REDUCING FIRE RISK AT WASTE MANAGEMENT SITES

NOTE: Below endorsements etc section dependent on organisation support renewal

This is the second edition of the WISH reducing fire risk at waste management sites guidance, the original document having been released in October 2014. It has been prepared by the Waste Industry Safety and Health (WISH) Forum, and is supported by, ESA (Environmental Services Association), The Scottish Environment Protection Agency (SEPA), Natural Resources Wales (NRW), The Health and Safety Executive (HSE), the Chief Fire Officers Association (CFOA), CIWM (Chartered Institution of Wastes Management) and other bodies. Specific messages from the HSE and EA are included at the end of this introduction. In addition, the main insurers providing cover to the waste management sector have been consulted for their views.

The aim of this document is to provide waste management operators with the guidance, information and standards to allow them to:

- Reduce the likelihood and frequency of fires at solid waste management sites
- Where fires do occur, reduce the potential safety, health, property damage, business interruption and environmental impacts

This guidance is intended as an umbrella document: It gives advice applicable to a wide range of waste management and similar sites which handle solid combustible wastes, but it cannot cover every specific aspect of all forms of waste management operation. As knowledge develops and as better information becomes available, further revisions of this guidance will be made to keep it up to date.

CIWM esa environmental services association CFOA Chief Fire Officers Association

It is also accepted that future guidance from sector specific bodies, or regulators, on specific waste technologies and/or specific wastes may impose higher standards. WISH would welcome the development of such specific guidance. Where such sector guidance is produced, and where appropriate, future revisions of this guidance will include signposts to such documents. If you are in any doubt about the standards which apply to your circumstances you should seek the advice of your regulators. You must always comply with regulatory standards and guidance.

It is not the intent of this guidance to be inflexible, and options and considerations have been given throughout to allow operators to tailor it to their circumstances. Nor is it the intent to provide a one-stop-shop for waste management and similar sites on fire risk – existing guidance and standards on general fire management and control, in particular on life-safety, should be read in conjunction with this guidance. It is the intent of this guidance to provide a framework through which operators can reduce the risk of fire on their sites and minimise the business and societal impacts of any fires that do occur.




Contents

For ease of reading this guidance is split: The first part covers general issues such as scope and fire risks. The second part provides specific guidance for waste management sites in four areas: Whole site issues, issues in waste reception, during waste treatment and for the storage of wastes. Appendices are also included on issues such as external storage, fire engineering and checklists to help you assess if your fire control is adequate.

To aid readers in seeing what has changed since the 2014 version of this guidance, a summary of main changes is provided at the start of each section, in green italic text.

Tips – throughout this publication you will find 'tips' in text boxes. These are from the experience of various waste management operators and other persons. They should not be considered part of formal guidance and are there simply to provide informal advice. They are intended to inform and share knowledge and you should consider these tips in the light of your own site specific requirements and your own individual situation.

1. Introduction and scope

Summary main changes from 2014 guidance: *A new section outlining changes made since 2014 has been added below, including what these changes are based on, a summary of the waste burn trials conducted in 2015 and 2016 and some detail changes and additions.*

Fire is an ever-present possibility at most waste management sites, if only because many wastes are readily combustible. Operators should therefore ensure they have adequate controls in place to prevent fires and, should a fire occur, that the risks to human health, property and the environment are minimised.

This guidance aims to give an overview of fire safety management on solid waste management sites (see scope in section 1.4). It is not the intent to provide a comprehensive guide on all aspects of fire safety, to duplicate general fire management guidance which is available elsewhere or to provide in-depth technical advice. It is your responsibility to ensure that your management of fire safety is adequate. For guidance on sources of competent advice see the glossary section of this guidance under 'competent advice'.

1.1 WISH waste fires guidance version II (what has changed?)

1.1.1 This is the second version of the WISH waste fires guidance. The original guidance was issued in October 2014. This current version II is substantially different in many respects. The main drivers for the changes made have included waste burns trials (see sub-section 1.2) conducted in 2015 and through 2016, increased industry and fire and rescue service experience, and improved knowledge of what works for waste management. In summary:

- A new fire engineering appendix (appendix 2) has been added, giving specific guidance on fire detection, alarm and suppression/extinguishing systems at waste management sites. This has allowed the deletion of much repetitive text in the main body of the guidance, and its replacement with as more detailed guidance

- The waste burn trials, as mentioned above, have increased knowledge of how wastes burn to the extent that sections 5, 6 and 7 on waste storage, and appendix 1 on the external storage of wastes, have been revised and simplified significantly, and further savings have been made on repetitive text contained in the main body of the 2014 guidance. The same waste burn trials have also led to the deletion of the previous appendix 2 in the 2014 guidance on the internal storage of wastes

- The waste burn trials have also resulted in significant changes to stack size and separation distances information for the external storage of wastes (appendix 1). For example, the move from simple set separation distances to a 'sliding-scale' for distances based on stack length and burn-face dimensions. Older guidance, including the 2014 WISH fire guidance, was based on a variety of data from disparate sources, much of which was not based on waste specific fire science

1.1.2 Despite the above improvements in knowledge and experience, there are still areas where further work is required. For example, on self-heating and the internal storage of wastes. Future versions of this WISH fire guidance will include any developments in these remaining areas of uncertainty.

