Risk Solutions

Fires in waste to energy power generation plants

A guide to loss prevention

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Power generation from waste to energy plants is now commonplace, with electricity being generated by mass burning of a variety of fuels derived from waste materials. Waste fuel streams, however, can present a range of fire risks due to their combustibility and other hazards.

Fires in waste to energy plants continue to be a major cause of insurance loss. Commonly used fuels include waste streams such as municipal solid waste from kerb-side collections, used tyres, waste wood, dried sewage sludge and organic biomass. The risks from waste fuel streams can include dust, spontaneous combustion, poor housekeeping, the delivery of already smouldering loads, ignition in bulk storage bins or conveying systems, the use of hydraulically actuated processing equipment, flue gas filtration systems and the use of combustion engine-powered loading shovels.

This guide provides advice on best practice engineering for fire prevention control systems, fire detection and firefighting arrangements within waste to energy facilities.

A list of common terms and definitions is located at the end of this document.

Design and construction

The energy and insurance industries within the UK recognise and refer to the USA's National Fire Protection Association (NFPA) and other associated NFPA organisation standards (NFPA 850, for example) for power plant design and construction. The NFPA's standards are applied as the basis for best engineering practice in the design and installation of fire protection systems in power plants, including waste to energy plants.

In many cases, British or European standards for fire protection guidance on specific items of plant and equipment used in the power industry do not exist. Where British or European standards do exist, these standards have been referenced in this loss prevention guide. In many cases, British and European standards are often based on NFPA standards.

Other organisations, such as Factory Mutual Global (FM), Underwriters Laboratories (UL) and the UK Loss Prevention Certification Board (LPCB), provide testing, approval and certification services for materials and equipment used in fire protection installations. These organisations also deliver fire rating and performance testing of materials and equipment used in the construction of waste to energy power generation plants.

Insurers recognise FM, UL or LPCB approval and certification as the standard required for the fire resistance rating of construction materials and for fire protection installations.

The hierarchy for control of the fire risk should be:

- Fire separation
- Fire prevention
- Fire detection
- Fire extinguishing

It is important that these risk control measures are built into design and management procedures adopted by power generation plants.

The design, construction, operation and fire protection of waste to energy power plants should meet the requirements of NFPA 850: Recommended Practice for fire Protection for Electrical Generating Plants and High Voltage Direct current Converter Stations. Chapter 9 is particularly relevant as it provides specific recommendations for the use of alternative fuels.

NFPA 850 requires that during the early stages of plant design, a Fire Protection Design Basis Document should be produced. This document evaluates the plant-specific fire hazards, the fire protection codes and standards that apply and the methods proposed to control those hazards identified.

In general, the power plant's overall design and layout should be based on process systems that will prevent inadvertent ignition in the fuel feed train. This includes physical separation and the use of non-combustible construction materials that will prevent the spread of fire. The installation of fixed automatic fire detection and protection systems to detect, control and extinguish a fire is an essential element of the design.

The layout of the buildings, plant and process equipment should allow unimpeded access by fire and rescue service emergency response vehicles to all areas.

All construction and thermal insulation materials should hold a certified non-combustible or limited combustible rating approved by the LPCB, FM or UL. All interior surface materials used in the floors, walls and ceilings should have Class A fire spread ratings.

Where thermally insulated composite panels are used for the external side walls and roofs of the building, the fill material should preferably be non-combustible, such as mineral wool. Composite panels using foamed fill materials are acceptable, providing they have been tested and certified by LPCB or FM to have a limited combustibility rating.

Waterproofing membranes in the roof should have a Class A fire spread rating. Torch-applied mineral felt or similar roofing materials are not recommended. This is because of the fire risk during construction or repair, and the potential to cause a fire to spread across the roof to other areas of the plant.

Lightning protection should meet the requirements of NFPA 780: Standard for the installation of Lightning Protection Systems.

In buildings where fuel is being handled, the surfaces of equipment and structural members should be designed to prevent dust and combustible materials accumulating and to provide access for cleaning.

Fire area separation
The installation of fire doors, fire dampers, fire shutters and windows should meet the requirements of NFPA 80: Standard for Fire Doors and Fire Windows. Spatial separation distances should be in accordance with NFPA 80A: Recommended Practice for protection of Buildings from Exterior Fire Exposure.

