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Risk Control

Recommendations for fire safety in the use of thermal oxidation plant

RISCAuthority

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IMPORTANT NOTICE

CONTENTS

SYNOPSIS

Thermal oxidation systems present similar fire and explosion hazards to furnaces and ovens. These recommendations aim to ensure that the flammable concentrations of the inlet gases to be treated remain well below their lower explosive limits and that effective process control safety measures are observed.

Suitable separation from adjacent areas is recommended and the need for effective fire safety management procedures, maintenance and emergency plans, backed up by staff training and rehearsal of the procedures, are emphasised.

SCOPE

These recommendations outline the general fire safety requirements for thermal oxidation air pollution control systems used for the abatement of gaseous effluent containing flammable solvents, hydrocarbons and volatile organic compounds (VOCs).

Recuperative, regenerative and direct-fired types are addressed in this document while process boilers and flares used for thermal oxidation are excluded, as are ventilation air methane thermal oxidisers (VAMTOX) that find application in the mining industry.

Although these fire safety recommendations are for plants processing potentially flammable gaseous mixtures, much of the advice would also apply to plants processing non-flammable mixtures such as those used for odour control.

This document is restricted to plants operating at limited inlet strengths in terms of the concentration of the incoming gaseous effluent and to the explosive limits of its mixtures. The fire and explosion recommendations for plants operating at higher concentrations should be based on an engineered solution determined through appropriate process risk assessment principles.

DEFINITIONS

Catalyst

A substance that facilitates a chemical reaction or reduces the temperature at which it occurs but is not consumed in the process.

Lower explosive limit

The lowest concentration of a gas or vapour in air capable of producing a flash of fire in the presence of an ignition source.

Polymerisation

The linking of small organic molecules to form chains or three dimensional networks, which may take the form of liquids or solids.

Upper explosive limit

The highest concentration of a gas or vapour in air capable of producing a flash of fire in the presence of an ignition source.

VOC

Volatile organic compounds, or VOCs are organic chemical compounds whose composition makes it possible for them to evaporate under normal conditions of temperature and pressure.

Zeolite

Zeolites are microporous rocks composed of aluminosilicates that are known as ‘molecular sieves’ as they have the ability to selectively sort molecules based primarily on their size. Zeolites also incorporate loosely held water molecules which permit reversible dehydration.

INTRODUCTION

The thermal oxidation process involves the decomposition of gaseous effluent at high temperatures to produce less harmful products which can be released into the atmosphere in concentrations acceptable to environmental legislation.

The plant is essentially a high efficiency incinerator where limited concentrations of vapours are burnt or oxidised at high temperatures in the presence of significant volumes of air or oxygen. Oxidation is normally achieved when the effluent is subjected to high temperatures which may be in the range of 540°C to 1100°C for an exposure time of one to two seconds. The less harmful products are then released into the atmosphere. Some gaseous effluents may require further treatment, filtration and scrubbing to remove particles, halogenated compounds and oxides of sulphur and nitrogen before the treated product may be released.

Common types of thermal oxidation plants include:

- direct combustion units without any form of heat recovery. This is probably the simplest form of thermal oxidation. The effluent stream is introduced into a combustion chamber near a burner and retained long enough to achieve the required level of oxidation; and
- direct combustion regenerative and recuperative units. The terms regenerative and recuperative refer to the type of heat exchange process being used to increase the efficiency of the system by preheating the incoming effluent stream.

The recuperative heat exchange process involves an exchange of heat between the incoming cold gaseous effluent stream and the outgoing, cleaner, hot exhaust gases following the oxidation process. This does not involve the storage of heat. It generally relies on the conduction of heat from one side of a metal tube or plate to the other.

The regenerative process involves the storage of heat from the cleaner exhaust gases in a large packed bed of suitable, dense ceramic material. More than one heat exchanger is provided which then operates on an alternating cycle. Heat is stored from the exhaust gases which pass through the unit in one cycle and is then used to heat the incoming gaseous effluent stream in the next cycle (using a cross/reverse flow principle).

Recuperative and regenerative catalytic oxidisers are also used. These use a catalyst to accelerate the process and can achieve oxidation at lower temperatures in the region of 200°C to 540°C.

In some installations, a rotor concentrator is utilised to absorb VOCs from a high volume, low concentration process air-stream and then desorb them to produce a reduced volume, high concentration stream before the thermal process, thus making the process more efficient. The VOC component is adsorbed onto a rotor concentrator wheel and the clean air exhausted; the adsorbed VOCs are subsequently desorbed to the oxidiser. Adsorption is an exothermic process and so many rotor concentrators use zeolite wheels as these reduce the fire risk; zeolite is not combustible and does not promote polymerisation of the materials being processed.

Thermal oxidation plants present similar fire hazards to other direct fired furnaces and ovens. The added complication, however, is that they are used for the processing of gaseous effluent containing flammable substances or explosive mixtures. The oxidation unit is part of a process combining the hazards not only from the unit itself, but also from processes upstream supplying the gaseous effluent to the unit and from those downstream, ie the heat exchangers and recirculation systems. Potential hazards associated with the process are set out in Figure 1 and Table 1.