1.2 Waste fire trials 2015 and 2016

1.2.1 Prior to the publication of the original 2014 version of this guidance a thorough literature review and search was made by the HSL (Health and Safety Laboratories) and the authors of this guidance. The aim was to identify any existing guidance from across the world on waste fires, and any research and similar information on the combustion properties of wastes and how they burn. Very little relevant information was found. This weakness was noted in the consultation process for the 2014 WISH waste fire guidance.

1.2.2 In the absence of comprehensive detailed information on the combustion properties of wastes, and with an urgent need at the time to provide the waste industry with guidance on the topic of waste fire management, what information sources which could be found were used. These sources included buildings fire research, caravan fire research, information from standard insurance industry codes and other similar sources. These were used as the basis for some of the information in the 2014 guidance, such as on storage stack separation distances. WISH was not alone in this approach. Various other waste management fire guidance and similar documents from other bodies also being based on the same or similar generally non-waste information sources. The flaws of this approach were noted in the 2014 guidance, which stated: *"As knowledge on the burn properties of specific wastes improves, experience of real fires accumulates and as better information becomes available, revisions of this guidance will be made to keep it up to date."*

1.2.3 Specifically on waste storage, the consultation letter accompanying the 2014 guidance (included in the guidance as an appendix) stated: *"There is little available fire testing or science specific to wastes to provide a firm under-pinning for the available information on stack sizes and separation distances – most of the current information is based on operational and fire-fighting experience. There is data on raw materials. Much of this indicates that the separation distances in table 1 in appendix 1 are conservative and separation distances in excess of those currently available for wastes may be required at sites with no fire prevention measures. For example, data on virgin, raw paper and plastics suggests separation distances between 10 - 11 metres and 18 - 27 metres respectively – that is well in excess of those distances quoted in table 1 of appendix 1. Whether this data for raw materials can be applied direct to wastes is not known - real testing on wastes is required."*

1.2.4 To address this gap in knowledge, in 2015 and throughout 2016 a series of waste burn trials were conducted. In 2015 smaller-scale laboratory type testing was conducted at the FPA (Fire Protection Association) research premises. These 'phase 1' tests provided baseline data on parameters such as burn rates and thermal heat outputs. However, some of the results obtained from this laboratory type testing did not reflect the experience of the fire and rescue services (FRS) when actually tackling waste fires. In brief, for some parameters the laboratory type testing was missing some factor or factors relevant to actual large-scale waste fires.

1.2.5 In 2016 larger-scale waste burn trials were conducted at a sites in Yorkshire and Essex (phase 2 tests). These tests involved much larger volumes of waste and aimed to replicate as closely as practical 'real life' waste fires. The results of these tests matched much more closely the experience of the FRS when fighting real waste fires, and revealed some of the different mechanisms at play during waste fires. Both phase 1 and phase 2 tests were conducted on a variety of wastes such as loose and baled wastes, plastics, paper and board, rubber, wood wastes, waste derived fuels such as RDF and SRF and others.

1.2.6 Between the above phase 1 and phase 2 tests we now have a much better understanding of how wastes burn, and firmer fire science on which to base guidance on issues such as storage stack separation distances. The tests also provided observational information which has been used in some parts of this guidance, such as on the interlacing of bales as a potential method of reducing chimney effects (see section 5.5). All guidance needs to be revised and changed in the light of new or better information. This 2017 version of the WISH fires guidance reflects this need. A non-technical summary of the waste burn trials is available on the WISH web site.

1.3 Risks of fires

1.3.1 Fires involving wastes can cause significant harm to people, property and the environment:

- There is the risk of death and/or serious injury and health damage from high thermal energy and smoke inhalation
- Combustion products, even those from non-toxic materials, release airborne pollutants which can cause short and long term effects on human health and the environment
- Firewater run-off can transport pollutants into drainage systems, rivers and lakes, groundwater and soil, threatening water supplies, public health, wildlife and recreational use
- Property damage can be significant and costly
- Explosions, sparks and projectiles can harm people and spread any fire

1.3.2 There are also some less direct sources of harm, such as:

- The significant cost and resources burden for the Fire and Rescue Services (FRS) and other public agencies when responding to a fire
- Civil claims from third parties relating to nuisance or potential health effects and fines and/or costs levied by environmental, fire and health and safety regulators
- You are likely to be responsible for the costs of clean-up, both on and off-site under the principle of the polluter pays. This can be expensive, as in many cases the solid remains of combustion products and partially burnt material can be classified as hazardous/special waste
- Interruption to your business and third party/neighbouring businesses - a major fire could effectively put you out of business
- Insurance premiums are likely to rise substantially following a major fire, or you may not be able to secure insurance at any economic cost
- Reputational costs can be substantial and may affect how the local community and others view you
- A major fire could affect your environmental permit/licence/exemption, including any subsistence or other fees you pay
- If you lease your site a major fire could result in the termination of lease, or burdensome conditions being added to any lease

1.3.3 No one wants to have a fire, but the consequences of a major fire can be disastrous. Simply ignoring or underestimating the risk is not acceptable (legally, morally, commercially or operationally).

