PART 2

TECHNICAL ELEMENTS

CHAPTER 1 - MEDICAL GASES

FUTURE

CHAPTER 2 - BOILER PLANT

2-1 INTRODUCTION

The boiler plant is the largest concentration of equipment in your facility. It is the very "heart" of your operation. In addition, the majority of other control systems are also located within proximity of your boiler plant. Operation of your boiler plant, therefore, consumes the greatest amount of time from the facilities engineering program. To deny it appropriate preventive maintenance is to neglect the greatest asset. A rigorous, structured program will allow a facilities manager to extend the life of the equipment.

2-2 BOILER REPLACEMENTS, MODIFICATIONS OR ADDITIONS

A. If major modifications to a boiler plant are contemplated the Director, Division of Facilities Management in Headquarters is to be notified by the Area facilities engineer.

   (1) Prior to installation or replacement of high pressure steam (15 p.s.i./16 kPa/cm^2 or above);

   (2) Prior to installation or replacement of high pressure hydronic/hot water boilers (30 p.s.i./32.1 kPa/cm^2 or above);

   (3) Installation of new fuel burning equipment on existing boilers;

   (4) High pressure boiler re-tubing in excess of 30 percent.

B. The purpose of this review is to ensure that design of replacement boilers include a preliminary study to determine the maximum steam consumption load and identification of alternative methods to reduce steam consumption.

2-3 BOILER FIRING RATES

When the normal load of a boiler on line exceeds 80 percent of the designated maximum rating, another boiler should be placed on line. This will provide a margin for load changes so that the firing rate will not exceed the designated maximum rate at any time.

2-4 BOILER FLUE GAS ANALYSIS

Waste which is inherent in the burning of fuel can best be minimized by proper control of combustion. This requires reading flue gas temperatures at least weekly and monitoring the chemical composition of the flue gas by the use of a portable Orsat analyzer to facilitate the proper adjustment of combustion controls. Each facilities manager should train designated facilities engineering employees in the use of the instrument so that flue gas samples can be tested. Results of these tests should be documented on the boiler plant logs for review by the facilities manager.

2-5 BOILER EXCESS AIR REQUIREMENTS

To ensure against incomplete combustion, boilers should be operated following the manufacturer's excess air requirements.

2-6 ADJUSTMENTS TO BOILER COMBUSTION CONTROLS

Each installation must obtain the services of an industrial burner service company to perform an inspection and combustion test of the fuel burning equipment (including safety devices and interlocks) at least quarterly. These controls and interlocks should be adjusted as necessary to provide and maintain excess air with no combustibles in the flue gas and no flame impingement on the boiler heating surfaces. The installation should also engage the services of a qualified service organization or the equipment manufacturer to service the boiler plant instrumentation at least annually, if the quarterly combustion control testing is accomplished in-house. This will serve as a quality control indicator on the work being performed in-house.

2-7 BOILER PLANT OPERATORS

A. Boiler plants shall not be left unattended unless they are remotely monitored at a central location 24-hours a day, 7 days per week. They should never be maintained or tampered with by unqualified persons even for short periods. Facilities engineering employees who are charged with the responsibility of operating the boilers should meet, at a minimum, the qualifications required by the State of jurisdiction. The facilities manager is responsible for ensuring that operators are duly qualified at all times.

B. Each operator should be capable of lighting off, warming up, changing fuel (if applicable), or shifting gas or oil fired boilers at any time. When there is difficulty or apprehension in lighting off or shifting boilers, the installation should have additional personnel present to ensure safe operating procedures.

C. Each operator should start up and operate at least one boiler per quarter. Each boiler should be operated on back up fuel (if applicable) at least quarterly for a minimum of one shift. This will ensure that the equipment functions properly, and equipment operators are proficient in operating the equipment. In addition, it will ensure that, if fuel oil is the back-up fuel it is being consumed at periodic intervals to avoid build-up in the tank that can cause problems during an emergency switch over. The facilities manager should develop a schedule so that all operators start up, operate and switch over fuel (if applicable) as required above.

2-8 BOILER WATER TREATMENT

A. WATER TREATMENT - Water used for boiler operation should be analyzed by a competent chemist, who should recommend the kind of treatment required to make it suitable for boiler use. A follow-up analysis of the water source should be conducted at least every three years.

B. BOILER WATER

(1) Boiler feed water should be tested daily. Complete treatment of boiler water greatly reduces the need for cleaning the water tubes and for laboriously removing encrusted scale from boiler drums. The inaccessibility of the fire tube boiler is another reason why a chemist must be asked to recommend the water treatment.

(2) Boiler water treatment cannot be introduced haphazardly by a "one-shot" method. Proper treatment should be applied to the feedwater by a proportioning system. In this way, the boiler surface is given constant treatment.

(3) There are external methods of water treatment for boiler feed. The soda-lime process and zeolite softener correct different types of deficiencies. These methods should be used only upon the recommendation of a highly qualified firm who sells service rather than "patent medicine."

C. BOILER RETURN CONDENSATE - Chemical treatment should also include protection of return condensate lines in steam systems. When condensate samples are taken, they should come from several widely separated points. In a system PH varies with distance and temperature.

D. TEST EQUIPMENT AND SUPPLIES - Each installation should obtain the necessary equipment, supplies, handbooks and procedures to conduct an appropriate treatment program.

E. SAMPLES AND TESTS - Each installation should test the boiler water weekly from each boiler in operation for blowdown control and to ensure that the proper chemical levels are being maintained within guidelines. Chemicals will be maintained at proper levels at all times that the boilers are in operation. Testing of boiler feed water should not be delegated totally to a vendor who occasionally (monthly) comes to the facility even if the testing is free or part of the cost of purchasing chemicals from his/her firm. Facilities managers should be knowledgeable in the procedures for conducting the tests to train new subordinates, refresh existing staff and conduct quality assurance on the testing program by conducting the testing him/herself.

F. HAZARDOUS CHEMICAL IDENTIFICATION - Each installation must verify that the chemicals being used for water treatment and their disposal conforms with State and EPA regulations. Consult with the local EPA or State office of Environmental Quality for assistance.

2-9 INSPECTIONS, PREPARATION AND REPAIRS

A. INSPECTIONS - Inspections should be conducted by an individual holding a certificate issued by the National Board of Boiler and Pressure Vessel Inspectors. One who is an experienced operator is not qualified to be an inspector. The requirements for such a certificate require the individual to pass the National Board examination for proof of competency. The inspector should be one who is regularly employed in that capacity by an authorized inspection agency. There is no code that fixes the interval for inspection of boilers. They merely state that they should inspected periodically. The practice in the private sector is based on the Insurance Underwriters policy which is explained below.

(1) Boilers

a. High Pressure - Each high pressure steam boiler will receive an internal-external inspection each year and one external inspection between the internal-external inspection. The latter may be performed while the boiler is under steam pressure, filled and idle, or empty and idle. Its purpose is to observe if it is in a condition to operate safely. High pressure steam is defined by code as 15 p.s.i.g./16 kPa/cm^2 and above. High pressure hydronic boilers are defined by code as 30 p.s.i.g..32.1 kPa/ cm^2 and above.

b. Low Pressure Boilers - Each low pressure steam boiler and low pressure hydronic boilers will be inspected at least once a year. Each low pressure hydronic boiler will receive an internal-external inspection every two years and one external inspection between the internal-external inspection. The latter may be performed while the boiler is under steam pressure, filled and idle, or empty and idle. Its purpose is to observe if it is in a condition to operate safely.

c. Unfired Pressure Vessels - Each unfired pressure vessel (e.g., control HVAC air compressor storage tank, and medical air compressor storage tank) should be inspected at least annually. The same inspector that performs your boiler inspections is also licensed to perform your unfired pressure vessel inspections. It is good practice to conduct the inspections simultaneously while the inspector is on site.