RECOMMENDATIONS

1. Compliance with fire safety legislation

1.1 Fire risk assessments of all premises containing thermal oxidation plants should be undertaken in accordance with the Regulatory Reform (Fire Safety) Order 2005 or the equivalent legislation in Scotland and Northern Ireland (refs. 1-5)

1.2 An assessment should also be undertaken in accordance with the requirements of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 (ref. 5).

1.3 The scope of the risk assessments should address idle time, maintenance, routine servicing and cleaning operations.

2. Business continuity

2.1 Even a small fire can have a disproportionate effect on a business if it occurs in a critical item of plant. Major items of plant such as thermal oxidisers are becoming increasingly expensive and with pressure to protect the environment they are a key part of many processes. Even a small fire that disables a thermal oxidiser temporarily can result in processes being held in abeyance with significant financial implications for the business.

2.2 All organisations should take steps to ensure the continued smooth running of their business by making a suitable emergency plan. Guidance for this is set out in **Business resilience: A guide to protecting your business and its people** (ref. 6). The emergency plan should address the implications of a fire, flood or other perceived disaster on all facets of the business model. It should indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of manufacturing plant.

2.3 When complete, the emergency plan should be tested by means of a table top exercise, with the results being assessed and amendments made to the plan as necessary.

2.4 Consideration may be given to applying commercially available computer programmes, such as the **ROBUST** software (**Resilient Business Software Toolkit**) that is available free of charge (ref. 8), or other appropriate product, to develop and check the adequacy of the plan.

3. Fire safety management

3.1 The fire safety management of the facility will rely on the following important registers and information which will usually be provided by the supplier at the time of installation and must be retained and observed, together with appropriate records:

- a handbook for the management and operation of the system that incorporates the hazards associated with the plant, recommendations for its safe use and hazards associated with residual gases and confined spaces; and
- recommendations and requirements for inspection and maintenance of the system including safety systems, correct inspection/maintenance functions and their frequencies.

3.2 Fire safety management will be enhanced by:

- understanding and controlling the hazards from up-stream risks. For example, it can be preferable to control the use of flammable solvents automatically to prevent overloading the thermal oxidation plant and causing an increase in concentrations of flammable vapours which could reach or exceed the lower explosive limit. If solvent handling in the process is undertaken manually, this will need to be controlled by well trained staff. In both cases, adequate procedures will need to be implemented to ensure the desired minimum concentrations are not exceeded;
- ensuring that suitable emergency procedures are implemented and rehearsed periodically; and
- ensuring all relevant staff are adequately trained in the process hazards, systems of work and emergency procedures for the plant.

3.3 Good liaison is often established by inviting the fire and rescue service to visit the site and be involved in an emergency evacuation of the premises.