1.4 Scope of guidance

1.4.1 This guidance applies to sites where more than 50 cubic metres of solid combustible waste material is stored at any one time, although the principles will apply to smaller sites. You should consider this guidance for sites below 50 cubic metres, if they pose significant risks to human health and/or the environment in the event of a fire.

1.4.2 Sites which are regulated under an environmental permit/licence/exemption are within the scope of this guidance, no matter their location. The principles of this guidance also apply to sites which are not regulated under a permit/licence/exemption. Whether under a formal permit or not, you must always comply with regulatory standards.

1.4.3 This guidance applies to the storage, treatment and handling of combustible wastes such as, but not limited to:

- Mixed wastes from domestic, commercial and other sources
- Paper, cardboard, plastics, wood and wood products of all types
- Rubber (natural or synthetic), including whole, shredded, crumbed tyres
- Fragmentiser wastes, such as that from vehicle dismantling
- Refuse derived fuels (RDF), solid recovered fuels (SRF) and similar
- Any other waste which may pose a fire risk similar to the above

1.4.4 WISH covers England, Scotland and Wales. This guidance is aimed at sites in these countries, although the principles outlined are not generally confined by national boundaries.

1.4.5 This guidance supplements but does not replace any statutory requirements under Local Acts of Parliament, the Regulatory Reform (Fire Safety) Order 2005, Fire (Scotland) Act 2005 or other applicable legislation.

1.4.6 Because of their specific issues and/or existing guidance this document does not apply specifically to:

- Landfill sites (but, it would apply to a recycling plant at the entrance to a landfill site)
- Composting sites, including in-vessel, green waste composting and anaerobic digestion plants
- Hazardous/special waste treatment and transfer facilities

- Waste to energy plants, incinerators and similar thermal treatments to the extent of the thermal treatment applied. It would, however, apply to a recycling plant as pre-treatment, reception/storage and mechanical handling of wastes etc at such a facility
- Some specific aspects of ELV (end of life vehicles) operations, such as air-bag dismantling. However, the general principles in this guidance do apply to ELV
- Sites which fall under the COMAH (Control Of Major Accidents Hazards) Regulations

1.4.7 This guidance applies to fire risks associated with combustible wastes. It does not provide detailed guidance on reducing fire risk from ancillary facilities on sites such as welfare facilities, offices and similar or specific fire risks such as diesel storage tanks, gas cylinder storage and similar. You should refer to general and specific guidance for the control of fire risks associated with these non-solid waste aspects. You must also consider the risk from, and to, these facilities in your overall fire plan and assessment as they could be the source of a fire, contribute to its severity or be affected by a fire.

1.4.8 If you do not follow this guidance, or appropriate sector specific guidance, you should ensure that the measures you take are equivalent or superior, and that they comply with regulatory requirements.

1.5 Regulators

1.5.1 In most workplaces, including most solid waste management sites, your local Fire and Rescue Authority (FRA) is responsible for enforcing general fire safety and if you need advice you should contact them first.

1.5.2 Other regulators also have responsibilities: The HSE (Health and Safety Executive) covers specific risks and legislation such as DSEAR (Dangerous Substances and Explosive Atmospheres Regulations) and environmental regulators (such as the Environment Agency, Natural Resources Wales and Scottish Environment Protection Agency) cover environmental and public health risks from fires at waste sites.

1.5.3 Having a fire plan/strategy agreed with your FRA may not mean that you have satisfied all of the requirements of your environmental regulator. Likewise being compliant with your environmental permit/licence or similar may not mean you have complied with fire and safety law requirements. You must ensure you have covered all aspects of fire management in your assessments and plans. It is your duty as an operator to comply, and not the duty of regulators to ensure your compliance.

1.6 Insurers

1.6.1 While not a regulator, property insurers have a role to play and may set their own standards. You should consult with your insurer to ensure that they are involved in your decision-making process, assessments and plans. You may achieve a standard that your regulators are content protects human health and the environment adequately, but which your insurers may not be content with because of property damage and business interruption risks – different stakeholders may concentrate on different issues and you should take account of this.

Tip – gaining advice on the technical aspects fire safety can be expensive. Insurers and insurance brokers can often be a good source of free or low charge advice. Many insurers have in-house fire technical experts and they have a vested interest in you not having a fire – if you have a major fire your insurer will also suffer cost implications. Insurers are an important stakeholder in your fire plans and can often offer good advice. See appendix 2 on fire/risk engineering for more detail.

1.7 Assessment and plans

Note – this section uses the expression ‘fire plans’. Different regulators and other bodies use different expressions. An environmental regulator may use the expression ‘fire prevention plan’, and an insurer or fire engineer may use the expression ‘fire strategy’ etc. Often these regulators/bodies are talking about different aspects with the same outcome. An insurer fire engineer when using the expression ‘fire strategy’ may concentrate on fixed systems, such as sprinklers and water deluges, whereas your local FRS may want to see more about fire risk assessment, fire-fighting tactics and evacuation procedures. However, the basic principle is the same: What is the risk, how are you controlling it, and have you included it in your ‘plan’.

