Highly Protected Risks in Power Generation

Stewart Kidd outlines the issues to consider when installing active fire suppression in power stations

THE TERM highly protected risk (HPR) is commonly used in the insurance sector to describe a property in which all the principle fire risk areas are fitted with some form of active fire suppression, buildings and structures are fully compartmented against the spread of fire and management of fire safety is of a high order.

The HPR approach is used at many major industrial sites, particularly power generation plants. At these sites, automatic fire suppression systems play a key role in such industrial activities.

Unless specifically exempt, new or refurbishment power projects should comply with all local laws and relevant codes and standards. Power stations in most countries must comply with the following mandatory life safety requirements of fire safety legislation:

- means of escape from the premises in case of fire, including fire escapes, fire exit signs, emergency lighting, fire doors and adequate compartmentation
- means for employees to fight fires, such as portable fire extinguishers and hose reels/racks
- access for the local fire brigade. Where there is a professional fire brigade, it is likely that access routes, hard standing, dry rising mains/fire service standpipe, a firefighter's lift and water supply facilities may be required
- in some countries, additional requirements may be imposed on distillate/fuel oil tanks or liquefied petroleum gas (LPG)/liquefied natural gas storage facilities

Other requirements may be imposed to require compliance with national standards – for example, in respect of hydrants or hose fittings. (Clearly, if this is not the case, it would make good sense to ensure that all hoses supplied as part of a plant's protective systems were compatible with the local fire service's own systems.)

The only generally accessible, published standards for the fire protection of power plants is the National Fire Protection Association's NFPA 850: *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*. In the case of nuclear or non-thermal plants, other standards will apply.

Risk control

Regardless of the levels of physical or system protection provided, all plants should have in place appropriate measures to provide:

- fire risk evaluation
- management policy and direction, including consideration of the need for a plant fire brigade
- fire risk control programme (including such measures as control of hot work)
- identification of fire hazards of materials

There are other, more specific regulations with which power stations must also comply. In England and Wales, for example, a range of legislation applies including Building

Regulations, regulations covering means of escape and provision of fire fighting facilities and regulations covering the storage and use of flammable liquids and chemicals

Plant design

A number of factors should be considered during the design of any HPR site. First is the plant arrangement, including physical separation, and location of key areas such as fuel tanks, chemical tanks and process equipment. Many modern power stations normally burn natural gas but use diesel fuel for start up or as a stand-by fuel, in case gas supply is interrupted. HPR doctrine would be to provide maximum separation from gas handling plant (including separators, drop out/knock tanks and bath heaters) from fuel oil or diesel fuel tanks and their ancillaries.

Life safety should also be considered, irrespective of whether or not it is specified by local standards. Many modern plants employ very few staff to actually operate the plant. During the day, when maintenance and management/administration staff are present, there may only be 20 or so people on site, while as few as three people may run an 800MW gas turbine cogeneration station between 5pm and 8am.

In some locations, where local fire departments may have limited capacity or may be a long way from the site then consideration should be given to building-in as much fire fighting facilities as possible, Apart from the means of protection mentioned below this could include master stream deluge systems (also known as fixed monitors) to provide exposure protection to minimise fire spread.

One important consideration is the possible risk to operatives when a carbon dioxide (CO_2) total flooding system is discharged. In one power station, a small fire in lagging on a gas turbine enclosure resulted in the discharge of a considerable quantity of CO_2. The gas extinguished the fire but also escaped from the enclosure and affected large areas of the turbine building and some below-ground areas, where dangerous concentrations of the gas gathered.

There are also specific requirements for separation distances between transformers and other structures; if the required degree of separation cannot be met then segregation with blast walls will normally be specified.

Building construction and materials

Most modern power station buildings are of relatively light steel-framed construction. with cladding that is not intended to offer any fire resistance. It is therefore necessary to carefully select materials in areas where fire resistance is needed. This could involve:

- concrete or proprietary protection of key steelwork, such as for turbine supports
- fire separation between cable tunnels/cable trenches and fire doors to break up cable tunnels into fire compartments
- fire sealing of cable penetrations
- adequate compartmentation for spaces storing lubricating oil, or other flammables or reactive chemicals
- distance separation for fire pumps

- blast/explosion proofing for large battery rooms and hydrogen generation modules
- location of control rooms and proper blast proofing or fire resistance
- use of waterspray to protect exposed steelwork
- where possible cooling towers and their internal structures should be constructed of non combustible materials

Consideration should also be given to the need for smoke and heat venting; drainage; emergency lighting; lightning protection; and general fire protection systems.