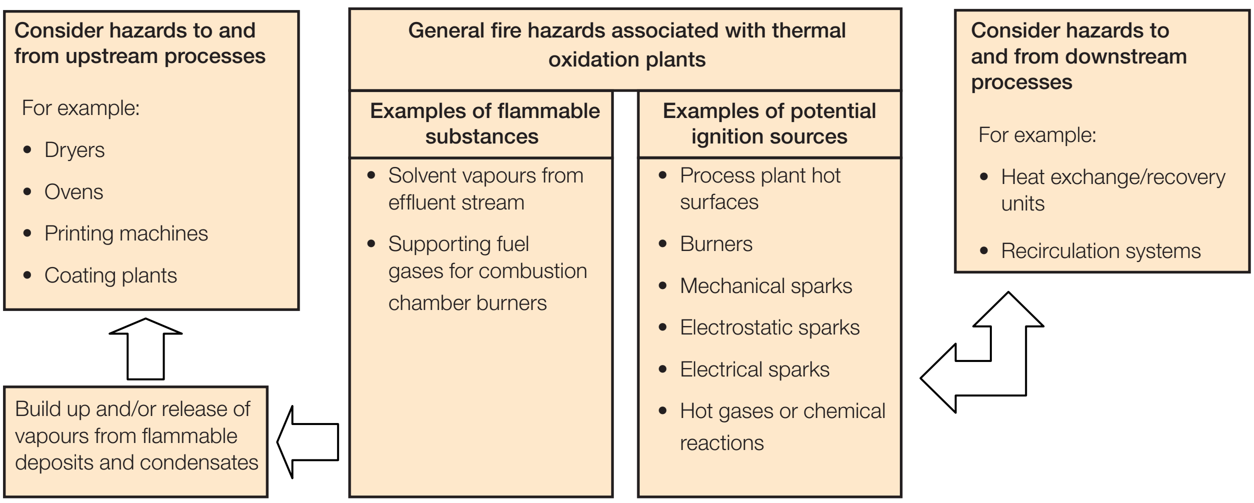

Figure 1: Overview of potential fire hazards

Fire/Explosion Hazard	Details
The generation and accumulation of mixtures above their lower explosive level (LEL) within the thermal oxidising plant	Any of the following has the potential to result in the accumulation of a flammable mixture: • Exceeding the maximum flammable concentration levels for the gaseous effluent being treated as per BS EN 12753: 2005 + A1: 2010 (ref. 8) • Linking more than one source of gaseous effluent to a single thermal oxidising plant without considering the accumulative effect on the likely overall concentration of the flammable vapour • A build up of condensate and deposits due to poor design, incorrect operation of the process or lack of purging after shutdown of the upstream plant, or before starting the plant • A lack of inspection and cleaning of the ducts, filters and similar of the ducts and filters. • Insufficient forced ventilation or insufficient oxidation • Absorption of flammable residue on the surfaces of the catalytic elements where used
Failure of process hardware or software	Possibility of: • Unintended start-up or shutdown • Impairment of ventilation and burner management systems
Potential ignition sources	Includes: • Hot surfaces-which may be exacerbated if overheating occurs • Burners using open flames • Mechanical and electrical sparks from malfunctioning equipment • Hot work
Exposure to fire from surrounding areas	Includes: • Possible overheating of the unit • Possible failure/malfunction of critical process control functions such as heating systems, forced ventilation and damper controls • Release of supporting fuel supplies if supply lines are breached • Propagation of fire from up-stream processes supplying gaseous effluent requiring thermal cleaning

Table 1: Specific fire and explosion hazards

3.4 Information should be provided for the fire and rescue service at a prominent location to indicate:

- the layout of the site;
- the location of the thermal oxidation plant;
- the location of emergency shutdown points for the process(es) and thermal oxidation plant;
- the nature of the automatic fire suppression system(s) and the location of any controls;
- contact details for specialist staff who may need to be consulted; and
- the location of hydrants, rising mains or other sources of water for firefighting purposes.

4. General considerations

4.1 Thermal oxidation plants may vary in size and capacity depending on the process being served. All such plant, however, should be designed and installed in accordance with BS EN 12753 (ref. 8).

4.2 As ignition sources exist due to the inherent nature of the process, fire safety measures should focus on preventing flammable vapours accumulating above their lower explosive limit. The prevention of the build-up of deposits, any condensation of flammable products and the control of ignition sources additional to those inherent in the process need to be addressed.

4.3 Where possible, thermal oxidation plants should be separated from surrounding processes by a form of non-combustible construction providing at least two hours' fire resistance or be sited in open air at least 10m from other buildings, plant and stored materials. The space between the plant and surrounding processes should be maintained clear of idle pallets, dry undergrowth and other combustible materials. Where a gap of 10m is not practicable due to the limited size of the facility, or for other valid considerations, the risk assessment should take into consideration the exposure risks to and from surrounding buildings, plant and processes when determining a suitable location for the thermal oxidation plant.

4.4 Heaters and heating systems should be designed to an appropriate standard. Heating systems involving gas burners should fulfil the requirements of EN 746-2 (ref. 10), or for electrical heating systems IEC60519-1 (ref. 11). The heating system should include suitable monitoring instruments and interlocks. High temperature shutdown devices and/or heat reduction systems should be fitted to avoid an unsafe condition arising through the failure of the temperature control system.

4.5 To help ensure efficiency in systems using catalysts, careful consideration should be given to selecting a catalytic material that is compatible with the gaseous effluent to be treated. Suitable preheating of the plant and the control of minimum inlet gas temperatures will help prevent absorption of the product by the catalytic material.