For small sites you may be able to combine all of the various requirements of regulators and other bodies into one ‘fire plan’ document. But, for larger sites it is likely that you will need several documents, and you may also need specific separate documents such as emergency plans and employee training documents. This is an issue for you to decide on. The section below gives the basics, how you apply these to your site will depend on your specific circumstances and the complexity of your operation.

1.7.1 In general under fire legislation you must carry out an assessment of fire risks at your site, and based on this assessment put in place appropriate controls and measures (your 'fire plan'). General guidance on fire risk assessments and plans is available on the gov.uk web site (see appendix 5 on useful links and further reading). Other stakeholders and regulators may also have their own guidance and requirements you will need to abide by. However, broadly a fire risk assessment involves:

- Identifying where on your site you have combustible and/or flammable materials
- Identifying where on your site you have potential ignition sources
- Identifying who or what (such as the environment) may be affected and how
- From the above information putting in place your plan of controls and measures aimed at reducing the risk of a fire occurring and the impact should a fire occur

1.7.2 It is your duty as an operator to produce your fire risk assessment and from this put in place appropriate controls and measures as part of your fire plan. You may seek the advice of regulators, but in the end it is not the duty of a regulator to ensure your fire assessment and plan is adequate – this is your duty.

Tip – fire risk assessments and plans can be complicated issues and you are likely to need competent advice if your site is at all complex. However, for smaller sites various cost-effective training courses are available and you could consider having one of your employees trained in fire risk assessment. Whatever the size of your site, this would also give you an accessible and in-house source of fire assessment advice for basic and general fire issues at an operational level.

1.7.3 Controls and measures as part of your fire plan may be physical, such as fire-fighting equipment or the segregation of combustible materials to prevent fire spread, or procedural, such as evacuation and emergency plans. For example:

- Your fire risk assessment may identify that wastes in reception areas (a combustible material) may be set on fire by hot exhausts on heavy mobile plant (an ignition source). You may decide that an appropriate control would be to instruct plant operatives to clear wastes from around exhausts at the end of each shift – and you should include this in your instructions/procedures to plant operatives
- You may identify that wastes (a combustible material) going through a shredder at your site (potential ignition source for reasons of friction and/or sparks) may be a fire risk. You may decide that an appropriate control measure would be to install a water drench or sprinkler system at the shredder

- You may decide that self-heating (an ignition risk) is a risk for some of the wastes (combustible material) you store at your site. You may put in place routine inspections of such wastes using thermal imaging equipment to assess if any hot-spots are occurring, and procedures on what operatives need to do in this case

1.7.4 Fire risk assessments need not be complicated, although you must ensure that you have identified all possible sources of fire and have appropriate controls in place.

1.7.5 As stated above, you must also include in your assessment who and/or what (such as the environment, or the health of third parties near to your site) may be harmed by a fire and/or the consequences of a fire. For the environment you should use the established model of source; pathway; and receptor. For example, if a fire occurs it is likely that water will be used to fight it, at least initially. This firewater will be contaminated with combustion products and other harmful substances. Where will this firewater run to and could it cause environmental damage? Your controls should address this type of consideration. Guidance on the management of firewater is contained in CIRIA Report 736 (see further reading section in appendix 5 below).

1.7.6 It is also recommended that as part of your plan that you discuss with your local Fire and Rescue Service (FRS) their likely fire-fighting strategy for your site, which may include a controlled burn to reduce firewater run-off and/or for fire fighter safety, and if water is to be used an estimate of the likely volumes of firewater that will be produced to help you determine how much containment will be required. Likely FRS fire-fighting response should be part of your assessment process.

1.7.7 For waste management sites there may also be conditions in your environmental permit/licence/exemption regarding issues such as maximum waste input and/or storage limits, requirements for environmental protection etc. These are a valid input into your assessment and must be included. Even if no such limits are stated in your licence or permit, the physical limitations of your site will impose practical limits to the amounts of waste can be handled and stored safely. These limitations should be assessed and considered as part of your fire risk assessment. Some environmental regulators may have their own guidance and requirements for fire prevention and similar plans. You should understand such guidance thoroughly. This WISH guidance should help you comply with some of such specific requirements, but in the end it is your responsibility to comply.

1.7.8 For some aspects of your fire management you may need to consult specialist guidance or take competent advice. For example:

- If you store gas cylinders (either for your use or waste cylinders) then you need to take account of this in your assessment and seek advice on issues such as cylinder cage construction and separation distances for cylinder stores
- If your waste processing plant includes dust extraction you may need to conduct a hazardous area classification (zoning) exercise under DSEAR.

1.7.9 Whatever the complexity or otherwise of your assessment and plan the aim should be to ensure you have considered all risks and put in place appropriate controls.

1.8 Technical standards

1.8.1 There is no shortage of technical standards for fire systems: These include:

- British Standards (BS Standards)
- European Standards (EN or BSEN Standards)
- Building Regulations and Standards (may vary from country to country)
- Insurance industry codes and guidance (see tip-box below)

1.8.2 For technical aspects of fire controls, such as specialist fire-fighting equipment and the standards for the installation of detection systems, you are very likely to require external specialist advice, unless you hold this competence in-house. There is little point, for example, in installing a sprinkler or deluge system if it is not to an adequate technical specification, is difficult to maintain, has not been installed correctly and/or does not meet your specific fire-fighting needs. See appendix 2 for a fuller discussion of this type of factor.

