



Property Risk Consulting Guidelines

A Publication of AXA XL Risk Consulting

PRC.17.12.1

FIRE PROTECTION FOR ELECTRIC GENERATING PLANTS AND HIGH VOLTAGE DIRECT CURRENT CONVERTER STATIONS

INTRODUCTION

National Fire Protection Association (NFPA) documents describe a level of fire protection agreed on by persons representing a variety of interests. The guidance in these documents does not reflect unique conditions for special considerations, such as system performance under adverse or unusual conditions. Nor does NFPA guidance reflect the increased system reliability that AXA XL Risk Consulting recommends for high valued properties.

This PRC Guideline states AXA XL Risk Consulting's position on provisions of NFPA 850 because AXA XL Risk Consulting believes they require clarification or changes. To understand AXA XL Risk Consulting position, this PRC Guideline must be read with a copy of NFPA 850. The provisions of the NFPA document are not repeated.

POSITION

General

NFPA 850 reference more than 80 publications which supplement loss control guidance for power plants. These standards and recommendations should not be applied blindly. Unique conditions can result in the need for other than standard levels of protection.

NFPA 850 addresses its applicability by stating that the recommendations "are intended for new installations only, as the application to existing installations may not be practicable." Regardless, NFPA 850 is a tool for measurement, a standard to which proposed and existing protection levels may be compared. Judgments concerning applicability should be made by those responsible for loss control.

Construction

Maintaining a space free of combustible continuity can stop fire spread. Flammable and combustible liquids and gases should not be conveyed through the area. This includes prohibiting oil piping.

Mechanical failure may result in the release of rotating parts or projectiles. Even a barrier might not be effective in stopping the projectile. Loss control must consider the separation needed for such incidents.

Maintaining a clear space of 75 ft (22.9 m) outdoors between noncombustible buildings, or 200 ft (61 m) indoors between low-to-moderate hazards within a fire resistive building may be sufficient to prevent the spread of loss.

Fire Areas

It is not the intent of this section to describe every area requiring detachment, separation or a cut-off. Generally, any loss-associated occupancy having a moderate or high value, critical or major production use, or combustible continuity should be separated from other occupancies and maintained as a unique fire area.

The wall which separates the control room from the computer room should have a fire resistance rating if there are concentrations of Class A combustibles in either room.

Any central storeroom, shop warehouse or other area over 100 ft² (9.3 m²) but not over 500 ft² (46.5 m²) used for the storage of Class A combustibles should be separated from surrounding occupancies by fire barriers rated for 3 h when the storage area contains any of the following:

- Storage greater than 8 ft (2.4 m) high;
- Commodities greater than Class III;
- Combustible storage in a pile exceeding 250 ft² (23.2 m²) floor area;
- Flammable or combustible liquids in or within 50 ft (15.2 m) of the area, whether or not the liquids are in an enclosed piping system;
- A fire loading greater than that defined for Ordinary Hazard Occupancy - Group 1;
- An inadequate sprinkler design.

Central storerooms, shop warehouses and other areas over 500 ft² (46.5 m²) used for the storage of Class A combustibles should be separated from surrounding occupancies by fire barriers rated for 3 h.

Any area used for both pumping and heating of fuel oil should be separated from other areas by a 3 h rated fire barrier.

Separate flammable and combustible liquid tanks and reservoirs, including combustible hydraulic oil tanks, lubricating oil tanks, and hydrogen seal oil tanks from other areas by fire barriers rated for 3 h. Where tanks have a capacity of 50 gal (189 liters) or less and where sprinklers, separation, dikes, and drains are satisfactory, a lesser barrier may provide a minimum level of shielding that can limit fire spread.

Where combustible loading is low and continuity of combustibles is carefully maintained at a minimum, a 2 h fire barrier provides reasonable separation for fire control. Barriers between moderate and higher hazards require greater fire resistance ratings. Explosion potentials may warrant explosion-resistant construction and increased separation or detachment.

Fire Protection

The Fire Protection Design Basis is critical in this case to determine the level of protection that will be provided for the IGCC plant. Since the gasifier operations look like a chemical plant, a separate fire risk analysis, will be necessary, utilizing PSM (Process Safety Management) principles. Gas detection and ESD (emergency shutdown) devices will be very important features of the overall fire protection package.

Just having the DBD is not enough when it comes to documentation of the fire protection design basis. All assumptions and the basis behind all decisions should also be documented.

New facilities, especially those under construction will likely have the DBD available from the design engineering company (they usually use NFPA 850 to the letter if they can). There should be objectives already determined by the owner with possible input from either their insurers or a third party engineering group like AXA XL Risk Consulting. These objectives should be kept on file for use during any changes to the facility.

AXA XL Risk Consulting recommends that all fixed fire protection systems be automatic in operation. At the very least, manually operated fire protection systems cause delays in response times, and at worst, result in the fire protection systems failure, due to non-operation by the control personnel.

Most of the resistance to automatic operation of fire protection systems is for turbine bearing systems, where the users are concerned about water on hot turbine surfaces. This concern is mostly unfounded as the EPRI Study "Turbine Generator Fire Protection by Sprinkler System" showed. The loss history (and activation history) of turbine bearing waterspray systems would also seem to bear this out.