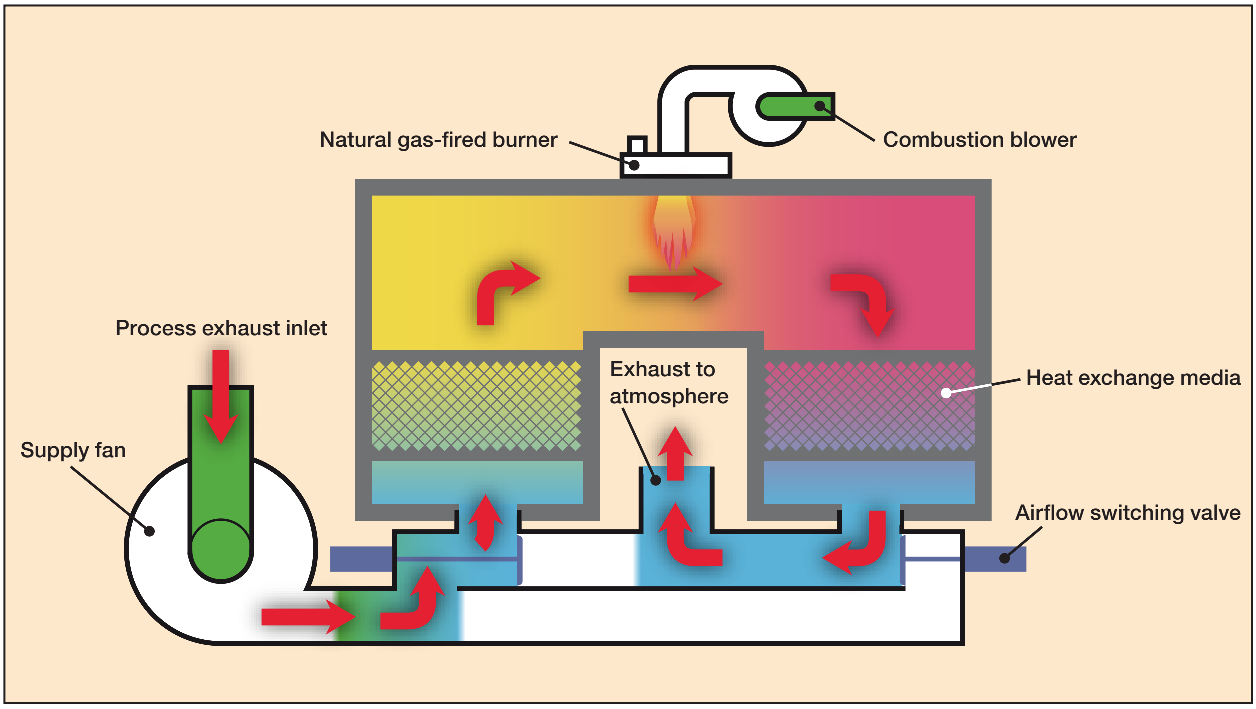

Figure 2: Simplified layout of a thermal oxidiser

4.6 The installed monitoring and control system should cover the whole plant including the flammable vapour generating process(es), pipework, ducting and thermal oxidiser. The system should ensure that emergency measures, including isolation of the thermal oxidiser from the source of flammable materials, occur quickly and reliably as soon as hazardous conditions, such as inadmissible concentrations of flammable materials, are detected.

4.7 Inlet gases need to be filtered where dusts that may adversely affect the efficiency of the process may be present.

4.8 When the waste process has high moisture content, consideration should be given to removing some of the excess moisture upstream from the thermal oxidiser. Even so, where a high level of excess moisture may be present in the waste stream a knock-out tank may be required. This tank should incorporate a drain or sump to allow condensates to be removed.

4.9 A high degree of reliability is necessary from process control equipment, particularly where safety related parts of a system are concerned. As a result, all safety related parts of the control system should meet the requirements of EN ISO 13849-1 (ref. 12).

Explosions

4.10 In addition to fire, the likelihood of explosions and the need for explosion protection provision commensurate with the level of risk should be identified and provided.

4.11 Explosion relief systems must discharge to a safe place and not into a workroom or other enclosed area. The design and implementation of protection or mitigation measures should be consistent with the likely operating conditions within the system. In particular, the hazards associated with the use of flame arrestors, such as backpressure and blockages, should be fully assessed before they are used in systems handling materials that may accumulate, form deposits, polymerise, condense or congeal.

During start-up

4.12 Before operations commence in plants incorporating a catalyst it should be ensured that the minimum inlet temperature for effective catalytic oxidation is identified and the temperature of the polluted gas stream entering the catalytic reactor can be monitored and controlled during operation. Provisions should be provided to prevent the system from being used when the inlet temperature is too low.

4.13 To ensure that adequate forced ventilation is provided to prevent flammable concentrations from developing, especially in plant incorporating a catalyst, the system should be purged during the start-up phase and prior to ignition. All spaces within the system and ductwork must be purged and any ducts not in use should be shut-off at the inlet to the collection duct. Minimum flow rates should be continuously monitored by flow control devices and variable speed fans should be interlocked with the air volume controls to manage fan speeds.

4.14 During start up or when the vent stream composition approaches the flammable range it may be necessary to utilise provisions to divert the polluted gas stream around the incinerator and directly to the stack or other discharge point. If this process is necessary care must be taken not to breach environmental levels of pollutants. The hazards associated with fire or explosion during the discharge of untreated potentially flammable mixtures should be fully identified during the assessment and appropriate arrangements made to ensure safe operation.

4.15 Controls and alarms for the vent system should include:

- high temperature alarms to detect flashback to flame and detonation arrestors; and
- interlocks to shut down the feed if flammable liquid is detected in the knockout tank.

During normal operation

4.16 When considering the prevention of flammable mixtures arising within the oxidiser, attention should be paid to controlling the concentration of inlet gases, avoiding the accumulation of solid deposits and liquid condensates and ensuring adequate forced ventilation. Regular inspections should be made and any solids and condensates removed.

4.17 Inlet concentrations should be kept well below the lower explosive limit of the vapours involved. For example, BS EN 12753 (ref. 9) recommends that inlet concentrations with less than 25% hydrocarbon content be limited to a maximum of 25% of the lower explosive limit while those with a hydrocarbon concentration of above 25% be limited to a maximum of 20% of the lower explosive limit.

4.18 BS EN 12753 also accommodates a higher concentration in relation to the maximum percentage of the lower explosive limit where the temperature of the heat exchanger does not exceed 450°C. This is, however, limited to 50% of the lower explosive limit. Where inlet concentrations cannot be ensured, the concentrations should be monitored and interlocked with dampers to dilute the process gas, isolate the process gas or bypass the system.