Tip – the insurance industry has produced its own codes on many aspects of fire safety management, including technical standards: Ask your insurer for advice as they will have access to these standards. For example, the guidance contained in standards and technical advice produced by the UK insurance industry through Fire Protection Association/RISC-A and the LPS standards, now produced by BRE Global. Useful other documents include those produced by the US NFPA (National Fire Protection Association) and FM Insurance (FM Global Data Sheets). These standards are generally accepted by insurers and their technical advisors/experts. If your site does not meet these standards then the purchase of insurance cover, or availability of insurance at an economic cost, may be difficult. Asking for insurer advice on technical standards in advance is likely to be better than arguing afterwards. But, beware of applying general standards to waste management where it may not be appropriate. See appendix 2 for some issues which may be associated with insurance industry guidance.

Tip – for technical standards relating to issues such as the installation of fire detection, fire fighting and fire suppression equipment, the suppliers of such equipment and reputable trade associations can often be a useful (and likely free) source of advice (although beware commercial interest, and in some cases contradictory advice). Such suppliers, especially when they hold third party certification will be familiar with applicable standards for the products they supply and how they should be installed. However, care should be exercised to ensure that your choice of equipment and supplier is appropriate to your site. For example, an installer of domestic fire equipment may not be that familiar with the standards required for industrial applications. Again, see appendix 2 for further detail.

1.8.3 Overall the technical standards applied to fire controls are complex and you need to be reassured that whatever controls you put in place meet these standards. If in doubt contact your local Fire and Rescue Service (FRS) and environmental regulator who should be able to advise you.




2. Whole site considerations

Summary of main changes since 2014 guidance: *Much of the section below is largely unchanged compared to the 2014 edition of this guidance. However, the previous sub-section on fire detection, alarm and suppression/extinguishing systems has largely been replaced by a new specific appendix 2, and additional information has been added to the sub-section on ignition sources and causes of fire at waste management sites. Changes have also been made to the sub-sections on water supply requirements, and sundry small changes and additions made based on developments in experience and knowledge since 2014.*

Typically, most waste management sites have three main areas of operation:

- A reception area/s where incoming wastes are discharged
- Treatment/processing area/s where wastes may be sorted, shredded, dried, sized etc
- Storage area/s where incoming wastes and/or outgoing wastes may be stored

These three main areas are considered in detail in the specific sections below. This section covers considerations which apply to the whole of your site and you should consider these before moving to specific issues.

Of course, not all waste sites have all three areas as above. A simple waste transfer station may only, in effect, have a reception area. However, most recycling and recovery type sites will typically have all three types of area: Reception, treatment and storage.

2.1 Protection of human life

2.1.1 Fire management must start with the protection of human life. This would include having adequate fire escape provision which is clearly marked, lit where required, not blocked and which is kept unlocked during operational hours, and effective evacuation procedures in which all staff are trained. You must ensure that you consult with existing guidance and your competent advisor to ensure that your fire management starts with the protection of human life (often called ‘life-safety’).

2.2 Location and neighbouring sites/businesses/environment

2.2.1 If you suffer a fire it may have an impact on your neighbours, such as smoke being blown towards a residential area. Conversely, a fire at neighbouring premises may affect you and may even spread to your site. Your general location may also affect the level of fire controls you put in place. For example, if your site is geographically isolated it may take a longer time for the Fire and Rescue Service (FRS) to respond.

2.2.2 Such factors which you may need to consider in your fire assessment include:

- Are there any sensitive receptors including schools, hospitals, care homes, major transport or other key infrastructure (such as main roads, railways, airports, overhead power lines etc), other businesses, shops, residential areas, rivers, canals and protected habitats that could be affected by a fire at your site?
- Where your assessment indicates that there is a risk to sensitive receptors, then you must work with your local FRS and/or your environmental regulator to reduce the risk and potential consequences of a fire
- Do any neighbouring premises pose fire risks to your site or could a fire at your site have a catastrophic effect on neighbouring premises? For example, nearby gas storage facilities or other hazardous material storage/treatment site, garages and workshops storing fuels and similar (even rail lines which can produce sparks). If this is the case you should liaise with these neighbours to ensure your and their accident/emergency plans take account of the possible risks. And, you may decide to arrange storage so that it is adequately separated from any higher-risk neighbouring premises. You may also want to hold joint fire/emergency plan drills and tests with your neighbours to ensure that in the event of a fire your response is co-ordinated
- How isolated is your site and what is the response time of the local FRS? Are your site fire-fighting provisions and water supply adequate to take account of any delay in the FRS arriving at your site?