Foam-water sprinkler systems are normally expected to extinguish oil pool fires more quickly than "water-only" sprinkler systems. However, foam-water sprinkler systems are more complex, have more components and are therefore less reliable than typical water-only systems. When proportioning fails or a foam supply is depleted, the system continues discharging, but only as a water sprinkler system. For turbine-generator fires, foam-water systems should be designed to discharge at the water-only rate. The NFPA single-point water-only design rate may be used.

The duration of foam-water discharge for turbine-generator hazards requires special consideration. Oil is likely to be discharged until rotation stops or the unit is put on turning gear. This is often in excess of the 20 min required by PRC.12.3.1.1. In general, the foam discharge time should be the **greater** of the time it will take to put the unit on turning gear or 20 min.

Foam-water sprinkler systems are particularly desirable in areas that cannot be adequately drained. A blanket of foam helps quickly extinguish pool fires.

Automatic Sprinkler Systems

Ordinary Hazard Group 2 classification may be used to determine sprinkler design where a less flammable hydraulic fluid represents the most severe combustibility. Extra Hazard Group I applies to protection above ordinary hydraulic fluids. See PRC.9.2.4.

If automatic sprinklers are located below open grating and in the path of a sprinkler discharge from above, water shields are necessary to circumvent delayed operation caused by the cooling of the low-level sprinkler heads. See PRC.12.1.1.3.

On the operating floor, areas subject to oil accumulation may include:

- Areas within enclosures for the front standard and turbine; and
- Open areas above solid flooring within a minimum 20 ft (6.1 m) radius around oil hazards that are not enclosed.

Lubricating oil lines and combustible-oil-operated controls and piping located within these areas should be protected. Enclosures allow the collection and detection of heat and the use of an automatic sprinkler system. Open areas will require a thorough analysis (e.g., curbs, exposures) and either automatic sprinklers or an automatic water spray system. The water spray system should have means of manual actuation from readily accessible remote stations in the turbine room and at the deluge valve. Manual actuation should be made a part of operator training.

Automatic sprinklers should be hydraulically designed for 0.30 gpm/ft² (12.2 L/min/m²) over the entire area. Water spray protection should provide coverage of 0.25 gpm/ft² (10.2 L/min/m²) over surface areas exposed to an oil fire. Foam-water sprinkler systems may also be used with these same density and area criteria.

Foam-water systems may effect better control than water-only systems.

Automatic sprinkler protection should be provided for combustible hydraulic systems and for conveyors exposed by them.

Belt conveyors may require sprinkler protection even when not enclosed. Detection devices and interlocks to shut off power to the belt drives can also help limit losses. Further information describing loss control for belt conveyor systems can be found in PRC.9.3.1.

Bearings

Bearing fires are not uncommon. EPRI reports that of 119 reported turbine-generator fires, 39 occurred at the bearings.

AXA XL Risk Consulting will accept automatic closed-head sprinkler protection designed in accordance with NFPA 850 recommendations. Alternately, AXA XL Risk Consulting will accept automatic open-head water spray for the bearings, arranged with manual release both at the deluge valve and as close as possible to the turbine-generator as long as the release is not exposed by a turbine-generator fire. Automatic actuation for the water spray system should be by heat actuated devices at the lower floor level, arranged to detect fire below the bearings.

Both arrangements result in automatic protection after fire spreads to the area beneath the turbine. This protection is likely to prevent major heat damage in the bearing enclosure.

Where the equipment design cannot preclude the potential for major water damage from operating nozzles or sprinklers, AXA XL Risk Consulting allows automatic carbon dioxide flooding for the bearing enclosures located at the exciter end of the unit.

Oil Storage And Pumping Equipment

Arrange oil reservoirs, tanks and pumps in a fire area separate from the turbine-generator. Provide a 2 hr rated cutoff. Historically, sprinkler protection is provided as a backup in case a gaseous extinguishing system fails. Foam-water sprinklers may be provided as the primary means of protection.

If the cut-off is less than 2 h rated, area protection should be automatic open-head water spray protection designed in accordance with NFPA 15 should be provided over major oil reservoirs, tanks, filters, purifiers, coolers and pumps; the system(s) should be operated by heat-actuated devices located at the protected hazard(s) and by manual operation from readily accessible remote stations in the turbine building and at the deluge valve. Design should be 0.25 gpm/ft² (10.2 L/min/m²) over the protected surface.

Exciter Housing

For the main generator to set up the rotating magnetic field needed to produce ac power, a dc current source must be provided to the rotating coils. A source of dc power typically used is an exciter (a small generator/rectifier) attached to the turbine-generator shaft such that the main generator is between the turbine and the exciter.

To protect the bearings, carbon dioxide protection may be used in lieu of sprinkler or nozzle protection and water spray shields. Carbon dioxide protection should have remote manual actuation capabilities and extended discharge.

When not directly connected, the exciter is not considered a direct exposure to the turbine-generator, and protection is not required.

Hydrogen Seal Oil Units

Oil pressures in hydrogen seal oil systems may be as high as 100 psi (6.9 bar). A high pressure oil pipe failure can produce an oil spray, which when ignited produces a "torch-like" fire with a high heat release rate. Hydrogen seal oil units including oil storage reservoirs, filters, detrainment tanks and pumps should be located remote from the turbine-generator, cut-off, and protected. Thus, only the piping to and from the turbine-generator poses a direct fire threat to the turbine-generator.