4.19 A thermal oxidiser should not be operated outside the conditions summarised in paragraphs 4.17 and 4.18 unless there is documented and well-established scientific or experimental data to show that this is safe and the following have also been completed:

- a suitable and sufficient assessment of the risks associated with use of the thermal oxidiser, flammable source(s), pipework, ducts and equipment has been carried out and documented in accordance with the requirements of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (ref. 5);
- the design, installation and operation of the thermal oxidiser system embody the measures required by the risk assessment; and
- appropriate documented operating instructions, maintenance information and training are provided. These should include defined permitted operating conditions, especially the maximum concentration of flammable substances, specific instructions and information to maintain safe operation and actions and responsibilities in the event of an emergency.

4.20 The build-up of deposits and condensates should be managed by ensuring that:

- the system temperatures are kept high enough in all relevant areas to prevent condensation;
- that ducts are designed and installed to prevent build-up;
- that suitable access is provided for effective inspection and cleaning where deposits may occur;
- that the system is effectively purged after shutdown.

4.21 In processes where cleaned gases are re-circulated, the possibility of insufficient oxidation of incoming gases needs to be prevented through effective monitoring and control of re-circulated gases, to prevent the build up of an explosive atmosphere.

4.22 If overheating occurs due to loss of temperature control within the combustion chamber, the heating system should be shut down and the supply of flammable substances into the thermal oxidiser system should be isolated. Consideration should also be given to incorporating purging/cooling arrangements that are initiated as part of the high temperature shutdown procedure.

4.23 The system should also be designed to shut down automatically in the event of:

- electrical power loss to the control panel;
- excessive outlet temperature; or
- burner malfunction.

4.24 Ignition prevention provisions should include:

- limiting the temperatures of hot plant surfaces to below the ignition point of the vapours of the solvents involved as described in BS EN 1127-1 (ref. 13);
- providing suitable insulation for surfaces where required. Insulation should not increase the fire risk or contribute to overheating;
- taking adequate precautions to avoid electrostatic charges where this has been identified as a potential problem. Further guidance is provided in BS EN 13463-1 (ref. 14);
- ensuring that areas within the process where hazardous atmospheres may occur have been identified and that all equipment, both electrical and non electrical, are rated and suitable for use in potentially explosive atmospheres. Further guidance in this regard is provided in BS EN 1127-1, BS EN 13463-1 and BS EN 13463-5 (refs. 13, 14 and 15);
- burner management provisions such as interlocks with forced ventilation controls and support burner fuel supplies;
- providing adequate temperature controls with interlocks and cut-outs; and
- the control of hot work as set out in RC7: **Recommendations for hot work** (ref. 16).

During shut down

4.25 Following the shutdown of the process producing vapours or dusts, the thermal oxidiser system and the relevant ductwork should be drained and purged to ensure that all residual flammable substances are removed before the furnace is shut down. If this is not done then a flammable atmosphere may be produced within the system as the deposits of material evaporate over time.

4.26 Following the shutdown of the process at least five complete air changes of the pipework/ductwork and the thermal oxidiser plant should be drawn through the system to ensure that all residual flammable substances have been removed and incinerated. The airflow through the plant used during the purge should be at least 25% of the maximum flow for the plant. During the purging process care should be taken to ensure that all parts of the plant are effectively purged and that no 'dead-legs' containing flammable substances remain.

4.27 Effective inspection, maintenance and fire safety management regimes must be observed in accordance with the instructions of the manufacturer or installer of the plant. They should include:

- Weekly or monthly as appropriate:
  - checks of moving parts, including the tension and wear of any fan belts;
  - checks of lubrication levels;
  - visual leak inspections.
- Annual preventive maintenance checks of:
  - oxidation efficiency;
  - electrical systems;
  - temperature and pressure controls;
  - the condition of mechanical components.

4.28 Some industries produce significant levels of particulate matter in the waste stream. When plant operations involve high levels of particulate matter consideration should be given to using special ceramic media in the design of the thermal oxidiser as this design allows a burn out cycle to be adopted. This burn-out cycle acts as a self cleaning feature by super heating the lower areas of the ceramic media bed and burning off any particulate matter that has not been able to cycle through the system. This feature will assist in minimising plant down time from media bed plugging and help reduce unwanted pressure drops within the system. The procedure should be adopted as part of the regular maintenance program.

Some designs of smaller items of thermal oxidisers incorporate a bin or access hatch that may be used to facilitate regular removal of accumulations of solid particles.

4.29 Measures should be in place to ensure that process waste streams containing dangerous substances are not permitted to enter any type of thermal oxidiser that is not operating, or is below its specified minimum operating temperature.

4.30 While shut down, the thermal oxidiser system should not be used as a vent for process streams; such use is dangerous and can produce hazardous conditions. It may result in flammable materials remaining in the plant which may subsequently desorb from the refractory lining or catalyst and produce a flammable atmosphere inside the plant when the system is next started up. In these circumstances an explosion is likely to occur.

5. Fire protection

5.1 The installation of an automatic fixed fire suppression or deluge system is strongly recommended as the facility is likely to run unattended. The fire suppression system should be designed to BS EN 12845 (ref. 17) or other recognised standard and operate automatically as soon as a fire is detected. The installation should be designed so as to minimise the likelihood of an unwanted actuation. In view of the heat sources present the most appropriate method for adoption may take the form of fusible links or other suitable mechanisms which react to the presence of excessive heat.