2.3 General ignition sources, causes of waste fires and precautions

2.3.1 From industry experience, it is worth noting the general issues below:

- While your employees may know your site rules and what to do in the event of a fire, you must also ensure all visitors, contractors and drivers using your site are aware of the correct safety and fire prevention procedures to follow whilst on site

- Discarded smoking materials are a major ignition source. You should apply a no smoking policy or ensure suitable designated smoking areas are provided, situated away from combustible materials. Any designated smoking areas should be signposted and supplied with a sand bucket or similar for discarded smoking materials
- You must control general sources of ignition such as heating pipes, naked flames, space heaters etc. Stacks of combustible and flammable materials such as waste stacks and fuel storage areas should in general be at least 6 metres away from these sources, or other controls put in place to reduce the risk
- As appropriate to your location you should put site security measures in place, such as security fencing, intruder alarms and CCTV, to minimise the risk of vandalism and arson. Your arrangements should cover both the working day and outside normal hours. If your site is located in an area where vandalism and similar is common you should consider a 24 hours manned security presence, or at least 24 hour coverage such as by drive-by security runs
- Electrical faults, both in processing equipment and general electrical systems, such as lighting and heating, can be a source of ignition. You should have regular and planned inspections of your systems. This should include portable electrical appliances (PAT) testing and fixed electrical equipment. You should also seek competent advice on issues such as grounding and bonding controls for electrical systems
- Fires may smoulder undetected after the end of the working day/shift. You should consider formal site ‘close-down’ procedures including inspection of the site after work has ceased to reduce the risk of a smoulder being undetected and turning into a fire
- Take advice on how to reduce the potential for fire to be spread by convection across the underside of roofs, through roof spaces and similar barriers to rising hot gases. In the Bradford stadium fire a significant cause of loss of life was the hot gasses rising under one part of the stadium roof, travelling along the roof and then descending many metres away at the other end of the stadium upon the spectators there causing asphyxiation and sparking significant secondary fires

Tip – thermographic cameras are becoming more economic to purchase, and are also becoming more common in use on waste management sites. Such cameras can be used as part of routine inspections to identify electrical faults, over-heating equipment and other potential ignition sources. The can also be used during fire watches after hot-works. Many waste operators who have invested in thermographic cameras enthuse about them and find them a useful tool in many areas, whether fire related or not.

2.3.2 One of the major waste management companies recently analysed its fire report data. This data was from a five-year period, covered 120 plus sites and more than 200 reports of fires/smoulders. This analysis was for general waste recycling and recovery type plants, and may not apply directly to your site, but regards the most likely causation of fires this analysis provides some interesting data:

- 31% of fires were likely caused by hot or hazardous materials and items in wastes accepted at sites, such as hot ashes, lithium batteries, gas cylinders, flammable liquids, aerosols etc
- 24% of fires were likely caused by self-heating, both in waste reception and storage
- 5% were likely caused by hot surfaces, 7% by electrical faults, 5% by hot-works such as welding and grinding and 9% by friction
- The remaining 19% were caused a variety of other smaller likely causes

2.3.3 If you have data for fire causation in your organisation you should use this to inform your site fire management and planning – where do your fires occur and what are the causes. If you do not, the data above may provide a starting point for you.

2.4 Housekeeping and dusts

2.4.1 In general the smaller the particle size of a combustible material the easier it may be to set alight. Likewise it is generally easier to set alight loose and free/discarded materials than compacted materials. In particular dusts may pose a distinct fire risk if they come into contact with hot surfaces and other ignition sources.

2.4.2 Some specific aspects of dust control and fire are included in section 4 on waste treatment. However, in general on dusts, small particle size combustible wastes, loose wastes and housekeeping you should:

- Introduce a regular maintenance and cleaning programme for all site areas including site machinery and buildings and ensure good house-keeping. This should aim to keep levels of dust, loose fibre and paper and other combustible materials in buildings and around the site to a minimum
- Ensure that as part of your housekeeping that flammable materials, such as oils, greases, fuels, paints etc, are always stored correctly and put back in store after use
- Include housekeeping in your routine site inspections and act to keep your site as free from loose/discarded combustible wastes and dusts as practical

2.5 Heavy mobile plant

2.5.1 Most waste management sites use heavy mobile plant, such as loading shovels, grabs and telescopic handlers. This plant can lead a hard life and is inevitably in direct contact with waste, much of which may be combustible. Mobile plant can pose ignition risks to the wastes they come into contact with:

- Hot exhausts can ignite wastes trapped near them. You should instruct plant operators of this risk and ensure that wastes are cleared from around exhausts and other hot parts at the end of each shift
- Mobile plant should be fitted with fire extinguishers and you may wish to fit automatic fire extinguishing equipment under plant engine bonnets and other high risk areas (your insurer may insist on this and you would be wise to check)
- You should ensure that mobile plant is well maintained to a specified schedule, in particular electrical systems which may be a source of fires. Note that maintenance schedules specified by suppliers may not be adequate for waste management use and you should consider whether you need to put in place more frequent maintenance
- Mobile plant should be parked after use away from waste stacks, waste left in reception areas and other places where wastes may be present
- Mobile plant shovels, blades and similar may produce sparks such as when scraped along a concrete or metal surface/wall. You should consider this during your assessment. For high-risk areas and materials, you may even want to consider precautions such as specialist coatings for mobile plant shovels and blades to limit or prevent the generation of sparks