(2) Controls - These may vary from easily identified pop valves to complex combustion control devices.

a. Safety Valves - All pressure vessels are equipped with at least one safety valve. All steam pressure generators are equipped with at least two safety valves. The size of the valve is set by code and is directly associated with the generating capacity of the vessel. One valve is set at a predetermined steam pressure. The second is set at a slightly higher pressure and comes into play only when the first fails to release the accumulated pre-set pressure fast enough. Safety valves should be tested at least once each week while the boiler is in operation. It can be done manually or by increasing the boiler pressure until the safety valves are brought into operation.

b. Water Level - Each boiler is equipped with a water gauge glass. The lowest visible part of the gauge glass must be at least 2 inches (2.54 cm) above the lowest permissible level of water. The column will be blown down at least daily to prevent sludge from settling in the connections and interfering with the water level. Some chemicals used in the water treatment process may damage the sight glass. They should therefore be cleaned frequently and discarded and replaced if they are etched or scratched in any way.

c. Low Water Fuel Cut Off - Installed to automatically cut off the fuel supply when the surface of water falls to the safe water line.

d. Pressure Control - Installed to automatically cut off the fuel supply when the boiler pressure reaches the required pressure setting.

e. Automatic Water Feeder - Installed to automatically compensate for heating system losses by adding raw or treated water to the boiler.

f. Flame Detection - Installed to detect the presence or absence of a flame so that combustion may continue or be interrupted.

Controls should be inspected and tested in accordance with the manufacturer's requirements. Some controls require daily or weekly testing to ensure proper operation. At a minimum, all others will be tested at least quarterly during combustion control adjustments. Written documentation of this inspection will be maintained by the facilities manager.

(3) Pumps - Boiler plants use a variety of pumps. Uses include fuel, domestic water, boiler feed, chemical feed etc. Manuals supplied by manufacturers should be used as a guide for maintenance and repair, including, lubricating bearings, inspecting packing for leaks, tightening of packing gland nuts and checking of the motor-pump alignment.

(4) Traps - Automatic equipment that holds steam in heaters, radiators, convectors and other space heating equipment until the steam has given up the latent heat of vaporization (conversion of steam to water). They are also used on lengthy steam mains to remove condensate that can be collected at predetermined points. Traps allow condensate and air to pass but to interrupt the passage of steam. Their main function is to prevent damage to lines and equipment and impede a water hammer caused by entrained water. They should be checked at least yearly by disassembling.

(5) Valves - Used optionally throughout the installation but generally are gate, globe and angle. Valves contain moving parts and materials that wear and therefore need lubrication, replacement and repair. Valves suffer as much from lack of use as actual use. For this reason, all critical valves should be inspected, tested (exercised) at least annually and documentation kept of this test in a log. The log documentation should include location, date of test, and the inspector's name. This will ensure their operation when needed. It is advisable that a quantity of some valves be kept in stock in the storeroom. Occasionally valves will need to be replaced and you will

need the replacement on site. Strategically located valves should be isolating the various sections of your installation. If you do not currently have them in place you should make it a practice to install additional valves as you encounter emergency utility shut downs.

a. Pressure reducing valves should be repacked and checked annually.

b. Boiler blow off valves should be checked daily to make sure they are not leaking.

(6) Heating and Steam Distribution - Inspection of the heating and steam distribution system must be made annually.

B. PREPARATION - COOLING DOWN AND EMPTYING BOILERS

(1) When taking a boiler out of service, it is desirable to reduce the load gradually and to maintain a low load for a time before actually shutting down the flame. This procedure will insure that any suspended sludges and scale flakes have a maximum opportunity to settle out of circulation in proximity to the blow off line so that they can be readily removed.

a. When the flame is being killed, the water level of the boiler should be raised to a high point because this can be done safely under a low load condition and there will be ample water reserve to blow down the water under pressure after the flames has been shut down.

b. When the boiler is at full pressure, the blow off valves should be given a quick blowdown (drain) to remove sludges and loose scale flakes as much as possible. This will reduce the water level, but should not be continued to a point where low water level is obtained, or to the point where feed water has to be admitted to restore the water level. Cold feed water should not be put into a hot boiler as it may contribute to loosening of rolled tube joints.

c. After being blown down under pressure, the boiler should be cooled slowly, at a recommended rate of approximately 100^{0}F/hr (38^{0}C/hr). A slower rate of cooling will do no harm, but a more rapid rate may be harmful by causing unequal contraction strains. The water level will settle as the boiler cools down, so long as it remains in sight at the bottom of the gage glass, feed water should not be admitted to the cooling boiler.

(2) When the furnace has cooled to a temperature at which a person can enter and remain in the furnace, the boiler may be entirely emptied without danger. It should be emptied at a rapid rate as possible by opening the main blow off valves wide because this will assist in removing sludges that settle out in the vicinity of the internal blow off lines. The steam drum vents or safety valves should be wide open, thus permitting the entrance of air to the drum, otherwise, the water will not drain from the boiler entirely.

(3) Follow the manufacturer's procedure for the boiler at your installation.

C. REPAIRS

(1) Refractory - Used in furnaces largely as a convenient means for containing the fire and forcing the hot gases to travel over boiler heating surfaces without damaging other portions of the structure. It is evident, therefore, that the refractories must be kept in good repair; otherwise, the equipment may be extensively damaged, or the efficiency may be reduced. The frequency or type of refractory repairs needed depends largely on the severity of the service, the type of materials originally used, their design and construction. When refractories must be replaced, it is usually advisable to use the same or better grade, because a large portion of the expense involved is the labor required for repair, not in the cost of the material. Repair work must be done carefully by skilled workmen, otherwise the repair cannot be expected to stand up to the severe requirements of boiler service.

(2) Tube Repairs - Repairs are required when blistering, rupturing, cracking, corrosion, leaky joints or other types of failure occur. Repairs may also become necessary when inspection reveals progressive deterioration and possibility of tube failure before the next outage can be scheduled. The method of repair to be used depends on the type of weakness found. It may vary from the re-rolling of a tube end to the complete replacement of the tube. Repair or replacement should only be done by specialized skilled workmen.

(3) Casing - There are various types of boiler casings which serve the general purpose of providing air tightness with structural support, improvement in appearance, aid to cleanliness, and reduced cost of maintenance. The type of casing used, the severity of service, and the desire to maintain a generating unit in first-class operating

condition at all times, will largely determine the kind of repairs, and frequency.

(4) Dampers - An inspection should be conducted when the boiler is out of operation. Shafts and blades are exposed to considerable stress due to high temperatures. Appropriate repairs should be performed to prevent possible leaking and assure free operation as intended.

(5) Reports - All repairs involving the magnitude outlined above should be recommended by the boiler inspector during inspections. Major repairs should be reported to the Area facilities engineer before the work is contracted.

2-10 CONTROL OF EXPLOSION HAZARDS

A. FLAME FAILURE CONTROLS - Flame failure controls (combustion safeguards) are intended to prove the presence of a flame. They are installed to shut off fuel supply in the event of flame failure and to prevent ignition under unsafe and dangerous conditions. Flame failure controls are not intended to relieve operators of the important duty of careful operation according to prescribed posted instructions and of proper attention to these devices.

B. FLAME FAILURE TESTS - Tests of flame failure controls, as specified by the manufacturer, must be conducted by boiler operators. These tests will be made weekly on boilers in operation and immediately prior to lighting of boilers that have been out of operation. Records must be kept of these tests showing date of test, type, name of employee performing the test, and the facilities manager's initials certifying that the test was performed. The documentation should be maintained in the facilities engineering office.

C. RECOMMENDATIONS FOR CORRECTION - Corrections to existing controls must only be approved by the manufacturer of the equipment or written authorization secured by the facilities manager from the manufacturer. Until correction is made, due precautions must be taken to ensure safe operation. The Area facilities engineer will be notified before any modifications are contemplated. The procedures recommended by the manufacturer will be the sole criteria to follow.

2-11 HYDROSTATIC TESTS

Hydrostatic tests will be performed only after a tube replacement or when the integrity of any portion of the pressure parts or the boiler

is in doubt. Licensed boiler inspector's are the only authorized individuals to determine the requirement and perform the test.

2-12 FUELS

A. OIL FIRED BOILERS - Storage capacity of sufficient size to meet the maximum demand of continuous operation for a period of 30 January days should be on hand at each installation.

B. NATURAL GAS FIRED BOILERS - Natural gas fired boilers with oil as a back-up fuel should normally maintain a back-up supply to meet the maximum demand of continuous operation for a period of 20 January days.