The fire areas within the plant should be separated from each other by two-hour-rated fire barriers or a minimum of 15m of spatial separation. The fire barriers must extend from the floor to the underside of a non-combustible roof. A two-hour-rated fire barrier or sufficient spatial separation should be provided to separate the following areas:

- Receiving/tipping floor and refuse pit
- Steam generator and turbine building
- Auxiliary equipment rooms
- Auxiliary boiler room
- Control room and DCS panel room
- Electrical switchgear and motor control centres
- Cable spreading room and cable tunnels
- Administrative areas and locker rooms
- Emergency generator room
- Fire pump room or pump house
- Battery rooms
- Telecommunications and server rooms
- Maintenance workshops and warehouses
- Flammable and combustible liquid storage rooms
- Processed fuel storage area
- Material recovery and fuel processing area
- Fuel oil pumping and conditioning area
- Plant rooms for air conditioning systems
- Hot-load unloading areas
- Overflow fuel storage areas
- Plant vehicle garages

All fire barrier openings should have fire doors or fire shutters installed with the same rating as the fire barrier. Ventilation ducts passing through the fire barriers should be fitted with fire dampers at the penetration point. Where cables and pipes penetrate the fire barrier, they should be sealed with a fire resistant material with the same rating as the fire barrier.

Viewing windows in designated fire barriers, such as the control room, crane operator room and process observation areas, should be fitted with automatic fire shutters or automatic water curtains.

The control room's ventilation system should be separate from other systems, and its fresh-air intake should be located in a position that avoids the ingestion of smoke and airborne combustion products. The control room's ventilation system should operate at a positive pressure to prevent smoke entry during a fire.

A fire damper is required where the boiler's forced draft fan removes air from the fuel tipping hall to reduce odour. The damper should be located where the ductwork passes through the tipping hall fire barrier. There is a risk of boiler implosion if the damper closes as a result of a fire and the forced draft fan continues to operate. A bypass system or appropriate process interlocks should be considered to allow shutdown without damaging the boiler.

Structural steel columns in the vicinity of the fuel reception bunker should be encased in concrete with a dedicated water spray system or an approved intumescent coating. This is to protect against distortion and collapse in the event of a reception bunker fire. The structural steel protection should extend over full height of the column within the fuel reception area. The structural steelwork protection system should itself be protected from damage by plant vehicles and fuel handling crane grabs.

A designated bunker area should be provided for unloading waste loads that are smouldering on arrival. This area should be at least 15m from any other structure or building and be provided with fire extinguishing equipment.

Containment and drainage
To prevent flooding or damage to other areas and equipment, liquids and firefighting water should be controlled and removed. Control and removal can be achieved by providing floor drains, trenches, curbs or bunds for containing or directing liquids to drainage pits or sumps. Equipment can be protected by elevating it on pedestals.

The curbing and drainage should be designed to control the largest potential spill of any flammable or combustible liquids in the area. It should also accommodate the maximum design discharge of the fire protection system and hose streams operating for a minimum of 10 minutes. The water volumes used in wash-down should also be considered.

To prevent the spread of burning liquids beyond the fire area, floor drainage from the areas containing flammable or combustible liquids should be trapped or discharged to a sump.

Lubricating and fuel oil bulk storage tanks should be of double skin design or bunded to contain 110% of the maximum tank capacity.

General requirements for fire detection and protection

Fire protection systems should be designed and installed in accordance with NFPA 850: Recommended Practice for Fire Protection for Electric generating Plants and High Voltage Current Converter Stations. Chapter 9 is particularly relevant with its coverage of alternative fuels.

All fire protection equipment must be approved and certified by either LPCB, FM or UL. Fire protection systems and equipment should only be designed, supplied and installed by companies having LPCB Quality System Certification.

Water supplies

The fire protection system water supply should be provided from a reliable source. Without making an allowance for reservoir filling, the water supply should be able to provide a minimum of two hours of operation based on whichever is greater of the following:

a. The volume required for the largest fixed fire protection system demand, or
b. Two fixed fire protection systems that are expected to be operating simultaneously.

In addition to the above, if the fire hose hydrant system takes water from the same source, the supply must simultaneously support a minimum of a 1,890 litres per minute hose stream demand.