Major oil reservoirs pose an exposure that may be difficult to control by ceiling sprinklers alone. It may be necessary to keep the tank cool by means of a water spray system. A water spray system directs water onto exposed surfaces providing cooling much more quickly and effectively than ceiling sprinklers alone.

Where oil systems are not cut off, automatic sprinkler protection must extend sufficiently into the peripheral areas subject to oil spray and oil flow, to control the heat produced by oil fires, and maintain building temperatures below those which cause deformation. Automatic open-head water

spray protection should also be provided for major lubrication oil and hydrogen seal oil storage tanks to keep them cool in a fire situation. Protection should be designed to provide 0.25 gpm/ft² (10.2 L/min/m²) over the exposed surface area. Actuation should be by heat sensing devices at the hazard.

Bag-Type Coal Dust Collectors

Automatic sprinklers should also be provided for any outdoor bag-type coal dust collector where either the value of the collector or the fire spread potential appears significant. Collector supports should be designed to handle water loading as might occur with a flooded collector following sprinkler discharge.

Flue Gas Systems

Collectors and hoppers should be provided with either an automatic fixed water spray system or automatic sprinklers. Protection should also extend to the supply ductwork to limit fire spread and heat buildup. The system should have a minimum density of 0.20 gpm/ft² (8.1 L/min/m²) over the described areas. The structures should be capable of supporting water loads that accumulate during firefighting.

Automatic sprinkler protection should be provided for all flue gas bag-type dust collectors for the following reasons:

- Errors in purchasing or maintenance procedures may result in the use of replacement bags that are not rated for use in environments exceeding 400°F (204°C).
- Incomplete combustion in the boiler results in combustible particles being collected. This can occur with start-ups, shutdowns and transient conditions.
- Excessive exhaust temperatures can ignite or damage even the high temperature bags.

Control, Computer, And Communication Rooms

AXA XL Risk Consulting does not recommend Halon 1301 fire extinguishing systems. Halon protection described in NFPA 75 is not an AXA XL Risk Consulting recommended method of protection. Automatic carbon dioxide flooding should be provided for protection under raised floors where there are significant concentrations of combustible cables.

Only necessary and limited quantities of files, records, paper supplies, books, manuals and other combustible storage should be allowed in the Control and Computer Rooms. Controlled storage may be allowed if properly arranged or protected, and if it does not present a significant fire threat. Generally, sprinkler protection is not required unless the rooms contain concentrations of Class A combustibles. Control panels, computers, signal and control systems, and instrumentation are important. Hazards inherent in electrical power generation are unique. For those reasons, smoke detection should be provided for control and computer rooms

Cable Spreading Room And Cable Tunnels

These rooms should be cut off. NFPA 15 allows individual trays to be protected by water spray systems designed for 0.15 gpm/ft² (6.1 L/min/m²) rather than the total room or area sprinkler protection concept identified herein. Where individual trays are the only source of combustibles, NFPA 15 protection may be installed as this will generally provide fast, effective protection.

Grouped Electrical Cables

Grouped cables in cable trays often create a significant concentration of combustible cable insulation that can sustain and spread fire. Major cable tray fire losses can be avoided by reducing the hazard through proper cable selection, reducing external exposures, limiting cable fault energy, and the provision of full cable coatings, fire breaks, cut-offs, alarms and extinguishing systems. Often, a combination of these approaches is needed to minimize losses.

Cables that have passed the Institute of Electrical and Electronics Engineers fire test procedure (either IEEE Std. 383 or IEEE Std. 1202) are considered to be "non-propagating." This means only that the cable passes a standard test procedure. It does not mean the cable is noncombustible.

Relying only on such test results may give a false sense of security if use and occupancy conditions are more severe than the cable evaluation test conditions.

“Low Hazard” cables include types labeled MI, MC and AC. These cables are permitted for use in trays by the NEC. Nonpropagating cables such as UL listed cables marked “for CT use” or “Type TC” are also considered “Low Hazard” and may be used in trays. Of the “Low Hazard” types, only listed mineral insulated (MI) cable is considered to be noncombustible. Extensive use of MI cable is generally cost prohibitive.

Table 1 provides general guidance for protection of cables in trays. Recommendations developed by use of the table may require modification to fit unique site conditions.

TABLE 1
Protection For High Priority Cable Trays*

Ceiling Area Protection:	Sprinklered			Non-sprinklered		
Number of Tiers of Trays:	1	2or3	4&4+	1	2or3	4&4+
LOW HAZARD** CABLE						
FIRE PROTECTION Water Spray (NFPA 15) One Line of Directional AS Approved Cable Coating			V&H	V&H	V&H	V&H
FIRE DETECTION (NFPA 72E) Heat Detection Cable in Tray Smoke Detection	V	V&H	V&H	V&H	V&H	V H
FIRE BREAKS 15 ft intervals 25 ft intervals 50 ft intervals	V H	V H			V H	V
OTHER** CABLE						
FIRE PROTECTION Water Spray (NFPA 15) One Line of Directional AS Approved Cable Coating		V&H	V&H	V&H	V&H V&H	V&H
FIRE DETECTION (NFPA 72E) Heat Detection Cable in Tray Smoke Detection	V&H	V&H	V H	V&H	V&H	V H
FIRE BREAKS 15 ft intervals 25 ft intervals 50 ft intervals	V H		V H	V H		V H

SI Units: m = 3.28 ft

HOW TO USE THIS TABLE: Find the applicable column by matching the on-site conditions with the Ceiling Area Protection and Tiers criteria at the top of the Table. The top section of the columns apply to low hazard cable; for other than low hazard cable, use the bottom. For horizontal trays, find each “H” in that section; for vertical arrangements, find each “V.” The suggested protection, detection, and fire breaks are shown in the left-hand column opposite the letter designations; these are minimums for the specified conditions.

