (which accounts for over 50% of failures) and accelerates positive grid corrosion or grid growth causing plate to strap shorts. Once the full charge condition has been reached, additional current through the battery causes excessive gassing and deterioration of the lead grid and internal paths.

Overcharging batteries on a regular basis causes water to be boiled out of the electrolyte and will eventually warp the plates from overheating and corrode away the positive plates. Overcharging is dependant on the voltage regulator setting. The correct voltage regulator setting is described as one that will keep the battery fully charged with minimum water usage under a wide variety of operating conditions.

High operating temperatures affects battery life as well. Batteries exposed to extreme heat will lose performance and experience a shorter service life. For every 15° F (9.4° C) degree over 77° F (25° C), battery life is cut in half. This holds true for any type of lead acid battery, whether sealed, gelled, AGM, or industrial. Battery temperature should not exceed 126° F (52° C) during normal use.

Ideally, store batteries in a cool, dry place with temperatures not below 32° F (0° C) or above 80° F (27° C). Typically batteries will self-discharge at faster rates at higher temperatures.

Consistent undercharging will decrease useful battery life. Operating a battery with a consistent charge deficit will lead to permanent plate sulfating and/or acid stratification, which causes the storage capacity of the battery to fall off.

Cycling the batteries deeply (80 to 100%) on a daily basis shortens their life. Using only 25 to 50% of the storage capacity of the batteries will put less strain on them and increase their useful life.

A deep cycle is when you start with a fully charged battery, use 80% of its rated capacity, and then fully recharge it. Depending on the type, all batteries have a certain amount of deep cycles they can withstand before they need to be replaced.

Excessive vibration loosens active material, separates active material from the plates, breaks grid wire structure, and separates individual plates from an element. Batteries designed for maximum vibration resistance should have a heavy-duty case with internal element anchoring at both the top and bottom of the element.

Using tap water causes calcium sulfating.

As the battery discharges its freezing point rises. Thus, a discharged battery can freeze and/or sustain damage before it can be recharged.

Lead acid batteries will last a long time if they are operated within the proper charge and discharge voltages. A charge control circuit is necessary for preventing battery overcharge. Conversely, a Low Voltage Disconnect (LVD) circuit prevents excessive battery discharge. By using a combination of both circuits it is possible to keep the battery operating at the proper range.

Charger

The manufacturer recommends the following inspections or maintenance for the battery charger:

WARNING:

There is a risk of explosive gasses, working in the vicinity of a battery is dangerous. Some batteries generate explosive gases during normal battery operation. For this reason, it is of utmost importance that each time before using this unit, you read the manufacturer's manual and follow the instructions exactly.

CAUTION:

To reduce risk of injury and/or damage to the batteries, use only the type of batteries specified on the charger.

The manufacturer of the batteries recommends the following preventive maintenance:

Every 3 Months:

1. Measure and record the string float voltage.
2. Measure and record a pilot unit voltage.
3. Measure and record the ambient temperature.

Every 12 Months:

1. Measure and record individual float voltages.
2. Inspect, re-torque, and clean all connections as needed.

CAUTION:

Do not clean plastic parts with any solvents, detergents, mineral spirits, or spray-type cleaners other than those mentioned here as these can cause crazing or cracking of the plastic materials.

3. Clean unit covers to remove accumulated dust. If any unit, or parts, appear to be damp with electrolyte or show signs of corrosion, clean with a solution of baking soda and water. Isopropyl Alcohol can be substituted for the baking soda and water. Examine again within 30 days to determine if the condition re-occurs.

(For additional information regarding the batteries and chargers used in the switchgear, refer to Appendix Section 4.2.4.4.10 of this manual.)

3.4.4.6 Transducer

The manufacturer of the transducer used in the switchgear recommends the only preventive maintenance required is periodically cleaning the exterior of the instrument. This can be accomplished by using a soft damp cloth applicator with cleaning agents that are not alcohol based, and are nonflammable, non-explosive.

(For additional information regarding the transducer used in the switchgear, refer to Appendix Section 4.2.4.4.11 of this manual.)