Fire pumps

Fire pumps should be supplied and installed meeting the specifications required by NFPA 20: Standard for the Installation of Stationary Pumps and Fire protection.

A minimum of two 100% duty fire pumps should be installed. At least one fire pump should be diesel engine-driven. The second pump may be electric motor driven, provided the power supply is from a secure source that is designed to supply site emergency services. The installation should also include provisions for routine flow testing of each pump.

Fire main and hydrants

A fire main and fire hydrants should be installed that meet the requirements of NFPA 24: Standard for the Installation of Private Fire Services and Their Appurtenances or BS 5306-0: 1986 Standard for fire extinguishing installations and equipment on premises: Guide for the selection of installed systems and other fire equipment.

A looped fire water supply main should be installed that encompasses the power block. Its capacity should meet the flow requirements set out in NFPA 14: Standard for the Installation of Standpipes, Private Hydrants and Hose Systems Fire Systems. The spacing of external hydrants should not exceed 100m and they should not be greater than 12.2m from the buildings they are designed to protect.

The local fire and rescue service should be consulted to ensure compliance with its fire hydrant connection and pressure requirements. How to prevent hydrant damage as a result of vehicle impact should also be considered.

Internal fire hoses

Internal fire hose points should be provided that meet the requirements of NFPA 14. They should be provided throughout the fuel handling and processing areas, hydraulic package unit areas and the boiler firing and charging floors.

Portable fire extinguishers

Portable fire extinguishers should be provided in accordance with NFPA 10: Standard for Portable Fire Extinguishers, or BS5306 Part 8 Code of practice for the Selection and Installation of Portable Fire Extinguishers.

Fire detection and alarms

All rooms within all buildings should be fitted with an automatic fire detection and alarm system meeting the specifications given in BS 5839 Part 1. The system should provide level P1 coverage, or the equivalent, as set out in NFPA 72: National Fire Alarm Code.

To avoid frequent false alarms, the specifications of the fire detection system selected should also accommodate the heat and dust conditions found in the protected zone.

The installation of very early smoke detection (VESDA) systems in electrical rooms, motor control centres, DCS panel and instrument rooms should be considered.

The operation of the fire detection and automatic fixed fire suppression systems should activate plant-wide audible and visual alarm signals. The systems should be supervised at a master fire alarm panel located in the control room.

Internal and external manual fire alarm call points should be provided inside all buildings and all process plant areas.

Fire protection for specific areas of plant

Waste to energy power generating plants operate using fuels and include process and equipment areas that require specific fire protection and design to minimise fire risks.

MSW and RDF tipping hall pit and MRF areas
Automatic sprinkler systems should be provided throughout the refuse reception and tipping hall area, including the fuel tipping pit. The MRF processing building should also be provided with an automatic sprinkler system that covers the whole floor area. Shielded areas, such as those below conveyors and equipment, may require local sprinkler heads.

These systems should be designed to a minimum density of 10.2mm/min over the floor area. The sprinkler systems should be designed and installed according to the requirements of NFPA 13 Standard for the installation of Sprinkler systems.

In addition to sprinklers, oscillating monitor nozzles with a manual override providing coverage of the whole tipping pit area should be installed. Monitor nozzle protection should be designed to deliver a minimum of 946 litres per minute at 6.9 bar at the nozzle tip with at least two streams operating simultaneously.

It should be possible to operate the monitor nozzles from the control room or crane operator's pulpit. They should be installed so that they do not interfere with operation of the grab crane and will not be damaged by the waste grab.

Conveyors
Conveyor belts carrying combustible materials should use fire retardant conveyor belt material. Automatic water spray or sprinkler systems should be provided on all enclosed conveyors and for all conveyors carrying combustible materials located outside of a building with sprinklers. Open conveyors within buildings should be covered by the building sprinkler system. Sprinkler or water spray coverage should be provided at all transfer points.

Sprinkler systems should be designed to provide a minimum density of 10.2mm/min over the area protected.

Below belt sprinkler heads may be required where areas below the belt are shielded from other sprinkler installations.

Conveyors should be tripped or reversed, if it is safe to do so, on detection of a fire on or near the conveyor to prevent fire spread. Alternatively, the conveying system should include a method of diverting or dumping a burning load into a bin or safe area where the fire can be extinguished with fire hoses or monitors. In some instances, it may be appropriate to run a burning load off the conveyor into the furnace.