C. GAS FIRED (PROPANE) BOILERS - Storage capacity of sufficient size to meet the maximum demand of continuous operation for a period of 30 January days should be on hand at each installation.

UNDER NO CIRCUMSTANCES SHOULD FUEL STORAGE BE KEPT AT LESS THAN HALF CAPACITY. PROCUREMENT SHOULD BE IMMEDIATELY INITIATED WHEN IT REACHES THE HALF LEVEL.

2-13 PREVENTIVE MAINTENANCE

Conducting a basic preventive maintenance program on your boilers can help you to minimize boiler plant problems.

The following steps should help you to avoid future problems:

A. DAILY

(1) Blow down the boiler regularly depending on the local conditions of the water supply at your installation. Use the contractor furnishing you with the boiler water treatment chemicals as the source of determining the frequency of blow down if you do not have the expertise to make the decision. You can also consult your boiler manufacturer or operators manual for your particular model.

(2) Blow out scum on the water's surface by surface blow down if your boiler is equipped for this.

(3) Blow down the water column at least twice daily by opening the water column drain for about 4 seconds to keep the control free of sludge and sediment that cause control failure. Blowing down the low water control with the burner operating on low fire will test its operation.

(4) Keep the boiler room clean every day. Dust, lint, and grit often cause improper operation of boiler controls.

(5) When starting a boiler, always make sure that you go through its correct starting cycle as recommended by the manufacturer.

B. MONTHLY

(1) Clean all electrical controls and check all starter contacts, but **MAKE SURE THAT THE MAIN SWITCH IS PULLED BEFORE ATTEMPTING THIS WORK.** Always keep the control cabinet's door shut when you are not servicing the electrical controls.

(2) If the boiler is an oil fired unit, clean the fuel strainer. Do this more than once a month, if conditions require it. Clean the strainer as often as needed depending on the source of the oil you use. Your source of oil sources vary from one shipment to another. The frequency may also depend on the last time that you cleaned out your oil storage tank. When closing the fuel strainer's body make sure that the gasket is not torn. Replace if in doubt.

(3) Clean the water strainer, and check the water pump's packing (or seal) for leaks. Check the torque on your pump and motor hold down bolts.

(4) If the boiler is an oil fired unit, remove the nozzle assembly out of the burner head. Clean the nozzles with a wood toothpick and/or soak them and the screens in a good solvent. You should check with manufacturer for a recommendation for the type of solvent that is compatible with your burner and components.

(5) Inspect the ignition electrodes to see that the spark gap is set properly and the assembly is clean.

(6) Check the condition of the steam traps (if you have steam generating boilers) in the condensate return system. Leaking traps waste steam and can cause vapor lock due to an increase in the return condensate temperature.

(7) Remove the plugs from the cross connection below the water level control, and clean any sediment out of the water leg and float

(8) Clean the air intake air-intake on the screen on the blower. Check the blower's fan wheel and clean the vanes at least monthly or more often if necessary.

(9) Check and clean the air hole in the gas regulator. If a barometric draft control is used, check to see that it's operating freely.

(10) Check the front breeching, rear cover plate, rear door and burner mounting flange, torque the nuts and replace gaskets if required. Allowing high temperature leakage to occur at this location can cause serious damage. Check for leakage only when the burner is in operation, preferably when it is in the full fire mode.

(11) Check all burner linkages to ensure that adjustments are locked in place and that the burner operates freely. Mark adjustments so that the proper settings can be duplicated if the linkages slip.

2-14 BOILER PLANT LOG

A. Each boiler plant shall have a log for recording readings taken at least weekly and other information on the operation of the boiler equipment as recommended by the manufacturer.

B. Logs should state upper and lower limits of the parameters involved so that visual analysis can be accomplished during review.

C. The facilities manager should review the log at least weekly and initial it certifying a review. Action resulting from log interpretation should be accomplished immediately or scheduled as soon as practicable.

CHAPTER 3 - AIR CONDITIONING

3-1 INTRODUCTION

Demands for conditioning of air to achieve certain specific parameters within a facility have made it necessary to install air conditioning in at least certain designated areas. The systems installed may vary from central systems for the entire building, to scattered packaged units for particular areas. Air conditioning systems deserve periodic care the year round, not just the customary spring and fall checkups at the time the system is started up or shut down. In far too many cases, however, inspection and maintenance are performed only when a breakdown occurs, at the time the system is started up or at the beginning of each hot weather period.

3-2 COMPONENTS

A. OUTSIDE AIR INTAKES - Outside air intakes should be examined at the time of inspection of the ducts. Among the things to look for are accumulation of combustible material and the condition of the automatic damper.

B. DUCTS - Ducts should be inspected semi-annually to determine the amount of dust or waste material in the ductwork (intake and discharge) and the cooling and heating coils should be cleaned. The amount of work involved and the severity of cleaning depends on the nature of the area serviced and the environmental conditions exterior to the systems. Scraping, brushing and painting sometimes are necessary. Vacuum cleaning at times is not the sole solution.

C. PLENUM CHAMBERS - Chambers should be inspected at least semi-annually. The frequency, however, may be varied to suit the local conditions.

D. FILTERS - Filters should be cleaned or replaced when the air flow resistance is five times greater than the original resistance at the time of installation. To ascertain this, all systems should have a draft gauge installed to facilitate the decision. Disposable filters should never be cleaned and reused. Dirty filters that reduce air flows can cause coil freeze up.

E. FIRE DAMPERS - Dampers should be inspected and tested at least once a year. Verify that they move easily and seal the ductwork appropriately when in the closed position.

F. COILS - Special care must be exercised to prevent the freezing of water in the preheat, reheat, and chilled water coils. Freezing can occur even if the unit is not in operation. Recommendations from the manufacturer should be followed regarding draining of water or use of an anti-freeze solution throughout the year.

3-3 REFRIGERATION EQUIPMENT

A. CHILLERS (Annually)

(1) An insulation resistance "megger" test of stator windings should be taken. Values below 50 megohms at an ambient temperature of 85°F (47°C) or less may indicate the presence of moisture in the windings and warrant manufacturer's consultation.

(2) Inspect the contacts in the magnetic starter for signs of deterioration.

(3) Check all line and load-side terminals for loose connections.

(4) Test control relays for proper timing sequence.

(5) Measure line voltage and ampere load for proper balance.

(6) Test motors that have been tripped by any of the protective devices. Do not start them until the windings have been tested and the motor starter circuits have been examined to determine the reason for the tripping.

B. RECIPROCATING COMPRESSORS

(1) Annually check the crankcase heater circuit for operation.

(2) Annually test the low pressure cut-off switch, which should be within the time delay rating and the pressure differential specified by the compressor manufacture if it fails, replace it.

(3) Every two years, or 10,000 hours, the cylinder heads should be removed for an examination of suction and discharge valves, valve springs and upper cylinder areas.

(4) Annually remove the crankcase cover plate and inspect the crankcase for metal particles that would indicate bearing.

(5) Every four years, or 20,000 hours, the connecting rods and piston assemblies should be removed to:

a. Check piston ring for wear.

b. Check connecting rod bearing surface for wear.

c. Perform dye penetrant tests on connecting rod yokes, caps, and bolts for fatigue cracks.

d. Check crankpin diameter for wear.

e. Remove the oil pump for examination.

C. CENTRIFUGAL COMPRESSORS

(1) Annually test all operating controls and safety devices to determine if they function properly at the settings specified by the compressor manufacturer.

(2) Every five years, or 40,000 hours, the compressor should be disassembled for an examination.

a. Examine the impellers by non-destructive testing for cracking in highly stressed areas.

b. Examine the area under the labyrinth seal for grooving.

c. Look for evidence of the impeller rubbing the casing, indicating excessive thrust clearance.

d. Clean impellers by vapor blast (solvent) prior to dynamic balancing.

e. Examine the guide vanes for fatigue cracking by non-destructive testing. Inspect the guide vane bushings and linkage for lost motion, wear and sticking vane system.

f. Examine the main shaft, pinions and speed increaser gears by non-destructive examination.

g. Check all bearings for wear tolerance.

h. Drain and clean the oil sump and test the cooler for leaks; examine the oil pump for wear.