3.4.5 Lighting

3.4.5.1 Site Lighting

The site lighting typically consists of incandescent fixtures mounted on the outside of the facility to provide lighting for exterior deck areas and stairways. Many of the exterior site lighting fixtures are enclosed with some kind of glass globe or lens. Some of these fixtures incorporate gasket-type seals.

WARNING:

Read and follow the lamp manufacturer's warning and use information before installing or repairing the light fixture.

Disconnect power before installation or servicing.

Install, operate, and maintain to meet all applicable codes.

Protect all wiring connections with approved insulators.

Selected fixture voltage must match supply line voltage.

Besides performing the annual maintenance per PM0460FA, periodically check the fixtures for moisture infiltration and inspect the globes, lenses, and seals for damage or deterioration. Operational testing of the lights should be performed monthly.

(For additional information on site lighting, see Appendix section 4.2.4.5.1)

3.4.5.2 Interior Luminaries

Interior luminaries typically consist of fluorescent units for general area lighting with a mixture of compact fluorescent fixtures, incandescent, high pressure sodium lamps, and HID lighting used for special purpose lighting.

WARNING:

Read and follow the lamp manufacturer's warning and use information before installing or repairing the light fixture.

Disconnect power before installation or servicing.

Install, operate, and maintain to meet all applicable codes.

Protect all wiring connections with approved insulators.

Selected fixture voltage must match supply line voltage.

Failure to disconnect power can result in electrocution, shock, or severe burns.

The interior lighting consists of both low-wattage and high output units. Many of the exterior site lighting fixtures are enclosed with some kind of glass globe or lens. Some of these fixtures incorporate gasket-type seals.

Besides performing the monthly maintenance per PM3405FM, periodically check the fixtures for moisture infiltration and inspect the globes, lenses, and seals for damage or deterioration. Operational testing of the lights should be performed monthly.

(For additional information on interior lighting, see Appendix section 4.2.4.5.2)

3.4.5.3 Emergency Lighting

The emergency lighting units (Equip. # LI00254, LI00313, LI00314, LI00315, LI00526, and LI00529) illuminate the immediate area during a power loss by the use of sealed beam type lamps powered by battery back-up power supplies. Several different types of emergency lighting are used throughout the Water Plant and Pump House. The back-up batteries in some units are maintenance free lead-calcium type with a rated capacity of 18W to 450W for 90 minutes of emergency operation. Other units use maintenance-free lead-acid type batteries.

Some of the emergency lighting units incorporate a *PRESS-TO-TEST* push button, which transfers the ballast from building power to the back-up batteries.

CAUTION:

Use caution when servicing batteries. Battery acid can cause burns to skin and eyes. If acid is spilled on skin or in eyes, flush acid with fresh water and contact a physician immediately.

Servicing of this equipment should be performed by qualified service personnel only.

Halogen cycle lamps may be used in this equipment. Halogen cycle lamps operate at high temperatures. Do not store or place flammable materials near lamp. To avoid shattering, do not operate lamp in excess of rated voltage. Protect lamp against abrasion and scratches and against liquids when operating or servicing. Dispose of lamp with care.

In accordance with NFPA 101, "Life Safety Code," conduct periodic testing of the emergency lighting units. Besides performing the monthly light inspection (PM #3405FM), the manufacturer recommends the following preventive maintenance and inspections:

Quarterly:

1. Conduct a short manual test to assure proper function. Actuate the unit test switch for a minimum of 30 seconds.
2. Units supplied with fault indicator LEDs should be visually checked to ensure operational status.

Annually:

1. Inspect the batteries for visible signs of corrosion or physical damage. Clean or repair as necessary.
2. Check all battery connections. Connections should be coated with vaseline jell.

3. Conduct a functional test for a 1 to $1^{1/2}$ hour duration. In accordance with NFPA 101, all emergency lighting units must remain illuminated for the entire duration.
4. Operational testing of the emergency lighting units should be performed during the annual building inspection.