* These are general recommendations. They do not apply to all situations. Unique conditions may warrant a greater level of protection. Refer to the text.

** Low Hazard meaning acceptable to AXA XL Risk Consulting, such as types MI, MC, and AC cables permitted for use in trays by the NEC and UL listed cables marked “for CT use” or “Type TC.”

Typically, the reduction of combustibles is basic to protecting grouped cables. TYPICAL CABLE INSULATIONS WILL BURN, some more easily than others. The fire and contamination threat can be minimized by controlling the use of combustibles including cable insulation selection. A reasonable level of loss control can be achieved by using these precautions:

- Use only “Low Hazard” cables in cable trays.

- Avoid multilevel cable tray installations.
- Separate horizontal cable trays as much as possible.
- Protect high priority cable trays as shown in Table 1.
- Limit the use of nonmetallic cable trays to highly corrosive areas where metallic trays are unacceptable. Additionally, limit the trays and cables to those required for use in the area.
- Limit tray cables that upon overheating will form halogens, to areas not highly susceptible to corrosion.
- Avoid totally enclosed cable trays.
- Use qualified companies/individuals for the design and installation of protection systems.
- Use approved equipment and components for protection systems.
- Install power cable in separate trays from control, signal, and instrument cable. In horizontal tray installations, install power cables in the top tray(s) and install signal cables in the lower trays(s).

A tray cable (Type TC) covered with a properly applied and listed cable coating may have greater flame resistance than bare cable insulation. However, it may be necessary to derate the cable ampacity because of reduced heat transfer rate if a coating is applied. Information should be maintained describing application requirements and listing or approval restrictions.

To minimize direct fire exposure to cables in a tray, a fire-rated cut-off is the most effective means of loss control. However, when a cut-off is not feasible, a tray may be deliberately wrapped with listed sheets and blankets to provide a fire-rated protective system and maintain circuit integrity. Derating of the cables may be necessary because the heat transfer rate may lower. Because heat may be trapped in a wrapped, totally enclosed cable tray, overheating and cable fire are more likely to damage all enclosed tray cables.

The enclosure can act like an oven, and can make maintenance more difficult. Wrapping should be considered only after other solutions have been exhausted.

Pulverizers

Manual steam flooding or carbon dioxide protection may be used to protect pulverizers and the pipes leading to the burners.

Carbon monoxide gas detection systems should be provided. Alarms should sound at a constantly attended location.

Water Supply

The preferred water supply arrangement is a standard, underground, private fire service system arranged to supply sprinkler systems, hydrants and other fire protection equipment. Some utilities use major private water systems to provide combined fire protection and domestic water. Certain features may allow these service water systems to be considered satisfactory fire protection supplies. The following criteria should be met:

- The supply should consist of multiple service pumps, with at least one being driven by a diesel engine or other acceptable non-electrically-dependent driver.
- The supply should operate continuously, and be reliably arranged with 8 in. (200 mm) or larger service water mains having sectional control valves to isolate breaks and minimize impairments.
- Automatic pumping should provide full fire protection and firefighting water demands in addition to full service water demands.
- The duration of the water supply satisfies PRC.14.1.1.0 and PRC.12.3.1.1 guidance.
- Yard hydrants should have individual control valves.
- Individual sprinkler systems should be supplied from the service water mains in the same manner that a single sprinkler riser would be supplied off a city water main. It should be under

the control of an outside post indicator valve (PIV) and have an alarm check valve and fire department connection.

- Where a second water supply is needed, it should be achieved through a separate fire protection water supply. For each building or area requiring this second supply, a standard valve and checked pit should be provided in the initial water supply connection to allow a downstream connection from the separate fire protection water supply.

AXA XL Risk Consulting should be consulted for acceptance of other than standard water supply arrangements.

Reliability Of Water Supply

Reliability of any water supply should be determined in the Fire Risk Design Basis. While reliability from an engineering standpoint is fairly easy to determine, it is a completely different story from a consequence of loss standpoint. Insurance values, how important the particular plant is to a company's generation scheme, and insurance company requirements all need to be considered in this determination. The results could mean that a multiple or secondary water supply is needed. This is an expensive proposition that needs to be evaluated fully before determining one way or the other.

Standpipe And Hose Systems

A system of hose connections, each equipped with 75 ft (23 m) of 1½ in. (40 mm) woven-jacketed lined fire hose and an adjustable spray nozzle, should be provided at the operating and intermediate floors of the turbine room, spaced at approximately 100 ft (30.5 m) intervals.

Transformers

The main power and auxiliary transformers which are normally located in the yard adjacent to the turbine building may contain thousands of gallons of combustible insulating oil. This large quantity of oil creates a significant fire hazard. Fires can ignite from surge protection failure, bushing failure, or internal arcing of the windings.