D. CENTRIFUGAL PACKAGED SYSTEMS

(1) Annually, test all system controls and safety devices to determine if they function properly at the settings specified by the manufacturer. These include thermostatic controls, flow switches and pressure controls.

(2) When provided, a purge unit should be overhauled at least once each year with interim service checks performed as recommended by the manufacturer.

(3) Test all system joints for leaks every year. Refrigerant will be lost through leaks at pipe joints in high pressure systems, or air will be drawn into the system where low-pressure refrigerants are used.

(4) Every ten years, examine the chiller and condenser tubes by eddy current analysis.

E. ABSORPTION MACHINES

(1) For lithium bromide machines over 100 tons (106 t), an annual inspection of the solution should be done to determine the presence of corrosion products and to determine the chemical balance of solution inhibitors.

(2) All operating controls and safety devices should be tested to determine if they function properly at the settings specified by the manufacturer.

(3) Every three years the solution pumps and motors should be disassembled for an examination of bearings, seals, and impellers.

(4) Every five years, all tubes should be examined by eddy current analysis to detect deterioration that could lead to tube failure.

F. RECIPROCATING PACKAGE UNITS

(1) Annually, test all system controls and safety devices to determine if they function properly at the settings specified by the manufacturer. These include thermostatic controls, flow switches and pressure controls.

(2) Check the super heat setting of the thermal expansion valve(s) at both low and full load.

G. GENERAL RECOMMENDATIONS (All compressors)

(1) When the compressor system is pumped down, the compressor should be valved off, thus preventing any loss of refrigerant through the compressor.

(2) If the compressor is belt driven, the motor should be shifted towards the compressor to loosen the tension on the belts. This prevents the belts from taking a "set." In the spring when the compressor is being readied for the

summer season, the belt drive should be adjusted so as to give the proper tension. This is a good time to check belts for replacement.

(3) If the compressor and motor are connected by a drive coupling, the coupling should be examined for tightness and wear.

(4) The drive motor should undergo annual cleaning; if it uses ball bearings, the grease should be removed and replaced.

H. WATER COOLED CONDENSERS

(1) Annually, in the fall, drain and check for scale and mud. Clean water-cooled condenser tube for optimum heat transfer to prevent high head pressure when the unit is in service.

(2) If the condenser is located in an area where subfreezing conditions are experienced, water should not be allowed to remain in the condenser, in the supply lines, or in the fittings.

(3) After ten years, examine tube and shell type condensers by the eddy current analysis method.

3-4 TOWERS AND EVAPORATING CONDENSERS

A. MAINTENANCE

(1) Cooling Towers (Annually)

* Check and clean wet deck. Remove all debris and dispose of properly.

* Inspect and clean protective finish inside and out. Look for signs of spot corrosion. Clean and refinish any damaged coating.

* Pressure wash, if possible, tower structure (depending upon condition and type of elements).

* Change oil in gear box.

* Check structure for deterioration. Tighten fasteners as required.

* Inspect motor, belts, etc., for proper operation.

* Check alignment of gear, motor, and fan.

* Lubricate all bearings. Remove old or excess lubricant.

* Check eliminator for buildup and clean if needed.

* Check water distribution. Adjust and flush out troughs if necessary.

* Check fans and air inlet screens and remove any dirt or debris.

* Check nozzles for clogging and proper distribution.

* Inspect keys and keyways in motor and drive shaft.

* Check water treatment equipment.

(2) Evaporative Condensers (Annually)

* Remove dirt, trash, algae from water pans and flush.

* Check water pans and paint if necessary.

* Check water outlets, spray nozzles and coil connections, flush and clean.

* Change oil in gear reducer.

* Check fan and pump and lubricate as required.

* Check gear box, bearings and alignment.

* Check drive shafts.

* Check control and float valves.

* Inspect eliminators and unclog if necessary.

* Inspect condenser coil, fins, sprays, and connections. Clean if scale has formed.

* Check air intake screen, flush and clean.

* Check water treatment equipment.

* Check motors and starters.

* Check structural fittings.

* Continuous bleed line should be open.

* Drain and flush out thoroughly.

* Clean chemically, and neutralize.

When shutting down for the season, all points should be examined for low spots where water might collect and freeze, thus causing breakage. Piping should be disconnected to permit venting and complete drainage. When water is drained from the pumps, they should be protected from corrosion while idle. Whenever drive belts are used, they should be stored indoors during the winter.

B. Treatment Programs

(1) Cooling tower water should be analyzed by a competent chemist, who should recommend the kind of treatment required to make it suitable for tower use. A follow-up analysis should be conducted no less than every two years.

(2) Tower water should be tested daily after receiving instruction from the chemist.

(3) Treated water cannot be introduced effectively by a one-shot method. Proper treatment should be applied by a proportioning system. In this way, the tower receives constant treatment.

C. Test Equipment and Supplies

Obtain the necessary equipment, supplies, handbooks and procedures to conduct an appropriate in-house treatment program. Do not rely on a monthly visit by the chemical company vendor.

D. Samples and Tests

Each facility will test the cooling tower water daily for blowdown control. Chemical concentrations will be maintained at proper levels at all times the units are in operation.

E. Hazardous Chemical Identification

Each facility must verify that the chemicals being used for water treatment and their disposal conform with local and EPA or State regulations. Consult with your local EPA or State Office of Environmental Quality for assistance.

3-5 FANS (Annually)

* Check blades for dust buildup and clean if necessary.

* Check fan blades and moving parts for excessive wear.

* Check fan RPM to design specifications.

* Check bearing collar set screws on fan shaft to make sure they are tight.

* Check dampers for dirt accumulations. Check felt, repair or replace as required.

* Check damper motors and linkage for proper operation. Adjust linkage on vanes if out of alignment.

* Lubricate sparingly mechanical connections of dampers.

* Clean coils by brushing, blowing, vacuuming, or pressure washing.

* Check coils for leaking and tightness of fittings.

* Use fin comb to straighten coil fins.

* Flush and clean condensate pans and drains.

* Check belts for wear, adjust tension or alignment, and replace belts when necessary. Multi-belt drives should be replaced with matched sets.

* Check rigid couplings for alignment on direct drives, and for tightness of assembly. Check flexible couplings for alignment and wear.

* Before heating season: Drain cooling coils, blow down to remove moisture; refill with anti-freeze and water solution. (Use solution in other coils.).

* Check freeze-stat for proper operation.

* Vacuum interior of unit.

* Lubricate fan shaft bearings while unit is running. Add grease slowly until slight bleeding is noted from the seals. Do not over lubricate. Remove old or excess lubricant.

3-6 CONTROLS AND ACCESSORIES

A. In a system using a control air compressor, the following should occur at least quarterly:

(1) Replace the intake filter.
(2) Change oil.
(3) Adjust belt tension.
(4) Clean strainers and oil filters.
(5) Check control operation.
(6) Drain air tank.

B. Control motors, damper operators and actuators should be inspected and lubricated at least semi-annually. All contact points in switches, thermostats and starters should be inspected and cleaned annually.

C. Check the unit over its range of control. If possible, simulate conditions to activate controls and check operation.

D. Check set point of controls.

E. Note the action of the controlling device (thermostat, humidistat, pressure stat) which arranges the controlled device (motor, valve, damper, etc.)

3-7 OIL AND REFRIGERANT ANALYSIS

A. Periodic analysis of oil and refrigerant samples is important predictive maintenance technique that can reveal information on the condition of chiller equipment.

B. Metal particles in the oil may indicate mechanical wear. An increase in the amount of tin may mean the chiller is experiencing babbitt bearing wear or bearing corrosion. High copper levels can indicate corrosion in evaporator or condenser tubing, or oil pump bearing wear. A close analysis of the oil itself can reveal oil degradation.

C. Analysis of refrigerant can detect excessive amounts of moisture, acidity, and rust, which could accelerate the corrosion of chiller components, and reduce efficiency.

D. If moisture is present, it can combine with the refrigerant to form hydrochloric acid, which will attack the metal surfaces in the chiller.