(For additional inspections and testing of the emergency lighting units, see Appendix Section 4.2.4.5.3 of this manual.)

3.4.5.4 Exit Lighting / Signs

The exit lighting fixtures installed within the Water Plant and the Pump House consists of dual-voltage (120 / 277) fluorescent, lighting fixtures with a maintenance-free lead acid battery that provides 90 minutes of back-up operation. The battery automatically recharges after battery discharge. Exit signs are mounted above all exit doors.

WARNING:

Installation and servicing should be performed by qualified service personnel only!

Connect no other accessories of any kind to this product.

In addition to inspecting the exit lighting unit monthly in accordance with PM #3405FM, the manufacturer also recommends:

1. Inspect the casing for impact damage or dents.
2. Inspect the battery compartment and batteries for damage and loose connections.
3. Test functionality of the back-up battery. If battery voltage drops off rapidly the batteries should be replaced.
4. Inspect the interior and exterior of the unit to insure connections are tight, clean, and free of corrosion. Wipe the outside of the unit with a dry cloth.
5. Verify the batteries are not out of date.

(For additional information on exit signs lighting, see Appendix section 4.2.4.5.4 of this manual.)

3.4.6 Heat Trace

3.4.6.1 Vent-Thru-Roof, Arctic Pipe

Heat trace within the facility was provided for vent-thru-roof piping, and waste piping and drains. Typically, all water supply piping are double traced while drain pipes are single traced. Exterior lines such as the lines to and from fresh water tank #4, untreated water lines, brine lines, sea water lines, lines to and from the Pump House, and 3 inch sprinkler lines may have been heat treated. Self-regulating, self-limiting cabling with thermoplastic insulation, parallel conductors, and a nominal output of 3.28 watts per linear foot is used.

WARNING

Damage to cables or components can cause sustained electrical arcing or fire. Do not attempt to repair damaged heating cable. Do not energize cables that have been damaged by fire. Replace damaged cable at once by removing the entire damaged section and splicing in a new length using appropriate splice kits.

Do not reuse grommets. Use new grommets whenever the heating cable has been pulled out of the terminations. Reuse of the grommet, or use of the wrong grommet, can cause leaks, cracked components, shock, or fire. Be sure the type of grommet is correct for the heating cable being installed. Use a new grommet whenever the cable has been pulled out of the termination.

Damaged heating cable can cause electrical arcing or fire. Do not use metal attachments such as pipe straps or tie wire. Use only manufacturer approved tapes and cable ties to secure the cable to the pipe.

The manufacturer and the 1996 National Electrical Code Sections 426 and 427 require ground-fault equipment protection on each heating cable branch circuit. To reduce the risk of fire caused by damage or improper installation, circuit breakers with a 30-mA trip level should be used.

Failure to follow this warning can cause serious personal injury, death or major property damage.

NOTE

Avoid abusing, cutting, twisting, or tugging the heating cables during maintenance. The cable is intended to be reinstalled after the equipment is serviced.

After maintenance work is done and the cable is reinstalled, be sure to test the circuit.

1. Periodically inspect the insulation and connections of the heating cable to make sure that no damage has occurred.

2. Check inside heating cable components for proper installation, overheating, corrosion. moisture, and loose connections.
3. Check the electrical connections to ensure that ground and bus wires are insulated over their full length.
4. Check for damaged or wet thermal insulation: damaged. missing or cracked lagging and weather-proofing.
5. Check that end seals, splices, and tees are properly labeled on insulation cladding.
6. Check Control and Monitoring system for moisture, corrosion, set point, switch operation and capillary damage.
7. After turning off all branch circuits, test the system with a meg. ohmmeter to determine whether damage has occurred that may not be readily visible.
8. With the system operating normally, measure the voltage, amperage, and ambient temperature for each circuit and record the values in the Inspection Record for future maintenance and troubleshooting reference.

NOTE

On ambient-sensing controlled systems, allow a minimum of five minutes operation before taking electrical and temperature measurements.