Shredders and mills
Shredders and mills have an elevated risk of fires and dust explosions. Undetected flammable or explosive materials in the feed material increases this risk. To control these risks, shredders and mills should be fire segregated from each other, and from other equipment, by physical distance or enclosures.

Shredder or mill enclosures, including the intake and outfall chutes and vents, should be fitted with automatic sprinkler protection designed for a minimum density of 10.2mm/min. The shredder or mill should be automatically shut down when the fire protection system is operated.

The shredder or mill enclosures should be designed to withstand and safely vent the worst case explosion.

If a shredder or mill has an open top feed hopper that will allow safe venting of an internal explosion, additional explosion protection is not required. However, if adequate explosion protection is not provided via the feed hopper, an explosion suppression system should be fitted in accordance with NFPA 69: Standard for Explosion prevention Systems and ASTM E 1248 Standard Practice for Shredder Explosion Systems.

Classifiers and rotating screens should be fitted with automatic water spray systems to prevent a fire from spreading downstream.

Boiler fuel feed system
Boiler fuel feed bins, hoppers, conveyors, chutes and ram feeders should be fitted with automatic sprinklers providing a minimum density of 8.1mm/min.

When designing fuel feed systems, the material and structural support strength calculations should allow for the weight of the contents when saturated with fire water. It may also be necessary to make provision for additional emergency water drainage valves and systems.

Hydraulic systems
Control and pressure systems used within hydraulically operated systems should be fitted with sprinkler or water spray protection systems designed to deliver a minimum of 10.2mm/min. This is unless:

- A listed fire resistant fluid is used
- There is no normal ignition source within 6m of any part of the hydraulic system
- The system contains less than 380 litres of hydraulic oil.

Tanks holding more than 380 litres of petroleum-based oil should have an automatic oil pump and oil flow shutdown. The oil pump should automatically shut down when a fire or a temperature rise of more than 30°C above the normally anticipated area operating temperature is detected.

Boiler and burner fronts
Boilers normally require a secondary fuel for light-off, and in some cases for use as a secondary fuel. Secondary fuels may be either oil and or gas (natural or propane).

The burner operation and fuel controls must meet the requirements of NFPA 85: Boiler and Combustion Systems Hazards Code.

If a liquid fuel oil is used, the boiler burner fronts should be protected by an automatic sprinkler, water spray, or foam-water sprinkler system installed in accordance with NFPA 13, NFPA 15, or NFPA 16: Installation of Foam-water sprinkler and Foam-water Spray system.

Indoor fuel oil pumping and/or heating facilities should be protected with a wet pipe foam-water automatic sprinkler system.

If a gaseous secondary fuel is used, a fuel gas emergency shut off valve must be provided that automatically shuts-off the fuel gas supply when a fire or gas leakage is detected. When the emergency fuel gas shut-off valve is operated, it should also raise an alarm on the central fire control panel.

Any auxiliary boiler burners and fuel systems should have the same level of protection as the main boiler.

Turbine generator
NFPA 850 recommendations should be applied for steam turbine generator fire protection.

All areas beneath the steam turbine that may be subject to oil flow should be protected by an automatic sprinkler or foam water system designed to a minimum density of 12.2mm/min. Lubricating and control oil lines above the turbine operating floor should also be protected by a sprinkler that provides a minimum density of 12.2mm/min.

Steam turbine and generator bearings should be protected by closed head pre-action sprinklers that provide a minimum density of 10.2mm/min. If shaft or casing water damage is a concern, then NFPA 850 permits shielding. An automatic activation system is preferable to manual operation. If the sprinklers are manually operated, then activation should be from a permanently manned control room or a safe but accessible place. A written procedure should describe how and when the system is activated, and operators should have approval to activate the system without first seeking authorisation.

If the steam turbine and generator are installed within a separate enclosure, as an alternative to a sprinkler system, one of the following systems may be used:

- An automatic total flooding water mist system meeting the requirements of NFPA 750
- A gaseous flooding system using Carbon Dioxide designed in accordance with NFPA 12
- An approved clean agent gaseous fire extinguishing system specified in accordance with NFPA 2001.