Suppression systems

A wide range of equipment and facilities will need to be provided with automatic fire suppression systems if the term HPR can be applied: fire detection systems (point and area detection); fire suppression – wet (sprinklers, water spray, water mist and foam); and fire suppression – gaseous (inert and chemical gases).

Sprinkler systems operate normally by the opening of individual sprinkler heads when the operating temperature is reached. Sprinklers are designed to control fires and prevent their spread (although in many cases fires are extinguished by the operation of only a few heads and consequently relatively little use of water or water damage).

Water spray systems normally utilise open spray nozzles and are usually actuated either by sprinkler head detectors on an airline or heat sensors connected to an electromechanical actuator or valve. In the absence of any UK or European standards for such systems, most are installed in accordance with NFPA 15: *Standard for the Installation of Water Spray Systems for Fire Protection*. Water spray systems achieve the extinction of burning materials by a combination of surface cooling, smothering (by the production of steam), emulsification and dilution. There are also effects that inhibit the chain reaction within the fire itself. NFPA 15 specifies typical application rates as follows:

Control of burning	20.4 litres/minute/m^2
Exposure protection	2.0 litres/minute/m^2
Exposed steelwork	4.1 litres/minute/m^2
Vessel protection	10.2 litres/minute/m^2
Transformers	10.2 litres/minute/m^2
Belt conveyors	10.2 litres/minute/m^2

NFPA 850 recommends that areas around or beneath turbo-generators should be protected with an application rate of 12.2 litres/minute/m^2, while the turbine and generator bearing should be protected at 10.2 litres/minute/m^2. However, re-insurers are concerned that their real fire experience of transformers and steam and gas turbines has not confirmed the adequacy of these rates. Some large-scale tests undertaken in Finland indicate that these rates should be doubled to ensure adequate fire control.

Water mist

The phasing out of the halon firefighting gases has had a marked effect on the level of research into alternative suppression systems. Several proprietary systems are available, each utilising water mist or fine water spray technology. The concept ranges from very high pressure (up to 110 bars) systems that produce a fine water particle mist, to low pressure systems that provide a fine water spray extinguishing medium. The water is propelled either by pumps or by an inert gas and dispensed from nozzles that are designed to deliver water in fine droplets to the area of fire. The suppression mechanism relies on a combination of cooling by the water, the production of steam that displaces oxygen from the area of the fire to a level that cannot sustain combustion and inhibition of the chemical processes of combustion.

A major advantage of water mist systems is the comparatively small amounts of water required to extinguish a fire, compared with traditional sprinkler systems. However, mist systems are less effective than traditional sprinkler systems at extinguishing slow, deep seated fires in 'normal combustibles'.

Tests have indicated that the design of water mist systems needs careful consideration where the protected location is prone to significant air movement, since this may impact on the effectiveness of the mist. This and other limiting factors, such as personnel presence and detection parameters, require a careful risk assessment to be made before any conclusion is reached as to the type of protection needed. In the absence of any recognised international standards for the design of water mist systems, care needs to be taken when deciding on the validity of manufacturers' claims – many of which are based on system technology and components developed for use in marine applications which may not be directly relevant for building protection but will be appropriate for use in HPR scenarios.

Application of systems

Steam and gas turbo-generators

These large machines, operating at high speeds, high temperatures and high pressure, contain large quantities of flammable lubricating oil and therefore constitute a major fire risk. Particular attention should be paid to the fire protection of a turbine's auxiliary plant, such as fuel forwarding skids, lubricating oil skids and filters/tanks and the turbine bearings. Where there is a clutch or reduction gear between turbine and generator fire suppression, usually in the form of water spray (deluge) protection, should be provided. Like the turbines, the generator bearings should be protected by water spray.