On line-sensing controlled systems, allow sufficient time for the system to reach the set point before taking electrical and temperature measurements. This may take as long as 4 hours for most circuits. Large, liquid-filled pipes may take longer.

(For additional information regarding heat tracing system, see Appendix Section 4.2.4.6.1 of this manual.)

3.4.7 Signal Systems

3.4.7.1 Telephone / Local Area Network (LAN)

Telephone system operability shall be verified during Master I.S. (Telephone preventive maintenance), PABX system, and cabling to the Water Plant.

Maintenance of the telephone system, wiring, and configuration is provided by the Information Technology (IT) Technical Operations Group. The IT Group maintains a user support Help Desk on station. All maintenance issues involving the telephone system, wiring, and configuration should be referred to the Help Desk. No user maintenance of telephone system equipment is required.

LAN system maintenance is performed during Data Systems preventive maintenance and is the responsibility of Information Systems.

Maintenance of the LAN, wiring, and configuration is provided by the Information Technology (IT) Technical Operations Group. The IT Group maintains a user support Help Desk on station. All maintenance issues involving the LAN, wiring, and configuration should be referred to the Help Desk. No user maintenance of LAN equipment is required.

3.4.7.2 Closed Caption Television System (CCTV)

The manufacturer of the CCTV System states this equipment does not require any preventive maintenance other than an occasional cleaning and inspection for damage, or loose/broken connections. Clean the units with a slightly damp soft cloth. Use a mild household detergent. Never use strong solvents such as thinner, benzine or kerosene as they might damage the finish of the units.

WARNING:

To reduce the risk of fire or electric shock, do not expose this product to rain or moisture.

Do not insert any metallic objects through any ventilation grills.

Power must be removed from the unit before removing circuit modules or ribbon cables.

These units contain circuit cards with integrated circuit devices that can be damaged by static discharge. Take all necessary precautions to prevent static discharge.

To reduce the risk of electrical shock, do not remove covers or backs. No user-serviceable parts inside. Refer servicing to qualified service personnel.

Repairs should only be attempted by qualified personnel.

To prevent electric shocks and risk of fire hazards, do not use other than the specified power source.

Do not attempt to disassemble the camera.

Disconnect the unit to be cleaned from its power source before cleaning. Do not use caustic, abrasive, or aerosol cleaners. Do not allow moisture or liquids to enter any vents.

(For additional information regarding the CCTV System, see Appendix Section 4.2.4.7.2 of this manual.)

3.4.7.3 Fire Detection and Alarm Systems

Maintenance is the work or repairs necessary to keep equipment operable. Repairs to fire protection systems must be made immediately to ensure that the systems will operate when needed.

Fire alarm equipment has no specific frequency for maintenance in NFPA 72, but it does require periodic inspections, testing, and maintenance in accordance with manufacturer's instructions. The frequency of maintenance and cleaning depends upon the type of equipment and the local ambient conditions.

An inspection is a visual examination of the system to verify that it appears to be in operating condition and is free of physical damage. The visual inspection is generally done form floor level by walking through the protected building. Testing is conducted to ensure the systems fully operational. Any system that fails an inspection or testing, should have maintenance performed immediately to correct the problem, then inspected and tested again. Records should be kept of the inspections, tests, and maintenance.

In compliance with National Fire Protection Association Publication (NFPA) 72, Chapter 7, *Inspection, Testing, and Maintenance*, perform periodic inspections, testing, and maintenance of the fire detection system (including all initiating devices and signaling appliances) in accordance with the schedules set forth in NFPA. Further guidance is available in the NFPA manual.

Any defective component that fails testing or inspection, it must be replaced immediately. Because the entire system is of modular construction, repair is accomplished by board level swap-out techniques. This allows even the most inexperienced maintenance personnel to return the system to full service within minutes.

This section details maintenance procedures for the electrical components of the system. Maintenance for the mechanical components is discussed in Section 3.3.5 of this manual.