5.2 Fixed fire suppression systems should be designed, installed, commissioned and maintained by a company with accreditation by an independent UKAS accredited third party certification body as complying with the requirements of LPS 1204 (ref. 18) or other appropriate standard.

5.3 Suppression systems should be tested and maintained according to the requirements of the relevant British Standard and/or the installer's recommendations by a competent engineer with accreditation by an independent UKAS accredited third party certification body. Suitable records should be kept.

5.4 On operation of the fire suppression system, the process should automatically shut down and signalling be activated at any remote control point. During this process dampers should be controlled in accordance with the design parameters of the plant to ensure that the concentration of flammable vapours does not exceed their lower explosive limit.

5.5 Arrangements should be in place for the prompt recommissioning of an automatic fire suppression system that has actuated. Back up supplies of extinguishing agents should be kept or arrangements made for their immediate replacement.

5.6 Following actuation of the fire suppression system, the process must not be left working unattended until:

- the automatic fire suppression system has been fully recommissioned, and
- the equipment has been inspected and found to be serviceable by a competent person, or
- appropriate repairs have been undertaken or replacement parts fitted by a competent person to render the equipment serviceable.

5.7 In addition to any automatic extinguishing system, a suitable number of appropriate portable fire extinguishers should be available and immediately accessible in the case of a fire. Such portable extinguishers should be approved and certified by an independent, third party certification body and be installed in accordance with BS 5306-8 (ref. 18) and inspected and maintained in compliance with BS 5306-3 (ref. 20).