2.5.2 Heavy mobile plant may also be useful in tackling fires, such as:

- Spreading wastes out so that a fire can be more easily tackled
- By removing wastes which are not on fire away from the location of a fire to prevent fire spread, such as by ‘sweeping’ un-ignited wastes away from a pile of waste which is partially on fire or by moving waste stacks away from a stack which is on fire to reduce the risk of fire spread
- By removing wastes which are on fire (smouldering) to a different location where fire-fighting may be easier, such as by moving waste from inside a covered reception hall to the outside: In essence taking the fire outside where it can be fought more effectively, although consideration should be taken as to where burning waste is moved to as it could spread a fire through means such as wind-blown embers/brands
- By pushing soils or other inert material over a fire to starve it of oxygen

2.5.3 However, if you intend in your accident/emergency plan to use heavy mobile plant in this manner you must ensure:

- That plant operatives are trained and competent in the task – and that they are completely aware that any such action must only be done without risk to their own health and safety or that of others
- That the heavy mobile plant is suitable to the task, such as by having completely enclosed cabs, fire and heat protected hydraulic systems etc
- Such action is included in your site accident/emergency plan
- If you intend to use soils or similar to smother a fire, that you always have an adequate stock of such on site to use

2.5.4 You should also consider where any unburnt, smouldering etc wastes could be moved to using heavy mobile plant – a 'quarantine area'. The size and location of such an area is a matter for site specific assessment. In some cases, such as large pit-type waste reception facilities (such as are common at waste to energy and some other larger waste management plants), it may be better to leave a fire where it is, as it is already contained. You should consider your site's specific situation and needs.

Tip – if you intend to use heavy mobile plant to fight fires you should conduct drills with your plant operators. For example, by practicing sweeping wastes away from a stack/pile or pushing inert materials over wastes. The retro-fitting of fire and heat protection systems (such as heat protection for hydraulic hoses) to heavy mobile plant can be expensive. But, it is often an inexpensive addition to the specification at the point of manufacture. When replacing your heavy mobile plant think about its specification in advance.

2.6 Hot works

2.6.1 Hot works, such as welding, grinding and cutting, take place at many waste management sites on a regular basis, such as during maintenance and repair. You should at least:

- Ensure staff and any contractors follow safe working practice when undertaking hot working, such as welding, grinding and cutting
- Ensure that fire extinguishers, hoses etc are provided at the scene of any hot work so that they can be used immediately should a fire occur. Such equipment should be stationed adjacent to the pathway of escape from the work area and not in a place where staff using them could be trapped by fire

- In areas where wastes or other combustible materials are present hot work should be a two-person job: One person doing the hot work and a second watching – someone who is welding will rarely look behind them at where any sparks may land
- So far as practical wastes should be cleared away from the area of any hot work before hot work starts (any residual waste which cannot practically be moved can be damped-down thoroughly with water in advance to reduce the risk of ignition)
- Potentially combustible materials, including mobile plant hydraulic lines, should be covered by a fire blanket, and/or damped down with water as appropriate, before hot work starts
- Conduct a fire watch at the scene of any hot work at least one 1 hour (or more) after hot work has finished – sparks from hot work can smoulder for a significant time period. Note – your insurer may have specific requirements regards fire watch after any hot works, and you would be wise to check this
- You may want to put in place a permit to work system to ensure that appropriate controls are in place before, during and after any and all forms of hot work

2.7 Site/plant shut-down processes

2.7.1 A significant number of waste site fires occur after working hours. To reduce this risk you should consider a formal close-down procedure including issues such as:

- Over-run of shredders, conveyors, screens etc to ensure that they are as clear of waste as practical
- Shut-off and lock-off of electrical power to plant and other equipment
- Shut-off of other electrical items such as space/room heaters
- Clearance of wastes which have accumulated under equipment
- Ensuring that any flammable materials such as fuels have been secured
- A fire-watch at least one hour after the end of operations
- Spread out any waste loads awaiting processing or in reception areas to ensure that there are no undetected hot items or other materials which could start a fire, such as discarded batteries, flammable liquids etc
- Where practical the removal of wastes from processing or reception at the end of the working day, or at least reduce the amount of waste in such areas to a minimum
- Check that mobile plant has been moved to a safe distance
- Check that fire detection systems have been activated and are working
- Check that security systems have been activated and that gates etc are secure

Tip – some recycling/recovery plant and equipment includes fans, for ventilation and extraction, for cooling (such as for hydraulic power packs) or as part of the equipment itself, such as for some air separation devices. Whether intended for cooling or not, these fans may have a cooling effect. You may want to consider arranging for fans to run-on for a period after shut-down to promote cooling. However, ensure that on emergency shut-down they stop immediately – such delayed shut-down should only be on functional stop systems.

2.8 Water supplies

2.8.1 While fire extinguishers may be useful in tackling small fires, the majority of larger waste fires are likely to be fought with water, in their initial stages at least. If you do not have a sufficient water supply the outcome of a major fire is likely to be predictable. The amount of water you may need will depend on a series of factors, such as how much and what types of wastes you have on site, how advanced a fire may be before fire-fighting commences etc. The issue of water supply is covered in more detail in appendix 2 of this guidance, in the sections on design of fire systems and general water demand requirements.