Perform maintenance on the Fire Detection and Alarm Systems, including all sub components and devices, in accordance with the following PMs:

#6700FM, #6705FM, #6719FQ, #6705FQ, #6705FS, #6705FA, and #6707FA.

3.4.7.3.1 Radio Alarm Control System

The Radio Alarm Control System is a modular, self-contained system designed for detecting the operation of any signal initiating device indicating by annunicator LEDs, the area of the alarm condition, operates all alarm and auxiliary devices, and transmits alarm, supervisory, and test messages to the base receiving station.

Maintenance and repair of the Radio Alarm Control System is extremely simple. Because the entire system is of modular construction, service is easily accomplished by using board level swap-out techniques. Inspections and maintenance on the fire alarm and detection control panel should be performed on a monthly, semi-annual, and annual basis using PMs mentioned above. Besides the above preventive maintenance inspections and procedures, the manufacturer also recommends the following inspections and testing be completed.

CAUTION:

Do not touch electrical connections before you ensure that the power has been disconnected using an approved lockout / tagout and / or proper personal protective equipment (PPE) is utilized. Electrical shock can cause serious or fatal injury.

Only qualified personnel should attempt the operation and maintenance of this equipment.

Chassis must be connected to earth ground. Hot and neutral polarity MUST be observed when connecting AC Power.

All test and service areas should be equipped with 120 VAC to 120 VAC isolated transformers and ground fault detecting circuit breakers, if possible.

DO NOT remove or install any circuit boards or field wiring while the panel is under power.

NOTE:

Before beginning tests, all parties, which may receive an alarm signal, should be notified so that there will not be an unnecessary response. At the conclusion of testing, all parties should again be notified. All equipment should be returned to normal condition and control panels locked.

The fire detection and alarm system has separate requirements and forms for inspections and for testing. For the purposes of this section:

An INSPECTION is a visual examination of the fire detection and alarm system to verify that it appears to be in good operating condition and free of physical damage. The visual inspection is generally done from floor level by walking through the protected premises.

A TEST is an actual operation of the equipment to verify that it functions as intended.

Routine Testing:

The transmitter panel should be tested on a regular basis. It is recommended that the panel be tested according to the NFPA 72 parameters.

If you wish to test a zone without transmitting an alarm message, the *Zone Disconnect Switch* may be placed in the ***OFF*** position prior to testing. This will cause a zone trouble condition until the switch is restored to the normal up position.

The manufacturer recommends the following should be checked:

NOTE:

Whenever the following procedure produces a transmission, wait at least one (1) minute after the third round is transmitted before proceeding to the next step.

1. Apply AC and Battery power to the interface, now power the transmitter, and verify the green AC power LED is illuminated and the transmitter transmits three rounds of a supervisory message.
2. Press the black ***TEST*** button on the side of the transmitter. Verify three rounds of TEST at the base receiving console.
3. ***OPERATE*** each switch. Trip a zone into alarm.

4. Place the *Alarm Audible Switch* in the ***OFF*** position. The common trouble LED and buzzer will pulse. After 2 1/2 minutes, the transmitter should transmit three rounds of a supervisory message. Confirm their transmission at the base receiving station.
5. Place each zone *Disconnect Switch* to the ***OFF*** position and check trouble annunciation. Return the switches to their ***NORMAL*** positions.
6. Remove AC power and check the operation of panel on battery backup. The common trouble LED and internal buzzer should pulse. Re-connect AC power after test.
7. Press the red CLOCK button to reset the automatic test clock. The transmitter will transmit the TEST message after 12 hours, and then auto TEST every 24 hours thereafter. To prevent overlapping TEST signals, space transmitters at least 2 1/2 to 3 minutes apart. Transmitters should also be spaced so that a TEST signal is transmitted at least every 60 minutes.

   RETURN ALL SWITCHES AND DEVICES TO NORMAL BEFORE LEAVING THE PANEL.
8. Document inspection and test results on the appropriate NFPA Inspection and Testing Form(s) included in Appendix Section 4.2.4.7.3.6 of this manual.