E. Analysis of oil and refrigerant should be completed by a laboratory familiar with the testing of chiller fluids; results

should be interpreted by trained professionals. Samples should be collected carefully, according to standards outlined and defined by the laboratory and the chiller manufacturer.

F. Most manufacturers recommend that an oil sample be analyzed annually, and that the filter be replaced (and sent for inspection) at the same time. Refrigerant analysis should be done whenever excess rust or other contaminants are suspected in the refrigerant system.

3-8 OPERATING LOGS

A. Operators will maintain a daily log with entries recorded at the beginning of a shift, halfway, and at the end of the shift. Specific log sheets should be obtained from the manufacturer.

B. At the very least, the log should contain motor voltage, current and power; oil condenser and evaporator temperatures and pressures; and cooling tower temperatures.

C. The facilities manager should review the logs at least weekly and initial them certifying a review. Actions resulting from log interpretation should be accomplished immediately or scheduled as soon as practicable. Logs should state upper and lower limits so that visual analysis can be accomplished during review.

CHAPTER 4 - FIRE PROTECTION SYSTEMS

4-1 INTRODUCTION

Maintenance of fire protection systems is extremely critical. The decision to install the systems in the first place was made based upon judgement that the areas they protect were essential and could not be dispensed for long periods of time. It is highly recommended that these systems be contracted out for maintenance as the majority of the work that involves knowledge and tools which are not readily available in Indian Health Service (IHS). Shortage of staffing to perform maintenance cannot be allowed to have the systems receive less than adequate maintenance. Since fire protection systems are not generally used on a routine basis, their state of readiness is not obvious. However, when they are called upon to perform, there is an emergency at hand and they must work properly the first time. There is not time to perform maintenance or repairs during the emergency.

4-2 FIRE ALARM SYSTEMS

A. DESCRIPTION - A fire alarm system provides audible and/or visual alarm signals as a result of manual or automatic operation of components of the system. Audible or visual alarm devices (bells, horns and lights) are known as signaling devices. Initiating devices (duct detectors, smoke detectors, water flow/pressure switches, heat detectors, pull boxes) sense or activate and trigger the fire alarm operation. Devices are connected to an alarm panel by electrical wiring to create a system. An electric current is imposed on the circuitry to supervise it for continuity. If the current is not received at the panel due to failure of a device (disconnection) or break in the connection (wire) a trouble alarm is initiated. Trouble alarms do not activate the fire alarm throughout the building. the trouble alarm is only received at the central console or annunciator panel. This is the reason that the fire alarm needs to be monitored 7 days a week, 24 hours per day.

(1) Type - Three methods are used to transmit a signal throughout a building when the fire alarm is activated.

a. Voice - Devices are "hard wired" within the building and signaling devices (bells and horns) may or may not be present. However, a speaker system with amplifiers and antennae throughout the building is used to communicate to the occupants the location of the fire, the need to evacuate and in which direction to evacuate.

b. Radio - Devices are "hard wired" within the building but the signal to transmit the alarm to the central station or fire department is by air waves.

c. Telegraphic - Devices are "hard wired" within the building. A coded transmitter at each building is connected by wire to a central receiving station. Each building has a specific code which identifies the fire location. Annunciator panels located at each building indicate the exact location of the alarm within the building.

(2) Function - Three methods are commonly used to notify occupants of a building when a device is activated. Alarm signals can be continuously ringing, march time or coded. continuously ringing and march time will ring until the alarm panel is reset. Code signals will ring usually for three or four rounds and stop. However, the alarm panel still needs to be reset.

a. General Alarm - In this method all alarm indicating devices are activated simultaneously throughout the building.

b. Selective Alarm - In this method only the alarm indicating devices in a particular floor are simultaneously activated.

c. Pre-signal - In this method only the central control panel receives a signal. In this method someone must go to the building to locate the fire.

B. INSPECTIONS

(1) Monthly

a. Visually check all fire alarm equipment to make sure nothing is damaged or inoperative.

b. Illuminate lamps and light emitting diodes (LED's) on fire alarm and annunciator panels.

c. Check water level of batteries if that is the secondary source of power.

(2) Semi-annually

a. Remove fuses and check ratings.

b. Check voltage of each battery cell.

C. TESTS

(1) Monthly

a. Operate a device on each initiating circuit. Each device tested should be operated in its normal manner, except break glass rods which may be removed from manual stations. Record the specific device tested on each initiating circuit so that different devices can be used in subsequent tests.

b. Listen to all signaling (indicating) devices and record the location of any which are inoperative.

(2) Annual

a. Test the supervisory device circuit by disconnecting a conductor from its terminal in the control panel. Once a trouble signal is received, reconnect the wire to its terminal and reset the control panel. Repeat the test for all supervised circuits.

b. Test the primary power supply during the test for initiating and signaling device circuits. Disconnect the primary power and make sure the fire alarm system performs normally using the secondary source of power.

D. MAINTENANCE - Perform maintenance on any component which fails to operate properly during tests. Repeat any necessary test after repairs are completed.

4-3 SMOKE DETECTORS

A. DESCRIPTION - Smoke detectors are devices wired into the fire alarm initiating circuits to automatically detect fire by sensing smoke particles.

(1) Type

a. Ionization - Contain a small amount of radioactive material that ionizes the air in the sensing chamber. The chamber conducts electricity through the air between two charge electrodes. When smoke particles pass by the electrodes they decrease the conductance of air. the detector is calibrated to sense a fixed

level of conductance. When the preset amount is decreased an alarm is initiated.

b. Photoelectric - One method works on light obscuration. That is, a light constantly strikes a photoelectric device. Smoke particles in the chamber prevent the light from striking the photoelectric device. This failure causes an alarm initiation. Another method works on light scattering. Light constantly is emitted but is not aimed at the photoelectric device. When smoke enters the chamber the light strikes the smoke particles and some light will be scattered and caused to strike the photoelectric device. This will cause an alarm initiation.

(2) Function

a. Walls/Ceiling - These smoke detectors are mounted on walls or ceilings and are meant to close doors within smoke compartments in buildings, upon initiation of an alarm.

b. Duct - These smoke detectors are manufactured for use in ventilation ductwork. These detectors are meant to shut down the air handling system to prevent recirculation of smoke in a building.

B. INSPECTIONS - (Monthly)

Check for damage or obstruction due to location too close to a source of air draft or removal resulting from remodeling projects since the last inspection.

C. TESTS (Semi-annually)

Testing consists of either spraying the detector with a test aerosol into the detector chamber; or using smoke produced from a burning cigarette or similar smoke source.

D. MAINTENANCE

(1) All smoke detectors must be calibrated annually. This requires the use of a sensitivity instrument to be used in accordance with the manufacturer's instructions. Record the operating sensitivity and serial number for each detector. If sensitivities are stable from one year to the next, conduct re-calibration every second year instead of annually, but document in writing the reasoning for the deviation.

(2) Smoke detectors (ceiling and duct) require periodic cleaning to remove accumulated dust, grime or dirt. The frequency or cleaning is totally dependent on the environment (i.e. construction) to which the detector was exposed since the previous inspection. Perform maintenance on any component which fails to operate during test. Repeat necessary tests after repairs are completed.

4-4 HEAT DETECTORS

A. DESCRIPTION - Heat detectors are devices wired into the fire alarm initiating circuits to automatically detect fire by sensing heat.

(1) Type

a. Fixed Temperature - These consist of a detector housing containing a fusible element that melts rapidly at a predetermined temperature. The element melting causes electrical contacts to operate, which in turn initiate an alarm.

b. Rate of Rise - These consist of a detector housing with a diaphragm that operates electrical contacts. Heat from fire causes the air to expand within the detector, causing the diaphragm to move the contacts and initiate an alarm.

c. Rate of compensation - These consist of two internal metallic elements which expand towards each other when heat is detected. Upon touching, electric contacts initiate an alarm.

B. INSPECTIONS - (Monthly)

Check for damage or obstruction.