The turbine generator lubricating oil reservoir, the seal oil system and the control oil system, if separate, should each be protected by automatic sprinkler or foam-water systems providing a minimum density of 12.2mm/min.

If a listed fire resistant fluid is used for the turbine-generator control oil system, and no ignition sources exist in the immediate area which could ignite fluid in the event of a leak, then sprinkler protection may not be necessary.

Electrical rooms
A total gas flooding fire protection system should be provided in all electrical switch and distribution rooms, instrument rooms, motor control centres, DCS panel rooms, UPS and battery rooms and the crane control room. Carbon dioxide or other clean agent gas flood systems should be installed in accordance with the appropriate standard. These include: NFPA 12 for a CO2 gas flood system, NFPA 2001 for a Clean Agent gas System and BSISO14520-1:2000 for gaseous Fire Extinguishing Systems.

Cable spreading rooms and tunnels
Cable spreading and cable tunnels should be protected with automatic sprinklers, water spray, foam water or an automatic gaseous extinguishing system. Sprinkler and water spray systems should be designed to provide a minimum density of 12.2mm/min over the whole area,

Transformers
For indoor installation, dry type transformers are preferred to oil-filled transformers. When oil-filled transformers are used, less flammable or non-flammable insulating oils are recommended. Oil-filled transformers should ideally be located outdoors.

NFPA 850 recommends a minimum 15m line-of-sight separation distance between individual oil-filled outdoor transformers that contain more than 1,893 litres of insulating oil and any other structure or plant. Two-hour-rated fire barriers can also be used as an alternative to achieve the 15m line of sight segregation.

The outdoor transformer should be protected by an automatic water spray system if the 15m line of sight segregation distance cannot be achieved by the transformer's location or fire barriers. The water spray system must be designed and installed in accordance with NFPA 15, delivering a minimum density of 10.2mm/min on all exposed surfaces of the transformer.

Oil-filled transformers holding more than 379 litres of oil and installed indoors should be separated from all adjacent areas by fire barriers with a three-hour fire resistance rating. The fire barrier rating may be reduced to one hour if the transformer is protected by an automatic water spray system.

Oil-filled transformers should be installed within a bunded area surrounding each transformer. The bunded area should be designed so that the entire oil content of the transformer, including the water volume due to operation of the fire protection system, can be held in the bunded area. Ideally the bund should be rock filled so that the leaking oil permeates below the rock and does not present a combustible surface.

Warehouses and workshops
Warehouse and workshops should be fitted with automatic wet pipe sprinkler protection systems.

Cooling towers
Cooling towers constructed of combustible material or having a distribution pack or mist eliminator of combustible material should be protected by an automatic sprinkler or water spray system that meets the requirements of NFPA 214: Standard on Water-Cooling Towers. Using non-combustable construction materials should be considered as an alternative.

Diesel engines
Emergency diesel engine-driven generators or other stationary diesel engines located within the main plant buildings should be protected by an automatic sprinkler system, water spray, foam-water or gaseous type fire extinguishing system. Sprinkler and water spray systems should be designed to a minimum density of 10.2mm/min over the fire area.

Vehicles
Vehicles and mobile plant operators should be trained in their operation and hold appropriate certificates of training for the vehicle(s) they are allowed to operate.

The engine bay of vehicles and mobile plant, both owned or hired in, used for handling materials should be fitted with fixed fire extinguishing systems of a type approved for off-road vehicles. Each vehicle should also be provided with a portable fire extinguisher of an appropriate type. The operators should be trained in the correct use of the potable fire extinguisher.

Vehicle and mobile plant refuelling must be undertaken in a designated area that is segregated from combustible and flammable materials.

Bulk fuel storage must be held in double skinned bunded tanks, segregated from other plant and equipment and securely locked when not in immediate use.

Where vehicles and mobile plant are garaged within a building, it must be constructed from certified non-combustible or limited combustible materials. The building should be kept free of combustible materials. If adjoining any other building, the building should have a two-hour-rated barrier, or should be separated by a minimum 15m.

Vehicles and mobile plant stored externally should be parked separated by a minimum of 15m from other mobile plant and any combustible materials or have appropriate separation provided by a two-hour-rated barrier.