AXA XL Risk Consulting concurs with the overall philosophy of transformer fire protection as presented in NFPA 850. However, NFPA 850 misuses the designation "firewall" to refer to a barrier installed outdoors for exposure protection. Further, some of the guidance is vague and some is inadequate for the subject. While the National Electrical Code® (NEC) also prescribes transformer protection, it too leaves much to judgment, and it does not apply to electric utilities.

PRC Guidelines dealing with transformer placement, maintenance and fire protection should be followed. PRC.5.0.1, PRC.5.4.5, PRC.5.4.5.1, PRC.5.9.2 and PRC.5.9.4 are tools which have been successfully used in property loss control. NFPA guidance should be followed if it results in a higher level of protection. Also, electrical equipment like large transformers should have full instrumentation and controls, and a good preventive and predictive maintenance program. A full description of these loss control measures is beyond the scope of NFPA 850.

The fire barrier walls between transformers should be designed so that there can be no interaction between an exploding bushing and an adjacent transformer. The referenced 1 ft. above the top of the conservator tank may not be high enough to keep shrapnel and burning oil from involving a closely spaced transformer. Fire barrier walls should extend to the top of the bushings, and be U-shaped wall systems if possible.

Smoke And Heat Venting

The spread of smoke and heat are often major factors in large fire losses. Smoke and heat vents remove soot, corrosive and toxic gases, moisture and heat. Oil fires and high-smoke emitting cable fires require reliable and effective smoke and heat venting to supplement sprinkler protection. PRC.2.1.4 describes vents acceptable to AXA XL Risk Consulting.

NFPA 204 is difficult to apply to a turbine room having a large floor area, high roof, and oil pool and oil spray fire hazards. Its use requires predicting the limit of fire spread, and sometimes results in impractical protection schemes.

Powered venting is the preferred method of providing venting in the Main Turbine Building for a lubricating oil fire. However, this isn't always available. A less effective method would be to use existing windows in the building (older facilities) to act as the venting area. The provision of traditional smoke and heat vents (auto or manual) is not considered to be an effective alternative unless they can be operated remotely. The excessive height of the Turbine Building ceilings (most in excess of 100 ft) will affect the heat signature at the ceiling and could cause delay in actuation of any automatic vents.

Without NFPA 850 guidance delineating how to apply NFPA 204 in turbine rooms, different users can obtain vastly different results. The application problems are too numerous to address here. Therefore, AXA XL Risk Consulting will continue to recommend turbine room smoke and heat venting protection meeting the following well established parameters:

- 1:50 venting ratio (1 square unit of vent opening for each 50 square units of floor area);
- A minimum of 100 ft² (9.3 m²) of venting over each turbine;
- Listed vents with automatic and manual operation.

A reliable, powered, smoke removal system should be provided in all other areas. It may be arranged for manual actuation. The controls should be clearly marked, accessible, and located immediately outside of the protected room. Based on the room height being no more than 12 ft (3.7 m), the venting design should be as follows:

- Control rooms, computer rooms and switchgear rooms with a moderate smoke-generating capability - 3 cfm for each ft² of floor area (0.9 m³/min for each m² of floor area);
- Cable spreading rooms and other areas with a heavy smoke-generating capability - 4 cfm for each ft² of floor area (1.2 m³/min for each m² of floor area).

Higher ceilings should be avoided. Where ceiling heights must exceed 12 ft (3.7 m), larger flows may be needed. Venting for high-ceiling control, computer, switchgear and cable spreading rooms cannot be reliably designed to provide effective smoke control.

Drainage

The failure of a lubricating oil system can cause severe turbine-generator mechanical damage. Therefore, lubrication systems are designed for high reliability to reduce the chances of mechanical failures. These systems typically maintain the lubricating oil supply even under fire or other adverse conditions for as long as the turbine continues to rotate. Unfortunately, this reliability can result in large quantities of oil being released into a fire. Oil discharges can normally be shut down once the turbine winds down. Large quantities of firefighting water or foam-water may also be discharged into the fire. These fluids must be safely handled.

Large turbines may take more than 1 hr to wind down to a speed where they can be safely taken off line and put on the turning gear drive. Approaches used to assist with deceleration include breaking the condenser vacuum and maintaining the generator field. But these approaches are not likely to reduce the coast-down time more than 25%. The characteristics of each unit will differ.

Drainage should accommodate the three identified flows for the greater of two time spans: the time it will take for the turbine to be placed on the turning gear drive or 10 min.

Regenerative Air Heaters

The water spray system should be arranged for automatic actuation. Water loading and drainage are other loss control considerations.

Electrostatic Precipitators

Fire Hazard

Incomplete combustion in a power boiler produces flays containing unburned combustible particles, or carbon. In many power generating stations, flays are carried into large electrostatic precipitators with the flue gas. While these precipitators are often arranged with continuous ash removal, ash

accumulates on exposed plates and other surfaces. Startups, shutdowns and transient conditions thus can lead to carbon buildup.

Sparking is a common phenomenon in an electrostatic precipitator. With sufficient oxygen, these sparks can ignite a carbon accumulation.

Carbon and oxygen levels are controlled by efficient burner design, modulation, instrumentation and controls. An excess combustion air supply promotes complete combustion. Flue gas from utility steam generators usually contains 2-8% oxygen content. Lower concentrations are the result of inadequate combustion and are associated with high combustible particulate levels.

Stable power demands promote stable boiler combustion conditions. Further, precipitator operating designs use a positive pressure mode to prevent outside air from leaking or being drawn into the unit, because the air brings in more oxygen and could raise the oxygen concentration in the precipitator to hazardous levels.