6. Checklist

		Yes	No	N/A	Action required	Due date	Sign on completion
6.1	**Compliance with fire safety legislation (section 1)**						
6.1.1	Have fire risk assessments of all premises containing thermal oxidation plants been undertaken in accordance with the Regulatory Reform (Fire Safety) Order 2005 or the equivalent legislation in Scotland and Northern Ireland? (1.1)						
6.1.2	Has an assessment also been undertaken in accordance with the requirements of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002? (1.2)						
6.1.3	Has the scope of the risk assessments addressed idle time, maintenance, routine servicing and cleaning operations? (1.3)						
6.2	**Business continuity (section 2)**						
6.2.1	Is the management of the organisation aware that even a small fire that disables a thermal oxidiser temporarily can result in processes being held in abeyance with significant financial implications for the business? (2.1)						
6.2.2	Has your organisation taken steps to ensure the continued smooth running of the business by making a suitable emergency plan? (2.2)						
6.2.3	Has the emergency plan been tested by means of a table top exercise, with the results being assessed and amendments made to the plan as necessary? (2.3)						
6.2.4	Has consideration been given to applying commercially available computer programmes to assist in ensuring the continuity of the business? (2.4)						
6.3	**Fire safety management (section 3)**						
6.3.1	Does the fire safety management of the facility rely on registers and information provided by the supplier at the time of installation and which is retained and observed records? (3.1)						
6.3.2	Is fire safety management enhanced by: • understanding and controlling the hazards from up-stream risks; • ensuring that suitable emergency procedures are implemented and rehearsed periodically; and • ensuring all relevant staff are adequately trained in the process hazards, systems of work and emergency procedures for the plant? (3.2)						
6.3.3	Has good liaison been established by inviting the fire and rescue service to visit the site and become involved in an emergency evacuation of the premises? (3.3)						
6.3.4	Is appropriate information provided for the fire and rescue service at a prominent location? (3.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.4	**General considerations (section 4)**						
6.4.1	Is the thermal oxidation plant designed and installed in accordance with BS EN 12753? (4.1)						
6.4.2	Do fire safety measures, including those to prevent build-up of deposits, condensation of flammable products and the control of ignition sources, focus on preventing flammable vapours accumulating above their lower explosive limit? (4.2)						
6.4.3	Is the thermal oxidation plant separated from surrounding processes by a form of non-combustible construction providing at least two hours' fire resistance or, alternatively, sited in open air at least 10m from other buildings, plant and stored materials, with the space between the plant and surrounding processes maintained clear of idle pallets, dry undergrowth and other combustible materials? (4.3)						
6.4.4	Do heating systems involving gas burners fulfil the requirements of EN 746-2, or for electrical heating systems IEC60519-1, and do they include suitable monitoring instruments and interlocks? (4.4)						
6.4.5	To help ensure efficiency in systems using catalysts, is careful consideration given to selecting a catalytic material that is compatible with the gaseous effluent to be treated? (4.5)						
6.4.6	Does the installed monitoring and control system cover the whole plant including the flammable vapour generating process(es), pipework, ducting and thermal oxidiser? (4.6)						
6.4.7	Does the control system ensure that emergency measures, including isolation of the thermal oxidiser from the source of flammable materials, occur quickly and reliably as soon as hazardous conditions, such as inadmissible concentrations of flammable materials, are detected? (4.6)						
6.4.8	Are inlet gases filtered where dusts that may adversely affect the efficiency of the process may be present? (4.7)						
6.4.9	Where the waste process has high moisture content, has consideration been given to removing some of the excess moisture upstream from the thermal oxidiser? (4.8)						
6.4.10	Where a high level of excess moisture may be present in the waste stream has consideration been given to providing a knock-out tank incorporating a drain or sump to allow condensates to be removed? (4.8)						
6.4.11	Do all safety related parts of the control system meet the requirements of EN 13849-1 to ensure a high degree of from process control equipment, particularly where safety related parts of a system are concerned? (4.9)						
6.4.12	Has the need for explosion protection provision commensurate with the level of risk been identified and provided? (4.10)						
6.4.13	Do explosion relief systems discharge to a safe place and not into a workroom or other enclosed area? (4.11)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.4.14	Have the hazards associated with the use of flame arrestors, such as backpressure and blockages, been fully assessed before they are used in systems handling materials that may accumulate, form deposits, polymerise, condense or congeal? (4.11)						
6.4.15	Where applicable, has the minimum inlet temperature for effective catalytic oxidation been identified and is the temperature of the polluted gas stream entering the catalytic reactor monitored and controlled during operation? (4.12)						
6.4.16	Have provisions been provided to prevent the system from being used when the inlet temperature is too low? (4.12)						
6.4.17	Is the system purged during the start-up phase and prior to ignition to ensure that adequate forced ventilation is provided to prevent flammable concentrations from developing, especially in plant incorporating a catalyst? (4.13)						
6.4.18	If it is necessary to utilise provisions to divert the polluted gas stream around the incinerator and directly to the stack or other discharge point during start up or when the vent stream composition approaches the flammable range, is care taken not to breach environmental levels of pollutants? (4.14)						
6.4.19	Have the hazards associated with fire or explosion during the discharge of untreated potentially flammable mixtures been fully identified during the assessment and have appropriate arrangements made to ensure safe operation? (4.14)						
6.4.20	Do controls and alarms for the vent system include high temperature alarms to detect flashback to flame and detonation arrestors and interlocks to shut down the feed if flammable liquid is detected in the knockout tank? (4.15)						
6.4.21	When considering the prevention of flammable mixtures arising within the oxidiser, is attention paid to controlling the concentration of inlet gases, avoiding the accumulation of solid deposits and liquid condensates and ensuring adequate forced ventilation? (4.16)						
6.4.22	Are regular inspections made within the oxidiser and any solids and condensates removed? (4.16)						
6.4.23	Are inlet concentrations kept well below the lower explosive limit of the vapours involved? (4.17)						
6.4.24	Where inlet concentrations of flammable gases cannot be ensured, are the concentrations monitored and interlocked with dampers to dilute the process gas, isolate the process gas or bypass the system? (4.18)						
6.4.25	If a thermal oxidiser is to be operated outside the conditions summarised in paragraphs 4.17 and 4.18 is there documented and well-established scientific or experimental data to show that this is safe? (4.19)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.4.26	Is the build-up of deposits and condensates suitably managed? (4.20)						
6.4.27	In processes where cleaned gases are re-circulated, is the possibility of insufficient oxidation of incoming gases prevented through effective monitoring and control of re-circulated gases, to prevent the build up of an explosive atmosphere? (4.21)						
6.4.28	If overheating occurs due to loss of temperature control within the combustion chamber, is the heating system shut down and the supply of flammable substances into the thermal oxidiser system isolated? (4.22)						
6.4.29	Is the system designed to shut down automatically in the event of electrical power loss to the control panel, excessive outlet temperature or burner malfunction? (4.23)						
6.4.30	Have provisions been taken to prevent ignition? (4.24). These should include: • limiting the temperatures of hot plant surfaces to below the ignition point of the vapours of the solvents • providing suitable insulation for surfaces where required; • taking adequate precautions to avoid electrostatic charges; • ensuring that areas within the process where hazardous atmospheres may occur have been identified and that all equipment is rated and suitable for use in potentially explosive atmospheres; • the provision of burner management systems such as interlocks with forced ventilation controls and support burner fuel supplies; • the provision of adequate temperature controls with interlocks and cut-outs; • the control of hot work as set out in RC7.						
6.4.31	Following the shutdown of the process producing vapours or dusts, is the thermal oxidiser system and the relevant ductwork drained and purged to ensure that all residual flammable substances are removed before the furnace is shut down? (4.25)						
6.4.32	Following the shutdown of the process, are at least five complete air changes of the pipework/ductwork and the thermal oxidiser plant drawn through all parts of the system to ensure that all residual flammable substances have been removed and incinerated? (4.26)						
6.4.33	Are effective inspection, maintenance and fire safety management regimes observed in accordance with the instructions of the manufacturer or installer of the plan? (4.27)						
6.4.34	When plant operations involve high levels of particulate matter is consideration given to using special ceramic media in the design of the thermal oxidiser to allow a burn out cycle to be adopted? (4.28)						
6.4.35	Are measures in place to ensure that process waste streams containing dangerous substances are not permitted to enter any type of thermal oxidiser that is not operating, or is below its specified minimum operating temperature? (4.29)						
6.4.36	While shut down, is care taken to prevent the thermal oxidiser system from being used as a vent for process streams? (4.30)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.5	**Fire protection (section 5)**						
6.5.1	Has the installation of a fixed fire suppression or deluge system been considered? (5.1)						
6.5.2	Where a fixed fire suppressions system has been installed is it designed to BS EN 12845 or other recognised standard and to operate automatically as soon as a fire is detected? (5.1)						
6.5.3	Is the fixed fire suppression system designed, installed, commissioned and maintained by a company with accreditation by an independent UKAS accredited third party certification body as complying with the requirements of LPS 1204 or other appropriate standard? (5.2)						
6.5.4	Are suppression systems tested and maintained according to the requirements of the relevant British Standard and/or the installer's recommendations by a competent engineer with accreditation by an independent UKAS accredited third party certification body? (5.3)						
6.5.5	On operation of the fire suppression system, does the process shut down automatically and signalling activate at any remote control point? (5.4)						
6.5.6	Are arrangements in place for the prompt recommissioning of an automatic fire suppression system that has actuated? (5.5)						
6.5.7	After actuation of the fire suppression system, is the process not permitted to be left working unattended until the following measures have been observed? (5.6) • the automatic fire suppression system has been fully recommissioned, and • the equipment has been inspected and found to be serviceable by a competent person, or • appropriate repairs have been undertaken or replacement parts fitted by a competent person to render the equipment serviceable.						
6.5.8	In addition to any automatic extinguishing system, are a suitable number of appropriate portable fire extinguishers available and immediately accessible in the case of a fire? (5.7)						
6.5.9	Are portable extinguishers approved and certified by an independent, third party certification body, installed in accordance with BS 5306-8 and inspected and maintained in compliance with BS 5306-3? (5.7)						