Transformers

Transformers range in size from auxiliary units containing a few hundred litres of oil to large generator transformers containing thousands of litres of (hot) oil. There can be defects within the transformer windings or the tapchanger; this can generate significant volumes of gas which can cause catastrophic failure of the transformer tank and a subsequent oil fire that will be difficult to extinguish. All transformers with an oil capacity in excess of 500 litres should be protected with a water spray system as mention above. It should be noted that the most reliable type of detection for such systems is that provided by an airline fitted with sprinkler heads.

Switchgear and relays

All switchgear rooms or cubicles should be supplied with automatic fire detection as a minimum and oil-filled switchgear must be protected with an automatic inert gas system (CO_2 or a proprietary nitrogen/argon mixture) or a chemical gas system (such as the latest halon replacement Novec 13 or the longer established FE 13). Increasingly, attention is being turned to the possibility of the use of water mist in such equipment.

Lubricating oil systems

All lubricating oil systems, tanks, pumps and filtration units should be protected by an automatic water spray system. Large gearboxes (for example of the type fitted to FD Fans) which contain say more than 200 litres of oil should also be protected if their loss would significantly affect the commercial operation of the plant.

Fuel storage and handling

In the case of coal, lignite or other solid materials (such as biomass), all fuel handling elements, including conveyors and elevators, should be fitted with fire detection and protected by a wet fire protection system. Sprinklers are probably the system of choice for conveyors, since the ability for single-head operation in the event of a spot fire in a conveyor is extremely useful. The belt drives should be linked to the fire detection system so that belts are stopped if a fire is detected; this will permit the sprinkler head to open. However, in countries where there is a risk of wet sprinkler systems freezing in winter care must be taken when specifying protection types. Systems can either be wet with trace heating and insulation, dry or alternate wet/dry. In the case of dry systems, care should be taken to ensure that an accelerator is fitted to systems protecting very long pipe runs. In addition, all belts should be fire resistant in accordance with one of the widely accepted international standards (such as Canadian Bureau of Mines).

Cooling Towers

Where cooling towers are constructed of combustible materials and especially where the internal structure of the towers are made of timber or plastic a water spray system should be provided to protect this key plant from fires during outages and overhauls.

Compressed gas storage

Modern power stations use a wide range of compressed gases, some flammable including propane/LPG and hydrogen. Sprinkler or deluge systems should be installed to provide adequate protection for tanks, cylinders and delivery points

Flammable liquid storage

Tanks storing fuel or diesel oil should be protected both from external fire (by a cooling spray ring) and also from internal fire with a foam system (either top pouring or base injection. An adequate supply of foam compound allowing for a full recharge of enough compound for one tank should be maintained on site (and as close to the tanks as possible). Tank protection is normally manually operated and care should be taken to ensure that the control valves are accessible in all predictable fire scenarios.

Control, computer and communications rooms

Great care should be taken to ensure that these key areas are provided with an appropriate level of protection where there is fully centralised control of the plant and equipment, in other words, when there are no unit control rooms allowing individual machines to operate safely and effectively. At the very least, the following should be provided:

- full fire detection, possibly including air sampling equipment in ducts, risers, cable tunnels and trenches
- underfloor inert gas protection
- sprinkler or water mist protection in key areas, the functions of which are not duplicated
- cable galleries should be fitted with sprinklers operated by either linear heat detection or an area wide detection system, such as infrared
- battery rooms should be effectively ventilated to minimise the risk of hydrogen build-up and fitted with hydrogen detection and explosion proof fire detection using ultraviolet or infrared sensors

Diesel generators

These should not be overlooked and fitted with a water spray or water mist system. (Diesel fire pumps should also be fitted with a water spray system).

Warehouses, workshops, offices and storage areas

These areas are frequently overlooked and in a number of instances a loss of key spare parts has closed down power stations. All these locations should be fully sprinkler protected and warehouses separated from other areas by a minimum of two hours' fire resistance.

Cooling towers are key points in any power station. Horizontal-type towers containing any combustible material (such as timber or plastic) must be fitted with a water spray system. (This requirement comes as a surprise to many, but when a cooling tower is shut down its internal fabric dries out very quickly and the nature of the material used is very prone to hot work fires.) ❑

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