Fighting a precipitator fire using hose streams alone cannot be expected to result in effective loss control. In the early fire stages, a fire may not be easily seen. Smoke and obstructions make manual firefighting difficult.

The size of a precipitator can be a factor in the size of a fire loss. Using of smaller units and fire barriers can be effective in limiting losses. Also, automatic deluge sprinkler protection using pilot heads and fixed fire detectors interlocked to de-energize the precipitator can be a way of addressing the fire hazard within a unit. Water loading should be considered in the design of the equipment.

NFPA 850 describes the fire hazard in an electrostatic precipitator, but does not describe interior fire protection, such as automatic sprinklers. Interiors of large precipitators at utility stations are generally not protected by automatic sprinklers. Minimal industry loss experience and debate concerning effective and practical sprinkler system designs prevent common acceptance of sprinkler protection. For these reasons, AXA XL Risk Consulting does not normally require interior sprinkler protection for electrostatic precipitators at electric utility power stations.

Instrumentation And Controls

Additional measures should be considered. The following may be effective means of fire detection and loss control:

- Dampers and interlocks to bypass the precipitator on boiler start-up, fuel change-over and safety shutdown.
- Inlet oxygen analyzer set to alarm when the O₂ concentration increases to 8%.
- Outlet oxygen analyzer set to alarm when the O₂ concentration increases to 8% and where the system includes a downstream induced draft fan.
- Inlet and outlet gas temperature switches arranged for safety shutdown at 200°F (111°C) above normal anticipated operating temperatures.
- Hopper temperature sensing devices.
- Emergency rapping override switch.
- Opacity indicator alarm for incoming gas to detect unusual levels of particulates in the flue gas entering the precipitator.
- Manual trip controls for the boiler and control room operators to each be able to de-energize the unit.

Hydrogen System

Buildings housing piping systems containing hydrogen should be adequately vented. Exposures should be controlled. Vented guard piping, hydrogen sensors and explosion relief may be appropriate.

Instrumentation

The hydrogen concentration in the generator should be **maintained above** the upper explosive limit. It is often maintained at 98% or higher. An alarm should sound in a constantly attended location if the hydrogen concentration drops to 95% by volume because this concentration is near the explosive range for the pressure, temperature and water vapor content involved.

Venting And Dump Valve

A hydrogen cooled generator dump valve should be vented as described. Carbon dioxide or some other inert gas should be introduced to purge all hydrogen upon initiation of the dump.

Hydraulic Control System

PRC.9.2.4 describes hydraulic system design considerations. It also describes the fire hazards of hydraulic fluids and fire protection requirements for systems using either low hazard or combustible fluids.

The reliability of hydraulic controls is vital to major power plants. Precautions should be taken to safeguard critical equipment. For instance, shielding may be needed to prevent fire protection water from directly impinging on the stems of steam stop and intercept valves, as thermal shock could impair their operation.

Manual means of actuating steam stop valves from the control room should be provided. Stop valve reliability is improved by regular testing which includes observing the valve operate through a full closure. To accomplish this with minimal interference to production, a redundant main steam line with steam stop and control valves can be provided in parallel with the primary line so one line can be tested while the other is maintained open. Because this approach is costly, typically, only one line is provided and only a partial, routine valve closure test is done. Full closure is tested during shutdowns.

Hydraulic drives will not be common on fans, but where used, cooling is critical for the system. Waterflow in the cooling system should be supervised and failure should alarm at the Control Room.

Lubricating Oil Systems

It is important to property loss control to maintain bearing lubrication even under adverse conditions, even if maintaining lubrication means enlarging a fire. This was partly reflected by an earlier NFPA 850 guideline stating "Emergency lube oil pumps, with power from normal and emergency power supplies, should be provided to allow for continued bearing lubrication in the event of failure of the main lube oil pump." Although no longer part of the NFPA guideline, the statement provides sound loss control guidance. Protection for the oil fire hazard will be described later.

NFPA 850 describes the term guard pipe construction as it is used by the electric power industry. In other industries, the term guard pipe may simply mean a system protected from mechanical injury.

However, AXA XL Risk Consulting experienced a large loss where the guard pipe was ineffective after a fitting ruptured. The guard pipe was not properly designed, and the flow rate of the escaping oil caused the guard pipe to overflow and ignite at the turbine. Guard piping size and termination points must be carefully evaluated.

Switchgear And Relay Rooms

Extraneous combustibles should be prohibited. Indoors, transformers should be limited to dry, nonflammable or less-flammable liquid insulated units. Switchgear Rooms and Relay Rooms of minor fire hazard and importance require only smoke detection systems. All others should be provided with smoke detection systems and emergency venting to limit smoke and corrosion losses.

Recommended alarms should sound at a constantly attended Control Room. Air sampling smoke detection systems can provide quick response to "cold smoke" and other products of overheating, pyrolysis and electrical breakdown.

Rooms containing oil-filled circuit breakers, or major equipment requiring forced ventilation for cooling should also be provided with automatic sprinkler protection having a design of 0.15 gpm/ft²

(6.1 L/min/m²) over 2000 ft² (185.8 m²) (Ordinary Hazard - Group 1). Automatic total-flooding fixed-pipe carbon dioxide systems with a connected reserve may be used as an alternate to sprinkler protection where no oil hazard exists.