REFERENCES

1. Regulatory Reform (Fire Safety) Order 2005, SI 2005 No 1541, The Stationery Office.
2. The Fire (Scotland) Act 2005, asp 5, The Stationery Office.
3. Fire Safety (Scotland) Regulations 2006, Scottish SI 2006 No 456, The Stationery Office.
4. Fire and Rescue Services (Northern Ireland) Order 2006, SI 2006 No 1254 (NI9), The Stationery Office.
5. Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), 2002, SI 2002 No 2776, The Stationery Office.
6. The Fire Safety Regulations (Northern Ireland) 2010, SI 2010 No 315, The Stationery Office.
7. **Business Resilience: A guide to protecting your business and its people**, 2005, Fire protection Association.
8. The **ROBUST** software (**Resilient Business Software Toolkit**) may be found at https://robust.riscauthority.co.uk
9. BS EN 12753: 2005 + A1: 2010: **Thermal cleaning systems for exhaust gas from surface treatment equipment – Safety requirements**, British Standards Institution.
10. BS EN 746-2: 2010: **Industrial thermoprocessing equipment. Safety requirements for combustion and fuel handling systems**, British Standards Institution.
11. BS EN 60519-1: 2011: **Safety in electroheating installations. General requirements**, British Standards Institution.
12. BS EN ISO 13849-1: 2008: **Safety of machinery. Safety-related parts of control systems. General principles for design**, British Standards Institution.
13. BS EN 1127-1: 2011: **Explosive atmospheres. Explosion prevention and protection: Basic concepts and methodology**, British Standards Institution.
14. BS EN 13463-1: 2009: **Non-electrical equipment for use in potentially explosive atmospheres: Basic method and requirements**, British Standards Institution.
15. BS EN 13463-5: 2011: **Non-electrical equipment intended for use in potentially explosive atmospheres. Protection by constructional safety 'c'**, British Standards Institution.
16. RC7: **Recommendations for hot work**, 2012, Fire Protection Association.
17. **LPC Rules for automatic sprinkler installations incorporating BS EN 12845: Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance**, British Standards Institution, 2009, Fire Protection Association.
18. LPS 1204: **Requirements for firms engaged in the design, installation and commissioning of firefighting systems**: Issue 12.1: 2005, Loss Prevention Certification Board.
19. BS 5306-8: 2000: **Fire extinguishing installations and equipment on premises. Selection and installation of portable fire extinguishers. Code of practice**, British Standards Institution.
20. BS 5306-3: 2009: **Fire extinguishing installations and equipment on premises. Commissioning and maintenance of portable fire extinguishers. Code of practice**, British Standards Institution.

FURTHER READING

NFPA 86 Standard for ovens and furnaces.

FM global Property Loss Prevention Data Sheets 6-11 Fume Incinerators.

RC39: **Recommendations for fire risk management in the printing industry Part 1: Printing Processes: General Principles**, 2007, Fire Protection Association.

The safe use of thermal oxidiser (Incineration) systems for potentially flammable mixtures, 2004, HSE.

The Provision and Use of Work Equipment Regulations 1998.

Air Pollution Training Institute, APTI 415: **Control of gaseous emissions**, Chapter 6, United States EP.

Fire Protection Association
London Road, Moreton in Marsh
Gloucestershire GL56 0RH, UK
Tel: +44 (0)1608 812500 Fax: +44 (0)1608 812501
Email: administrator@riscauthority.co.uk
Website: www.riscauthority.co.uk

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