C. TESTS

(1) Every 5 and 15 Years

a. Fixed temperature cannot be tested by application of heat because once heat is applied they must be replaced. They are tested by using an insulated electric wire to jumper across the contacts on the base of the detector unit. The detector must be removed from its electrical outlet box to perform this test.

b. Every 15 years and every 5 years thereafter, two detectors for every 100 fixed temperature detectors in the system must be removed and laboratory tested. If they both fail then all detectors must be replaced. If they pass only the tested ones must be replaced. If one fails, either test some additional detectors or replace all existing detectors.

c. Rate of rise and rate compensation can be tested using a hair dryer or heat lamp. If the detector contains a fixed temperature element in addition to the rate of rise feature, remove the heat source element immediately after the rate of rise operates. If it is not removed, the fixed temperature element might melt and will have to be replaced. Ten percent of all detectors must be tested semi-annually so that all detectors are tested within a five year period.

D. MAINTENANCE - Perform maintenance on any component which fails to operate during tests. Repeat necessary tests after repairs are completed.

4-5 MANUAL STATIONS, CHIMES, BELLS, AND HORNS

A. DESCRIPTION - Manual stations with chimes, bells, or horns are common to all fire alarm systems. Manual stations are electric switches covered with a red-colored housing and located near exit or stairwell doors. They are wired to alarm initiating device circuits.

(1) Chimes - Normally used to generate the audible signal to alert staff of the presence of fire.

(2) Bells or Horns - Normally used to generate loud audible noises in areas where there is much background noise which could overshadow chimes. (i.e. boiler rooms, printing rooms, laboratories)

(3) Visual - For the hearing impaired a light is wired to the chime/bell to blink on and off when an alarm is initiated.

B. INSPECTIONS (Monthly)

(1) Check all manual stations for damage or obstruction.

(2) Check all chimes, bells, horns for damage or obstruction.

(3) Check all visual lights for damage or obstruction.

C. TESTS - (Semi-Annually)

(1) Manual Stations - Operating tests consist of pulling the face of the station in the manner indicated on the device. Some stations have a "break glass" feature which consists of a piece of glass rod within the station. After operating, the glass rod needs to be replaced. The face of the station with non-coded manual alarms needs to be opened to reset the station. Resetting is accomplished by use of a key, screwdriver or allen wrench.

(2) Chimes, Bells or Horns - Tests consist of initiation of the nearest manual station. Most have an adjustment screw for varying the striking force that causes the audible sound.

D. MAINTENANCE - Perform maintenance on any component which fails to operate during tests. Repeat necessary tests after repairs are completed.

4-6 WATER SUPPLY SYSTEMS

A. DESCRIPTION - These systems include the methods used to store, move and increase the pressure of water supplies for fire protection. System components include water mains, fire department siamese connections, gravity tanks, suction tanks, ground level tanks, ponds, pressure tanks, and hydrants.

(1) Water Mains - Normal connection is fed from domestic water supplied through the use of fire hydrants.

(2) Siamese Connection - This system involves a double 2 ½ inch outlet outside the building which is connected to the standpipe or automatic sprinkler system. The fire department can pump water using their fire truck pumper to boost the water pressure needed in the building.

(3) Gravity Tanks - Consist of an enclosed storage tank elevated some distance above the highest floor level being supplied with water. The tank is filled with domestic water, with pumps connected to a float system in the tank.

(4) Suction/Ground Level Tanks and Ponds - Consist of water that requires a fire pump to furnish the water due to their elevation relative to the building being served.

(5) Pressurized Tanks - Consist of tanks approximately 2/3 filled with water and 1/3 air at about 75 psi. A compressor system maintains air pressure modulation.

(6) Hydrants - Devices connected to water mains used in directing water through the hydrant to fire department hoses, and apparatus in order to disburse water as needed. Measure the pressure.

a. Dry Barrel - This type of hydrant has its control valve below the frost line. They are commonly called "frost proof" hydrants. Although connected to a water main, it normally has no water in the barrel. To activate, an operating nut at its top must be rotated to open a valve at its base.

b. Wet Barrel - Sometimes used where there is no danger of freezing. They have a compression type valve at each outlet.

B. INSPECTIONS

(1) Weekly

a. Check air pressure in pressure tanks.

b. Check water level in storage and pressure tanks.

c. Check control valves to assure they are properly arranged (generally open).

(2) Annually

a. Check accessibility of fire department siamese connections.

b. Check that caps are provided for fire department connections.

c. Check that fire department hose threads are in good condition.

d. Check that automatic ball drips on fire department connections are operational.

e. Check general condition of water storage tanks, including loose scale and leaky seams or rivets.

f. Check ladders on water storage tanks for structural adequacy and the presence of rust.

g. Check the roofs of storage tanks for structural stability and the presence of rust.

h. Examine sway bracing of elevated water storage tanks for structural adequacy and the presence of rust.

i. Inspect condition of paint for water storage tanks.

j. Inspect elevated storage tank columns and pits to keep them free of dirt, rubbish and trash.

k. Inspect the condition of paint on pressure tanks.

l. Have interiors of pressure tanks inspected by a qualified pressure-vessel inspector.

m. Check the heating system for water storage tanks within two months before the start of the heating season.

(3) Hydrants

a. Semi-annually - Dry barrel fire hydrants

Perform the following inspections:

* Check for tightness of hydrant outlets.

* Check for leaks in top of hydrant.

* Check for leaks in gaskets under caps.

* Check for cracks in hydrant barrel.

* Check hydrant drain.

* Inspect operating nut for wear or rounded corners.

b. Annually - Wet barrel fire hydrants

Perform the following inspections:

* Check for tightness of hydrant outlets.

* Check for leaks in top of hydrant.

* Check for leaks in gaskets under caps.

* Check for cracks in hydrant barrel.

* Check hydrant drain.

* Inspect operating nut for wear or rounded corners.

* Inspect nozzle threads for damage.

C. TESTS - Flow tests need to be conducted annually. They should be recorded and compared with previous test to make sure that equipment is performing properly and that all valves are in the position that they are required. (open or closed)

D. MAINTENANCE - Perform maintenance on any component which fails to operate properly during tests. Repeat any necessary test after repairs are completed.

4-7 FIXED DRY CHEMICAL EXTINGUISHING SYSTEMS

A. DESCRIPTION - These systems are primarily utilized for protecting against fires involving kitchen cooking equipment. the system has a canister of dry chemical stored under pressure 374 kPa/cm^2 (350 psi) by a gas carbon dioxide or nitrogen connected to fixed piping. Nozzles above the cooking area and/or inside the exhaust ductwork above the grease filters involves melting of a fusible link which is tied to a cable enclosed in piping which triggers the canister to discharge. A manual release remote from the cooking surface is required in addition to the automatic activation. Gas or electric valves are interlocked with the fire alarm to shut the fuel source upon activation.

B. INSPECTIONS

(1) Weekly

a. Check the nozzle cap-if the system is designed to have caps- to make sure they are in place

b. Check to make sure that grease is not accumulating on the fusible links and nozzles.

c. Check to make sure that corrosive cleaning solutions are not being used on links, cable or nozzles.

d. Check to see if any new cooking equipment has been added or existing equipment relocated.

e. Check to make sure that nozzles are still aiming at the surfaces they are designed to protect.

f. Check to make sure the connection for the gas or electric shutoff is interlocked with the fire alarm to shut the fuel source upon activation.

(2) Semi-annually

a. If the dry chemical agent is stored in a pressurized cylinder, check the pressure.

b. If the system has a separate expellant gas cartridge, check cartridge for proper operation. For nitrogen cartridges, this requires checking of pressure. For carbon dioxide cartridges, this requires weighing the cylinder and comparing it with the manufacturer's minimum.

(3) Annually - Check the dry chemical agent for lumping or caking in systems having a separate expellant gas cartridge. If lumping or caking is noted, discard and replace the dry chemical agent.

C. TESTS

(1) Annually - Conduct an activating test of the system with the chemical agent disconnected.

(2) Every 6 years - Discharge test of the system.

(3) Every 12 years

Hydrostatic test of the following:

a. Dry chemical chambers

b. Auxiliary pressure containers

c. Valve assemblies

d. Hoses and fittings

e. Check valves

f. Directional valves

g. Manifolds

D. MAINTENANCE - Perform maintenance on any component which fails to operate properly during tests. Repeat necessary test after repairs are completed. Replace fusible links semi-annually.