Battery Rooms

Smoke detectors and hydrogen gas detectors should be provided and arranged to alarm at a constantly attended Control Room. The rooms should have a 2 h rated fire barrier wall separating them from the rest of the facility.

Storage Rooms, Offices And Shops

Storage rooms, offices and shops which offer an exposure to critical facility operations, or which alone pose a significant fire potential should be equipped with automatic sprinkler protection installed in accordance with the AXA XL Risk Consulting interpretive guides to the appropriate NFPA Standards.

Cooling Towers

Cooling towers can stand idle before plant start-up; when the plant is shut down for inspections, repairs and routine maintenance; and when there is no need for water cooling, such as when the generating unit is itself shut down. Fire development and spread in a cooling tower which is standing idle and is of combustible construction is easy to envision.

However fire development and spread in operating cooling towers with water cascading through them and a water spray appearing to envelop the combustible fill is not as easy to envision. But experience proves that major fire losses do occur in operating cooling towers which contain wood or plastic structural members or fill. In fact, AXA XL Risk Consulting's loss experience shows that approximately 50% of cooling tower fires occur while the units are operating.

The many voids and unwetted spaces mean the potential for a very serious fire does exist. The same construction features that facilitate heat transfer for cooling, facilitate rapid fire development and severe fire intensity even during operation. The cooling tower design provides a fresh air supply, good air circulation, and combustibles spaced for maximum fire development and spread. The design also makes manual firefighting difficult because hose streams cannot be directed effectively into the structure. Fixed protection with design criteria as described in NFPA 214 is generally recommended as a minimum level of protection.

Wind Turbine Generating Facilities

Wind turbine generating units are by their very nature difficult to provide fixed fire protection for protection of the hazards inside the nacelle. These units are on the top of pole supports, usually at a height of 200 ft (61 m) or more. Offshore wind farms have the additional problem of being away from normal means of access. As such, investigation into the criticality of the wind units and the overall effect of the wind farm is to the generation scheme of the generating company. The Fire Protection Design Process

Fire Protection Systems

Storage rooms, offices and shops which offer an exposure to critical facility operations, or which alone pose a significant fire potential should be equipped with automatic sprinkler protection installed in accordance with the AXA XL Risk Consulting interpretive guides to the appropriate NFPA Standards.

Unless good enclosures are provided, which would allow the use of other gaseous fire extinguishing systems, water mist is likely the best choice for protecting oil hazards in the nacelle.

Solar Thermal Power generation

There are two forms of solar power generation, the use of HTF fluids in solar fields to produce steam and drive a steam turbine generator unit and Photovoltaic systems. For commercial sized plants, the use of HTF fluids is by far the more commonly used technology.

The Power Block areas are usually very compact areas that are attached to the solar heating field. An HTF fire in the heater or more likely the heat exchangers, will likely involve the turbine generation equipment due to close proximity. Determination should be made of the hazard presented by the HTF fluid and what additional fire protection, whether passive or active, is needed.

If there are curbed areas under any of the equipment that can have significant HTF holdup (greater than 100 gallons), provisions should be made to allow for the removal of HTF away from the power block equipment. This can be through concrete channels, sloped ground to sumps/drains, collection ponds.

Protection For Equipment Supports

Largest hazard is a pool fire involving HTF in and around the Power Block area. This will approximate a chemical or hydrocarbon spill and as such the metal supports for much of the equipment will be exposed. The preferred protection for these supports is fireproofing, much like a chemical plant. The Fire Protection Design Basis Document/Process should be used to determine the level of protection needed.

Geothermal Power Plants

Geothermal technology is centered around the Direct Steam, Flash Steam and Binary types of facilities. The first two plant types are providing steam to turn steam turbine generation, and the hazards are typical to the steam turbine and generator. The third type of plant, the Binary type introduces a significant additional hazard since it uses hot brine that is withdrawn from the geothermal well to heat a working fluid, such as isopentane, isobutane, and n-pentane, which has a very low flash point. With the Binary system usually being a closed loop, under significant pressure, with significant holdup of the working fluid, any escape has the potential to be a vapor cloud, with subsequent explosion potential. Chapter 12 deals primarily with Binary plants.

Risk Considerations

Although there are 5 considerations in this section, first and foremost should be the exposure presented by the working fluid. The remaining considerations are common to all power generation plants. As long as any working fluid pumps, storage vessels, significant piping, etc. are kept clear, or as far as possible from the Main Power Generation Block buildings, it should not come into play should there be a major release.

Prevailing wind conditions as noted in NFPA 850 should be evaluated to help determine how far away the working fluid equipment should be sited.

Fire Risk Control Program

Use of AXA XL Risk Consulting's *OVERVIEW*, or a comparable program that incorporates the intent of each section of *OVERVIEW*, results in total management of a loss control program. The development of corporate loss prevention and control policy statement, plus the implementation of the "Action Plans" for the 14 interlocking elements identified in *OVERVIEW*, are effective modern management techniques for achieving effective loss prevention and control.

Any program incorporating the features of *OVERVIEW*, even though structured differently, will promote effective loss control. Where one or more features are missing, vulnerability to loss increases. Many public utilities, owing to their high visibility to the public, will have complete, or nearly complete programs.

The material covered by NFPA 850 4 can best be implemented by following the advice contained in AXA XL Risk Consulting's *OVERVIEW*. *OVERVIEW* does not limit itself to fire-associated loss prevention and control but covers all aspects of property loss control.