(For more information regarding the Radio Alarm Control System**,** reference manufacturer's documentation Appendix Section 4.2.4.7.3.1 of this manual.)

3.4.7.3.2 Intelligent Suppression Control/Fire Alarm System

The Intelligent Suppression Control/Fire Alarm System is an addressable fire alarm/suppression control system interfaced to the local, auxiliary, and remote protective intelligent loop signaling and releasing devices throughout the Water Plant and the Pump House. The system uses a microprocessor based design to interface with these intelligent detectors and loop devices. The system uses distributed intelligent field devices. These devices are typically smoke detectors, contact input devices relay outputs and signal output modules which represent a single fire alarm initiation/indicating zone.

Besides performing the monthly, semi-annually, and annual inspections and preventive maintenance procedures, the manufacturer recommends routine maintenance procedures should include the following:

1. Physically inspect the panel at least once a year.
2. Verify all connections are tight at all terminals.
3. Annually test the system display Light Emitting Diodes (LEDs).
4. Conduct loop-testing (electronic stimulation) of intelligent smoke and heat detectors.
5. Battery voltage testing to verify battery capacity. The battery should read 12.5 vdc. under load. If the battery is 11.9 vdc. or less, replace the battery.
6. Perform an operational walk test.
7. Perform an alarm simulation test.
8. Operate all switches.

WARNING:

Any outputs which are controlling critical processes or agent releasing should be physically disconnected from the process or agent container to avoid unwanted shutdowns and / or agent releases. When the Alarm Simulation Test (AST) function is enabled, the pre-programmed outputs for the activated input(s) will activate.

Use safety precautions when removing solenoids and connections from initiators (i.e. use the shorting cap when the initiators are disconnected) to prevent unwanted discharge or activation.

When the solenoid(s) is (are) removed from the storage container(s) the suppression system is fully disarmed from all automatic activation and, in some cases, all manual activation.

CAUTION:

Ensure that the panel does not have any active alarms before powering it down. If alarms do exist during power-down, power-up of the panel will cause a reactivation of the alarm sequence and possible activation of the suppression system.

Ensure that all solenoids are disconnected from the storage containers during power-up to prevent unwanted discharge or activation.

Before beginning tests, all parties which may receive an alarm signal should be notified so that there will not be an unnecessary response. At the conclusion of testing, all parties should again be notified. All equipment should be returned to normal condition and control panels locked.

NOTE:

Prior to testing the system, read, understand, and follow the notes below, from Chapter 10 of the *National Fire Alarm Code* (National Fire Protection Association publication NFPA 72):

"Testing personnel shall be familiar with the specific arrangement and operation of the suppression system(s) and releasing function(s) and cognizant of the hazards associated with inadvertent system discharge."

"Discharge testing of suppression systems shall not be required by this code. Suppression systems shall be secured from inadvertent actuation, including disconnection of releasing solenoids / electric actuators, closing of valves, other actions, or combinations thereof, as appropriate for the specific system, for the duration of the fire system testing."

"Occupant notification shall be required whenever a fire alarm system configured for releasing service is being serviced or tested."

"Testing shall include verification that the releasing circuits and components energized or actuated by the fire alarm system are electrically supervised and operate as intended on alarm."

"Suppression systems and releasing components shall be returned to their normal condition upon completion of system testing."

"Occupant notification shall be required whenever a fire alarm system configured for releasing service is being serviced or tested."

Document all inspections and preventive maintenance results on the appropriate forms found in Appendix Section 4.2.4.7.3.6.

(Specific procedures for testing the Intelligent Suppression Control/Fire Alarm System are contained in the manufacturer's documentation in Appendix Section 4.2.4.7.3.2 of this manual.)

3.4.7.3.3 Initiating Devices

All alarm initiating devices (e.g. manual stations, smoke detectors, heat detectors, gas detectors, air duct detectors) are connected to and controlled by the fire system's control panel located in the Intelligent Suppression Control/Fire Alarm System. Detectors found to have a sensitivity outside the listed and marked sensitivity range shall be cleaned and re-calibrated or replaced. The detector sensitivity cannot be tested or measured using any device that administers an unmeasured concentration of smoke or other aerosol into the detector.