4-8 PORTABLE FIRE EXTINGUISHERS

A. DESCRIPTION - Fire extinguishers are rated by the type of fire on which they are intended to be used. fire types are classified as follows:

(1) Type

a. Class A - Ordinary combustible material which requires the heat absorbing effect of water, the coating effect of certain dry chemicals or the interruption of the combustion reaction as in halogenated agents.

b. Class B - Fires in flammable liquids, gases, greases or similar materials which can only be put out by excluding air, inhibiting the release of combustible vapors or interrupting the combustion chain reaction.

c. Class C - Fires in electrical equipment where there is a potential for shock hazard. Agents used for fighting the fire must be nonconductive.

d. Class D - Fires in certain combustible metals (magnesium, sodium, etc.) which require heat absorbing extinguishing mediums that do not react with the burning metal.

(2) Function

a. Stored Pressure Water - Available in various sizes with a rating for class A fires.

b. Carbon Dioxide - Available in various sizes in hand portable units or wheeled units with a rating for class B and C fires. Can be used in unheated locations.

c. Dry Chemical - Available in 1 to 30 pounds for hand portable or 125 to 250 pounds for wheeled units using the stored pressure type expellant. Cartridge operated expellants are available in 4 to 30 pounds for hand portable or 45 to 350 pounds for wheeled units. this type can be used for class B and C or A, B and C depending on the type of agent used for the dry chemical.

d. Halon - Available in 2 to 22 pounds for stored pressure type and a class rating or B and C or A, B, and C.

e. Foam - Available in various sizes with a rating for class A or B. They must be located in a heated environment.

B. INSPECTIONS

(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, check to make sure 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 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 pressure or can just have a zone indicating "normal." If the indicator is not in the normal range, the extinguisher should be removed and recharged.

C. TEST - All refillable fire extinguisher require hydrostatic testing at intervals varying according to the type of extinguisher. The frequency is outlined below.

Type	Frequency (Years)
Storage Pressure	5
Carbon Dioxide	5
Dry Chemical	12
Halon	12
Foam	5

D. MAINTENANCE - Maintenance should include a thorough examination of the extinguisher's mechanical parts, the extinguishing agent and the expellant means. See NFPA 10, Appendix A for detailed procedures for each type of extinguisher.

4-9 FIRE DOORS AND DAMPERS

A. DESCRIPTION

(1) Fire Doors

a. Fire doors are used to protect opening in fire rated partitions and walls. Only labeled fire doors and frames and listed or labeled hardware should be used, as they have passed tests confirming that they will withstand a standard fire exposure for a specified time.

b. Doors are now referred to by their hourly rating. Formerly, a combination of the alphabet letter and an hourly rating was used. the alphabetical designation referred to the type of opening and not the opening protection (door). See definitions in NFPA 80, Standard for Fire Doors and Windows.

The hourly ratings for fire doors are:

* 3 Hour Fire Doors: Doors used to protect openings in walls separating buildings or dividing a building into separate fire areas.

* 1 ½ Hour Fire Doors: Doors used to protect 2-hour vertical enclosures. These doors can also be used to protect openings in walls having a 2 hour fire resistance.

* 1 Hour Fire Doors: Doors used to protect openings in 1 hour vertical enclosures.

* 3/4 Hour Fire Doors: Doors used to protect openings in 1 hour rated walls and partitions (expect for vertical openings), and openings in exterior walls subject to moderate or light fire exposure from outside.

* ½ Hour (30 minute) and 1/3 Hour (20 minute) Fire Doors: Doors used to protect openings in corridor walls to specified circumstances (refer to NFPA 101, Life Safety Code, or local building code for permitted uses) and doors used for smoke control.

c. Fire doors are generally kept closed to protect the opening at all times (self-closing). However, some codes do permit doors to be maintained open but to close automatically upon activation of smoke

detectors, the building alarm system, or fusible links (automatic closing). Fusible links are generally used to hold open sliding doors used to protect openings in fire walls. fusible links are not permitted on doors to exit stairs and other doors in the means of egress.

(2) Fire Dampers

a. A fire damper is installed in an air distribution system to close automatically upon detection of heat, to interrupt migratory air flow, and to restrict the passage of flame. Fire dampers are usually held open by a listed fusible link or other approved heat actuated device located where readily affected by an abnormal rise of temperature in the duct.

b. Fire dampers are tested and listed by Underwriters Laboratories Inc. for use in air conditioning and ventilating ducts in accordance with the Standard for Fire Dampers, UL 555.

The hourly fire resistance ratings are as follows:

* 3 Hour Fire Dampers: Used for the protection of openings in fire walls, or of walls and partitions having a fire resistance rating of 3 hours or more.

* 1 ½ Hour Fire Dampers: Used for the protection of openings in fire walls, or of walls and partitions having a fire resistance rating of less than 3 hours.

(3) Smoke Dampers

a. Smoke dampers are special dampers designed to resist the passage of smoke. They must be listed by Underwriters Laboratories Inc. in accordance with UL 555S, Leakage Rated Dampers for Use in Smoke Control Systems.

b. Combination fire and smoke dampers must meet the requirements for both, resisting the thermal effects of fire as well as the passage of smoke.

C. INSPECTIONS

(1) Annually

a. Doors - Doors should be inspected periodically to make sure that all parts are operating properly. The frequency of these inspections will vary depending on each door's location and frequency of use; however, all doors should be inspected at least annually.

These visual inspections should include:

* Door - The door is not damaged and the vision panel is intact and firmly mounted in the frame.

* Closer - The closer works properly to completely close the door with sufficient force to make it latch.

* Latch - The latch is properly aligned and will maintain the door closed.

* Hinges - The hinges are securely attached to the door and frame.

* Coordinator - Coordinators on double doors are securely attached and adjusted properly to allow the first leaf (inactive leaf) to close before the second leaf (active leaf). This is checked by completely opening both doors and releasing them.

* Tin clad and calamine doors should be regularly inspected for dry rot.

* Chains and cables used on sliding and suspended doors should be checked for excessive wear and stretching.

b. Dampers

Inspections should include:

* Verify that dampers do not bind and will close freely.

* The correct fusible link is installed and wire is not used to hold open the damper. (Note: Fire dampers are often shipped with the blades wired open, or the contractor will wire the damper open during construction.)

* Nothing will interfere with the closing of the damper.

D. TESTS - No specific tests are required.

E. MAINTENANCE (Quarterly)

(1) Fire Doors: Perform the following maintenance periodically as needed, depending on door use and location.

a. Guides and bearings should be kept well lubricated.

b. Doors normally held open by automatic closing devices should be operated to assure their proper operation. Sliding doors should be allowed to close completely to check the operation of the guides and rollers and to make sure the doors have adequate clearance to close completely.

(2) Fire Dampers (Annual) - Examine each fire damper. Inspect hinges and other moving parts to see that they are in good operable condition. Remove fusible links (where applicable), operate damper, check latch (if provided), and lubricate moving parts if necessary. It is desirable to operate dampers with normal system air flow to make sure they are not held open by the air stream.

4-10 AUTOMATIC SPRINKLER SYSTEMS

A. DESCRIPTION - A sprinkler system consists of a series of pipes with nozzles (sprinkler heads) located throughout a building. The system is divided into sections, each with its own flow switch "hard wired" to the fire alarm panel. When a sprinkler head is activated the flow switch senses the movement of water and sends a signal to the alarm panel. Each flow switch may have a code to identify the location of the sprinkler branch. Activation of heads occur when heat rising from the fire melts a solder link holding the water (wet system) or air (dry system) pressure and allows it to activate water into the fire. The water impinges on the sprinkler deflector to provide a spray pattern. Different heads have different temperature ratings and different spray patterns. Each sprinkler head discharges a fixed amount of water.

(1) Type

* Wet Pipe - this type has piping filled with water under pressure; therefore it should be use only in heated buildings maintained at 22 degrees Celsius or higher.

* Dry Pipe - this type has their piping filled with air under pressure keeping a valve closed which holds the water pressure back from flowing into the piping system. When a sprinkler held is activated the air escapes through the head relieving the pressure in the piping thus allowing the water to fill the piping and be released through the sprinkler heads that are activated. Dry pipe systems are therefore ideal where freezing temperatures are encountered or as a substitute to heating a portion of a building merely to install a wet pipe system. The master valve for dry systems must be installed in an area 40 degrees Fahrenheit or higher.