The importance of implementation of the Hazardous Materials Evaluation and the Hazard Identification and Evaluation programs, as outlined in *OVERVIEW* (PRC.1.8.0 and PRC.1.13.0), cannot be overemphasized. These two, complemented by the other 12 elements, accomplish a total risk evaluation. Unless corporate and local management are committed to the development and

implementation of an aggressive program of loss prevention and control, efforts to provide adequate protection of the facility will ultimately prove futile.

Emergency plans and operator training in the power industry have resulted in a new generation of professionalism. Training simulators that mimic normal and emergency conditions produce highly proficient operators. Simulator training allows operators to react to controlled, lifelike emergency situations; this results in more effective reactions to crises and more effective loss control. A side benefit of simulators is that they are used to evaluate new procedures and equipment. Simulator training has become an important part of effective loss control programs for the power industry.

Fire Brigade

Because of high values at electric generating plants, and the need for prompt response, AXA XL Risk Consulting strongly recommends that management provide staffing, training and equipment for an interior structural fire brigade.

DISCUSSION

NFPA 850-1990 recommended sprinkler coverage for “at least 20 ft (6.1 m) beyond the lubricating oil system and oil collection areas.” It also specified a two-point design criteria to protect from lubricating oil fires under the operating floor as follows:

“The sprinkler system beneath the turbine-generator should be designed to a density of 0.30 gpm/ft² (12.2 L/min/m²) over an application of 3000 ft² (279 m²) and 0.2 gpm/ft² (8.1 L/min/m²) over an area of 10,000 ft² (929 m²).”

AXA XL Risk Consulting recommends protection meeting the 1990 recommended practice for risks it services because:

- Smoke and heat will often travel beyond areas “subject to oil flow, oil spray, or accumulation.” The extension of sprinkler protection to these surrounding areas may be necessary to control smoke and heat. The 20 ft (6.1 m) criteria was acceptable as a minimum guideline.
- Loss experience has not proven that a sprinkler protection design for turbine-generator oil fires can be safely limited to 5000 ft² (465 m²). Fires have occurred where over 50 heads operated and well over 5000 ft² (465 m²) was involved.

Loss control involves more than turbine-generator fire protection considerations. It includes automatic and manual response to devices that warn of any dangerous condition or significant loss potential. Effective loss control monitors electrical conditions, temperatures, pressures, positions, speed and vibration. Effective loss control also requires reliable design and maintenance. Emergency lubrication systems and dismantle inspections are also necessary. Because NFPA 850 does not describe these needs, other guidelines should be reviewed to complete loss control programs.

The major turbine-generator fire hazards are the combustible oils used for lubrication, hydrogen seal and some hydraulic control systems. In general, automatic, fixed pipe, water based, fire extinguishing systems are the preferred methods of protection for these oil hazards. But sprinkler and water spray discharges alone cannot control losses. Drainage, barriers, venting and other loss control features are needed along with such protection.

Controlling turbine generator oil fires is not simple, because these fires are not ordinary 2-dimensional spill fires. High oil pressures, high-valued equipment, high roof areas, sprinkler discharge obstructions, limited firefighting access, and lubricating system design make these 3-dimensional fires difficult to control. The lubricating system design incorporates high reliability to allow oil to be pumped even under adverse conditions.

Storage reservoirs and filters placed far from the turbine-generator and in a separate fire area may lower the fire loss potential and may assist firefighting efforts. The severe fire potential at the turbine still exists since it will be necessary to pump oil for seals and lubrication to the turbine until hydrogen has been dumped and the turbine-generator coasts down to turning gear speed. Thus, oil will be pumped into a fire while fire control is being attempted.

Because of large building areas and isolated hazards, it is not uncommon to find sprinkler systems designed for protection of specific hazards rather than complete area coverage. Spot sprinkler protection approaches should be carefully designed to consider all areas where oil may flow and where heat from a fire may spread.

Sprinkler protection must be designed for the most severe hazard in the area. This may lead to complex sprinkler designs and special arrangements. Where an oil hazard exposes an extremely hot stem of a steam stop valve or complex electrical equipment, such as an exciter, shields may be needed to protect mechanical and electrical components from sprinkler discharge. The Electric Power Research Institute (EPRI) research project 1843-2 reports that of 24 incidents in which water was applied to hot portions of the turbine, none resulted in major damage or unit downtime. EPRI reports that major concerns of two turbine manufacturers can be resolved by providing water spray shields, insulation, deflectors, enclosures and dampers, and it gives specific recommendations for their respective equipment. It further describes a “properly engineered fire protection system” for turbine-generators. AXA XL Risk Consulting guidelines follow the more general NFPA 850 recommendations. The knowledge and experience of designers and installers can resolve or minimize problems caused by water discharge.

Generally, a fixed fire protection system will not significantly reduce a generator winding loss and is not required for the generator enclosure. Design and operating features allow even a hydrogen cooled unit to be considered safe. Before energizing a hydrogen cooled generator, the enclosure is first inerted, then charged with hydrogen. With a hydrogen concentration above the explosive range, the interior of a hydrogen-cooled unit has less fire hazard than that of an air-cooled unit. Upon shutdown, purging and inerting brings the hydrogen concentration below the explosive range so the unit can be opened for maintenance.