Before starting work, vehicle and plant operators should complete a prestart check on their vehicle in accordance with the manufacturer's instructions.

Vehicle repairs and maintenance should be completed in a designated area separated by at least 15m from combustible or flammable materials.

To prevent the accumulation of combustible materials on vehicles, a daily wash-down and cleaning programme should be established. This should also include the engine compartment.

Flue gas emissions control equipment

Fabric bag filters
Automatic sprinkler protection is the preferred solution in fabric bag filter enclosures. If sprinkler protection is installed, there should be a method of draining fire water from the hoppers.

Bag filter fabrics should be made of a material with an operating temperature limit exceeding 204°C. The filter enclosure should be divided into filter compartments by non-combustible partitions. The filter area provided in each compartment should be sufficient so that a single compartment can be isolated without limiting the boiler load.

If no sprinkler protection is provided, collectors equipped with other types of filter bags should be subdivided into compartments by partitions with 30–minutes-rated fire resistance. If sprinkler protection is provided, the partitions should be of non-combustible design. Partitions should extend from the hopper through the bag area to the clean air chamber.

Each filter compartment should be fitted with temperature sensors that will activate an alarm in the control room when the temperature exceeds 28°C above the normal operating temperature.

To prevent damage to the filter bags by high temperature inlet flue gases, one of the following should be provided:

- Where permitted, an automated isolation damper and bypass duct should be installed to divert the inlet gas stream around the bag filters during emergencies
- A flue gas water tempering spray system in the duct between the boiler and the flue gas bag filter.

Access doors/hatches and viewing ports in all compartments should be provided with manual firefighting equipment.

Flue gas desulphurisation scrubbers
NFPA 850, Section 7.6.5, provides detailed guidance on the design, construction and fire protection of scrubbers, scrubber buildings and exhaust ducts. Guidance is also provided for fire protection and fire prevention during maintenance. This guidance should be followed for flue gas desulphurisation equipment installed on waste to energy power plants.

Electrostatic precipitators
Electrostatic precipitators should be equipped with temperature sensors in the inlet and outlet ducts. There should be alarms provided in the control room that indicate abnormal operating temperatures.

Fuel stock piles

Fires in outdoor fuel stockpiles are a frequent cause of damage and loss in waste to energy facilities. Due to the nature of the fuel, fires can be deep seated and difficult to extinguish quickly.

Spontaneous combustion, smoking, arson, the delivery of smouldering loads, adjacent hot-work and ignition by glass refracted sunlight are all common causes of stockpile fires.

Outdoor stockpiles
Stockpiles of combustible materials should be separated from buildings and plant by a minimum distance of 15m with a minimum of 5m clear separation from the site perimeter fence line. Where 15m separation is not possible, a two-hour-rated fire barrier is required to protect adjacent plant and buildings.

Fire rated barriers must extend a minimum of 2m above the maximum stockpile height and the stockpile height must not exceed 4m. Stockpiles must not exceed 1,000m² per pile.

A regime should be established to monitor the core temperature and emissions from stockpiles. Stockpiles should be regularly turned and damped down to prevent spontaneous combustion. Allowing longstanding stockpiles to develop should be avoided.

Smoking, hot-work and open fires should be prohibited within 15m of the stockpile and signage should be provided to this effect.

At all times, fire and rescue service vehicles should have unobstructed access and no portion of the stockpile should be more than 45m from an access road.

At least two public or private fire main hydrant points should be provided within 90m of the stockpile perimeter. Providing remote controlled oscillating monitor nozzles covering the whole stockpile area should be considered.

Bailed biomass fuels
Covered warehouses for storing baled fuels should be sprinklered in accordance with NFPA 13.

Smoking, hot work and other sources of ignition must be prohibited within the warehouse and signage must be provided to this effect.

Site security

Site security should be provided to restrict access by intruders who intend to commit theft, arson or malicious damage. Perimeter fence lines should be at least 3m high with intruder control fixtures on the top.

The site main entrance should be controlled at a manned gatehouse and only authorised personnel should be allowed access to the facility. All visitors should be accompanied by an authorised person at all times.

Intruder detection should be installed on all buildings and the intruder and fire detection systems should be linked to a remote monitoring location.

Site security should include a permanent security presence with intermittent patrols or a remote monitoring service using CCTV.