* Deluge - This type is similar to a wet or dry system except that sprinkler heads are opened (activated) with no solder link. This will allow water to flow immediately out of all heads when the control valve is opened. The control valve is normally closed and activated by another separate activation device (pull box/heat detector, etc.). Deluge system are used where large quantities of water are needed quickly to control a fast developing fire.

* Pre-action - This type is similar to the deluge except that the sprinkler heads are not in the open (activated) position. a pre-action valve is operated by a separate detection device. When heat activates the device, the pre-action valve opens and allows water to fill the piping system. Each sprinkler head must be individually activated to allow water to flow into the fire. Opening of the pre-action valve in essence converts the system to a wet pipe system.

B. INSPECTIONS

(1) Daily - Dry Pipe Systems

During freezing weather, the heated enclosure for the dry pipe valve should be checked to assure it is adequately heated.

(2) Weekly

a. All Sprinkler Systems

* Inspect control valves (if sealed).

* Water Supply valves, including post indicator and roadway valves, should be checked to assure that they are open.

* Inspect condition of sprinkler heads.

* Heads should be checked to make sure they are not damaged or blocked by storage and have not been painted or otherwise impaired. Note: An 18-inch clear space must be maintained below the sprinkler to assure an adequate discharge pattern. Attachment of 18 inch-long paper or plastic streamers to the sprinkler piping helps remind people working in storage areas of the minimum clear space requirement.

b. Dry Pipe Sprinkler Systems

* Inspect air pressure and water pressure gauges. Be sure that air and water pressures are within the normal range for that particular system.

* Record pressure readings. It is recommended that the normal pressure be noted on the gauge or a tag attached to it. A loss of pressure of more than 10 percent should be investigated.

(3) Monthly

a. All Sprinkler Systems

* Inspect fire department connections. Connections should be accessible and visible at all times. Caps or plugs should be in place and threads clean, undamaged and lightly lubricated with graphite. The connection should be drained through the ball drip from the check valve to assure it will not freeze.

* Inspect control Valves (if locked).

* Water supply valves, including post indicator and roadway valves, should be checked to assure that they are open.

(4) Quarterly

a. All Sprinkler Systems

* Determine dry pipe system priming water level by slowly opening the priming water level test valve.

* If only air escapes, close the test valve and add priming water. This is done by closing the lower

priming valve, opening the upper priming valve, and adding approximately 2 liters of water through the priming funnel. The upper priming valve is then closed and the lower priming valve opened, which allows the water to run into the dry pipe valve. Again, check the test valve. If water does not run out, repeat the procedure. When sufficient water has been added so that water drains from the test valve, allow it to drain until air begins to escape, then close the valve securely. also be sure that upper and lower priming valves are closed securely.

(5) Every Five Years - Sprinkler system piping must be maintained free of obstruction, so periodically, sprinkler systems (including valves and piping) should be examined internally. Where unfavorable conditions such as those listed below are found, the systems should be examined for blockage immediately, and at five-year intervals.

Check the system for;

a. Pipe blockage

b. Defective screens at pump intakes where pumps take suction from streams, ponds or lakes. Failure of the screens might allow debris into the pump suction and into the system piping.

c. Debris and obstructive material discharged during routine water tests, such as from hydrant water flow tests or 5 cm main drain tests.

d. Debris found in dry-pipe valves, check valves and fire pumps during maintenance.

d. Heavy discoloration of water during 5 cm drain tests, or plugging of the inspector's test connections.

e. Plugged piping, which is found during system alterations or after system failure during fires.

f. Failure to flush underground mains following installation or repairs. Debris might have been left in the piping during construction.

C. TESTS

(1) Quarterly

a. All Sprinkler Systems

* Flow test main drains - This involves noting and recording the pressure of the gauge on the lower side of the sprinkler valve (This is the residual water supply pressure.) If the pressure readings vary significantly from those readings previously recorded, there is indication that something may be wrong with the water supply (such as a closed valve or blocked pipe). Loss of pressure of more than 10 percent should be investigated immediately to determine its cause. The effect that the drop in pressure will have on the sprinkler system operation should also be determined to assure that the system will perform satisfactorily.

b. Wet Pipe System

* Test water flow alarms - Test Alarms by opening the inspector's test connection. This simulates the flow of water from one sprinkler head and will activate the water motor alarm as well as the flow switch or pressure switch. (When freezing weather prohibits using the inspector's test, the alarm by-pass connection can be used. However, use of the alarm by-pass does not test the operation of the valve clapper and is not considered as good a test as using the inspector's test connection.)

c. Dry Pipe System

* Test low air pressure alarm - Close the water supply valve so the system will not be accidentally tripped. Slowly release air from the system by gently opening the inspector's test valve. The low air pressure alarm should sound when the pressure drops to that recommended by the manufacturer. Do not allow pressure to drop sufficiently to trip the dry pipe valve. After the test, make sure that the air supply valve is open and that the system air pressure has returned to normal, then reopen the water supply valve.

* Test water flow alarm - Open the alarm by-pass valve. Use of the inspector's test connection is not desirable as it will cause the dry pipe valve to trip.

(2) Annually - Dry Pipe Sprinkler System

a. Trip test the dry pipe valve. Before the trip test, the main valve should be fully opened and the water supply flushed out until the water flows clean. If a hydrant is located on the system supply, it should be flushed before the main drain is flushed. This flushing will help to reduce the amount of debris getting into the dry pipe system. Each dry pipe valve, including quick opening devices if provided, should be trip tested. This test should be done in the spring after freezing weather, with the water supply control valve only partially open. Once the valve trips, the water control valve can be quickly closed so that the system is not filled with water. (Caution: Some dry pipe valves will not operate properly without and adequate flow of water to fully lift the clapper valve.)

b. The valve is tripped by opening the inspector's test valve which releases air pressure within the system. After the test, open the 5 cm main drain valve to drain the system. Remove the valve cover and thoroughly clean the valve interior. Renew worn or damaged parts as required, reset the valve, and replace the cove. Add priming water and open the air supply to fill the system with air. When the air pressure has reached its proper level, open the 5 cm main drain to reduce the chance of a water hammer tripping the system, then slowly open the water supply valve. When the water supply valve is fully open, slowly close the 5 cm main drain.

(3) Every 3 years

a. Trip test the dry pipe valve.

b. The dry pipe valve should be trip tested with the water supply valve fully open. The test should be terminated when clean water flows from the inspector's test connection. A full trip test should also be conducted whenever the sprinkler system undergoes a major alteration or extension.

(4) Every 50 years

a. Remove a representative sample of sprinklers from service provide new sprinklers in their place. Send the removed sprinklers to a testing lab for operational testing in accordance with NFPA 13. If the sprinklers fail to perform satisfactory during the

operational tests, all of them should be replaced with new sprinklers of similar rating. After the 50-year operational test, the test should be repeated every 10 years.

Note: A representative sample consists of the larger of:

* **Two sprinklers per floor or individual riser but not fewer than a total of four, or**

* **One percent of the number of sprinklers per individual sprinkler system.**

D. MAINTENANCE

(1) Quarterly - Exercise post indicator and outside screw and yoke (OS & Y) valves. Fully close and reopen each valve. When opening, the handle should be turned until resistance is felt in the operating rod, thus assuring that the rod has not become detached from the valve gate. The handle should be backed one-quarter turn from the fully opened position to prevent jamming.

(2) Annually

a. All Sprinkler Systems

* Lubricate all valve stems.

* Graphite or graphite in light oil should be applied to the valve stem. The valve should be fully closed and reopened to test its operation and distribute the lubricant on the valve stem.

* Clean strainers if provided. This will generally involve shutting off the water supply and removing the strainer to clean it. Some strainers are self-cleaning and simply require rotation of the operating wheel.

b. Dry Pipe Sprinkler Systems - Drain all low point drains (drum drips). The draining should be repeated daily until the condensation is removed.

CHAPTER 5 - ELECTRICAL DISTRIBUTION

FUTURE

CHAPTER 6 - ELEVATORS

FUTURE