At 15 years and every 5 years thereafter, 2 detectors for each 100 fixed-temperature detectors in the system must be removed and laboratory tested for operation. The 2 detectors must be replaced with new detectors.

If the detectors fail during the laboratory tests, replace all existing detectors with new detectors. If 1 of the 2 detectors fails, either test some additional detectors or replace all existing detectors.

CAUTION:

Before beginning tests, all parties which may receive an alarm signal should be notified so that there will not be an unnecessary response. At the conclusion of testing, all parties should again be notified. All equipment should be returned to normal condition and control panels locked.

In addition to the scheduled PMs, the manufacturers of several initiating devices recommend the following preventive maintenance:

1. Inspect all initiating devices for cracks, broken or cracked glass plates, dirt or distortion, and signs of physical damage. Replace devices showing signs of physical damage.
2. Annually clean dust from the device by using suction from a vacuum cleaner. Cleaning programs should be geared to the individual environment in conformance with NFPA 72-1999.
3. Visual check for pipe network integrity.
4. Take a battery status check of all power supply batteries.
5. Perform a gross smoke test of all installed detectors.
6. Conduct a system transport time test.
7. Conduct a detector sensitivity test.

Document results on the appropriate forms found in Appendix Section 4.2.4.7.3.6.

CAUTION:

Do not attempt disassembly of any factory sealed device. These devices are sealed for your protection and are not intended to be opened for servicing.

(For more information on initiating devices, see Appendix Section 4.2.4.7.3.3 in this manual.

3.4.7.3.4 Signaling Appliances

All alarm signaling / notification appliances (strobe lights, horn / strobe alarms, speaker / strobe alarms, and annunciator panels) are connected to and controlled by the Intelligent Suppression Control/Fire Alarm System.

CAUTION:

Before beginning tests, all parties which may receive an alarm signal should be notified so that there will not be an unnecessary response. At the conclusion of testing, all parties should again be notified. All equipment should be returned to normal condition and control panels locked.

In addition to the scheduled PMs, the manufacturers of several signaling appliances recommend the following preventive maintenance:

WARNING:

Make sure all fuses used on NAC circuits are rated to handle the maximum inrush or peak current from all appliances on those circuits. Failure to do this may result ion loss of power to the NAC circuit and the failure of all appliances on that circuit to operate, which could result in property damage and serious injury or death to you and/or others.

1. Inspect all signaling appliances for cracks, broken or cracked glass plates, dirt or distortion, and signs of physical damage. Replace appliances showing signs of physical damage.
2. Annually clean dust from the device by using suction from a vacuum cleaner. Cleaning programs should be geared to the individual environment in conformance with NFPA 72-1999.

Document results on the appropriate forms found at the end of Appendix Section 4.2.4.7.3.6.

(Additional information regarding the Signalling Appliances is contained in Appendix Section 4.2.4.7.3.4 of this manual.)

3.4.7.3.5 Battery Packs & Charger

The battery packs installed in the fire detection and alarm systems requires no maintenance other than periodically checking for loose, corroded connections, and the scheduled PMs. The batteries will last longer if kept in a charged state by the charger.

CAUTION:

Do not short battery leads. The batteries are capable of extremely high short circuit currents, even when partially discharged. This high current can cause internal heating of the battery and permanent damage. A shorted battery can also be a fire and/or explosion hazard. Be sure to always use the polarized connectors supplied on the batteries. Never remove wires from the connector.

A battery discharge tested should be replaced when the voltage drops below 11 volts.

A battery that refuses to take a charge can sometimes be restored by charging the battery for 1 hour, discharging it to 10 volts, then charging the battery again. If no improvement in battery voltage or discharge time results, the battery is irreversibly damaged and should be replaced.

The manufacturer of the charger listed no maintenance requirements.

(Additional information regarding the battery packs and charger is contained in Appendix Section 4.2.4.7.3.5 of this manual.)

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