Housekeeping

To avoid the accumulation of combustible materials, dust and debris, good site housekeeping should be an ongoing process throughout the site.

There should be a programme in place to regularly clear dust and debris accumulations from beneath and on top of all process equipment, conveyors, hoppers, hydraulic packages and ledges at all levels. Mobile plant should also be checked and cleared of debris accumulations, particularly around tracks, engine compartments and suspension components. Daily, weekly, monthly and annual checklists should be provided to monitor and confirm that the cleaning schedule is being followed.

Fire incident pre-planning

The site should develop a fire action incident plan in coordination with the fire and rescue service. The plan should

consider the full range of potential fire scenarios and the type and level of response required.

An on-site incident controller should be designated to manage any fire incidents from start to finish. A dedicated radio communication system or channel should be allocated so that the incident controller can receive information and give directions.

Fire and rescue service vehicles should meet at a designated rendezvous point and escorted to the incident site.

The plan should include the names of responsible persons, their responsibilities and contact phone numbers for people and services that may be required during an incident.

The fire incident plan document should be held in the control room and at the main gate. It should include drawings showing the site layout, locations of key equipment and the location of fire protection equipment and systems.

A procedure should be established to immediately notify the facility's insurers of any impairment of fire protection or detection systems.

Operational considerations

The following systems and procedures should be in place for operational plants:

Permit to work system

The site should operate documented permit to work system including lock-out-tag-out (LOTO) of electrical and mechanical systems before work is permitted on any process plant item.

Control of hot work

The site should operate a permit system for the control of hot work, such as flame cutting, welding and grinding. The fire prevention requirements for any hot work should include the following:

- A suitable portable fire extinguisher available at the point of work
- A fire watchman, trained in firefighting, to be stationed at the point of work
- The work area should be cleared of combustible materials before work commences
- Fire retardant sheets or blankets should be used to prevent sparks and hot materials falling on equipment below
- Hot work should be carried out at least 20m from any combustible materials
- Hoses and bottle sets should be examined and be in good condition before work begins.
- Flammable gas bottles and torches should be fitted with flash-back arrestors
- The work area should be examined periodically during the hour immediately after work is completed to ensure there are no smouldering or incipient fires

Smoking policy

Smoking should be banned within any building in accordance with legal requirements.

Ideally, there should also be a ban on smoking anywhere on site but if this cannot be imposed, a limited number of designated outdoor smoking shelters may be provided which should be sited at least 15m from buildings and any combustible materials.

Smoking within site vehicles and mobile plant should be prohibited.

Maintenance and inspection

The site should establish a maintenance and inspection regime that covers all installed plant and equipment. Maintenance and inspection should be of a type and frequency recommended by the equipment supplier or manufacturer as a minimum requirement.

Regular thermal imaging inspections of motors, bearings, transformers and electrical equipment should be carried out to detect possible overheating as a cause of fires.

To prevent the accumulation of combustible materials, equipment should be regularly cleaned and washed down.

Electrical installations and portable equipment should be routinely checked to confirm the continued safety of the equipment, installation or system.

Storage of flammable liquids and gases

Flammable liquids should be stored in fire resistant steel cabinets specifically designed for the purpose. The volume of stored flammable liquids should be maintained at the lowest possible level. HSE Guidance Document: HSG 51 The storage of flammable liquids in containers provides further information.

LPG and flammable welding gases should be stored and secured in the upright position in locked and well-ventilated cages outside. Full and empty flammable bottles should be kept in separate cages and all oxygen bottles must be stored separately. Gas bottle storage areas should be sited as far away as is reasonably practical from any building or boundary fence. The use and storage of acetylene is discouraged and an alternative should be found.

Note: Where the fire service is called to attend a fire and acetylene gas bottles are involved, current fire service practice is to establish a 200m hazard exclusion zone around the incident and leave the cylinders involved undisturbed for 24 hours. All fire-fighting activity in the designated hazard zone must cease and the area must be evacuated.

Waste to energy plants – a summary of risk control measures

The hierarchy for control of the fire risk should be: fire separation, fire prevention, fire detection and fire extinguishing. It is important that these risk control measures are built into design and management procedures adopted by the power generation plant. The following table summarises the risk control measures:

Risks	Controls to mitigate the risks
Fire separation	
Design and construction	– Design and construct the plant to provide appropriate fire separations, spacing, compartmentation, fire barriers and fire resistance. – Use construction materials with non-combustible or low combustibility fire ratings certified by FM, LPCB or UL.
Fire prevention	
Smouldering loads	– Maintain close observation of delivered loads and provide a safe and suitably equipped place to dump and extinguish the load.
Elimination of ignition sources	– Prohibit smoking and control spark generation and hot work processes. – Segregate high temperature areas. – Provide security provisions to prevent arson. – Select plant and equipment to minimise fire risks and limit ignition sources. – Select approved non-combustible or limited combustible lubricating, hydraulic and insulating oils.
Fuel stockpiles	– Monitor fuel stockpiles regularly to detect overheating or incipient fires. – Avoid long standing static stockpiles and turn the pile frequently. – Provide local fire hose stations or monitors to extinguish burning areas before a small fire gets out of control.
Education and training	– Provide fire training to all staff in fire prevention, fire extinguishing and emergency response.
Housekeeping	– Establish a continuous process of removing accumulations of dust and combustible materials to reduce fire risks.
Fire detection	
Installation of detection systems	– Install approved and appropriate fire, smoke and heat detection systems throughout the plant. – Install manual fire call points and audio-visual alarm systems throughout the plant. – Ensure regular patrols by operators and security staff to detect fires.
Fire extinguishing	
Installation of fire control measures	– Develop a major fire incident response plan. – Seek advice and coordinate the major incident response plan with the fire and rescue service. – Complete a Fire Protection Design Basis Document to asses fire risks before construction and install appropriate and approved fire control measures.

Common terms and definitions

MSW	Municipal Solid Waste. Unsorted refuse collected from the kerb-side by local authorities.
RDF	Refuse Derived Fuel. Refuse which has been pre-sorted to remove the majority of recyclable and non-combustible materials. It may be pelletised or mass burnt.
Biomass	Biomass includes various types of bulk organic materials such as wood-chip, forestry waste, sugar cane, chicken litter, straw, nut shells and olive kernels.
Used/old tyres	Tyres that may be burnt whole or shredded into tyre chips.
Sewage sludge	Effluent from a sewage treatment plant from which the majority of the liquid has been removed.
Mass burn	Bulk burning of fuels in a furnace with a moving grate.
Waste to energy	The conversion of waste materials into usable electrical energy.
MRF	Materials Recycling Facility or Materials Recovery Facility. A processing area where delivered waste is sorted to remove non-combustible or recyclable materials before mass burning.

References and guidance

BS5306 Part 8:	Code of Practice for the Selection and Installation of Portable Fire Extinguishers
BS 5839 Part 1:	Fire detection and fire alarm systems for buildings
BSISO14520-1:	2000: Gaseous Fire-Extinguishing Systems
HSG51:	The storage of flammable liquids in containers (second edition, published 1998)
NFPA 10:	Standard for Portable Fire Extinguishers
NFPA 12:	Standard on Carbon Dioxide Extinguishing Systems
NFPA 13:	Standard for the installation of Sprinkler systems
NFPA15:	Standard for Water Spray Fixed Systems for Fire Protection
NFPA16:	Standard for the Installation of Foam-water Sprinkler and Foam-Water Spray Systems
NFPA 20:	Standard for the Installation of Stationary Pumps and Fire protection
NFPA 24:	Standard for the Installation of Private Fire Services and Their Appurtenances
NFPA 69:	Standard for Explosion prevention Systems and ASTM E 1248 Standard Practice for Shredder Explosion Systems
NFPA 72:	National Fire Alarm Code
NFPA 80:	Standard for Fire Doors and Fire Windows
NFPA 80A:	Recommended Practice for protection of Buildings from Exterior Fire Exposure
NFPA 85:	Boiler and Combustion Systems Hazards Code
NFPA 214:	Standard on Water-Cooling Towers
NFPA 780:	Standard for the installation of Lightning Protection Systems
NFPA 850:	Recommended Practice for fire Protection for Electrical Generating Plants and High Voltage Direct current Converter Stations
NFPA 2001:	Standard on Cleaning Agent Fire Extinguishing Systems

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