2.8.2 The information in appendix 2 takes a technical approach. Experience from fighting waste fires indicates that large volumes of water are required in some cases: Volumes as high as 10,000 litres per minute for several hours or more have been required for some large waste site fires (this is an example, and not intended as guidance).

- How good is the water supply to your site? If it is only a standard industrial supply it is unlikely to be able to provide sufficient water for significant fire-fighting purposes
- How close is the nearest public hydrant to your site?
- If the nearest hydrant is more than 100 metres away, or your site is large, you should consider an on-site hydrant/s and/or installing a fire main to allow sufficient water to be available
- If the above is not practical, do you need to install water storage tanks on your site?
- Are there alternative water sources near to your site, such as rivers, lakes, lagoons etc? And, could the Fire and Rescue Services (FRS) use these alternative sources? If you do identify alternative water sources such as lakes and rivers, you may also need to consult with your environmental regulator to ensure such use is appropriate
- If you have installed fixed fire suppression/extinguishing systems, such as sprinklers and water deluges, water supply requirements should have been part of the design specification for such equipment. However, you will still need a supply for fire-fighting equipment such as fire hoses and this needs to be taken into account

Tip – if you intend to use an alternative water source such as a lagoon, then consider particulates which may be in this source (such as mud, silt etc). You may need to consider large capacity filters and/or floating suction inlet to allow such water to be used – or face the potential for pipes and the pumps handling water from such sources blocking entirely or working at a much reduced effectiveness.

2.8.3 You should check you have adequate water supplies when you carry out your fire risk assessment. If you have any questions consult your local Fire and Rescue Service (FRS). As above, on larger sites the provision of a private fire hydrant system with the necessary supply of water may be required.

2.8.4 You should include in your assessment whether you would plan to use water to damp-down waste materials (such as stacks) which are not already alight during a fire to minimise the risk of fire spread – if this is the case then your water supply will need to be adequate to do this in addition to fighting a fire.

2.8.5 The location of hydrants, on or off site, should be included in your accident/emergency plan and should remain easily accessible. Hydrants should also be tested periodically to ensure they work, and that they flow sufficient water for your needs.

2.8.6 If you have, or plan to, install fire-fighting equipment such as water-spray/deluge or sprinkler systems, fixed water monitors etc then these will also have their own water supply requirements. You should consult appendix 2 of this guidance for an overview of the issues involved, and seek competent advice on your site's likely total water supply demand for fire–fighting/suppression/extinguishing equipment to ensure it is adequate to the total demand required.

Tip – the technical standards on required water supplies for sprinklers, drenches etc are complex. Your insurer may have access to such technical standards (such as the FM Global Data Sheets and NFPA standards and relevant BS and EN standards) and may be able to provide such advice to you at low or no cost. See appendix 2 of this guidance for more detail.

2.8.7 In summary, no fixed guidance can be given regards water supplies, such as you will need 'XX' litres per minute per tonne of waste etc. There are a wide range of variables here, such as type of waste, amount of waste, and type of fire (outside-in or inside-out – see appendix 2 for information on these fire types). It is a matter of experience that a number of waste operators who have suffered fires have found to their cost that their water supply was inadequate, and you should consider water supply carefully.

2.9 Contaminated firewater

2.9.1 Should a fire occur it will most likely be fought, at least initially, using water (although foams and other agents may also be used). This water will very likely be contaminated once it has been used to fight a fire. Foams may also pose risks to the environment. If this firewater/foam escapes from your site it may cause pollution – pollution you will likely be responsible for in terms of clean-up costs and potential civil or criminal action:

- All waste storage and stacks should be on an impermeable/fire resistant surface
- You should consider installing secondary and tertiary containment facilities for firewater run-off such as:

    - Bunds
    - Storage lagoons
    - Drain shut-off valves/penstocks
    - Isolation tanks
    - Modified areas of your site, such as a bunded car park to contain water
    - Block drains and/or divert firewater to a containment area or facility using pollution control equipment such as: firewater booms and drain mats

2.9.2 You may also wish to consider in consultation with the Fire and Rescue Services:

- Reducing the amount of firewater run-off by applying water through spray and fog-nozzles rather than jets or installing automatic fire suppression such as deluge systems which can apply water quickly and effectively directly to the heart of the fire
- Recycling firewater if it is not hazardous and it is possible to reuse
- Separating burning material from the fire and quench it with hoses or in pools, or in tanks of water. This has the advantage of reducing the amount of firewater produced
- A controlled burn – any decision to attempt a controlled burn must be taken by the FRS, in consultation with environmental and public health bodies, and should not be attempted by a site operator
- Burying the fire using soil, sand, crushed brick and/or gravel. This may be appropriate if there are limited water supplies and smoke is threatening local people, but it should only be used when:

    - Groundwater vulnerability is low
    - You have consulted your environmental regulator about this option beforehand
    - Contaminated material is removed and legally disposed of

Tip – Before deciding to smother or bury a fire consideration should be given to the likely timescales for the cooling and removal of the resulting entombment. Materials entombed in this way are likely to be insulated from heat loss and therefore liable to reignite upon re-exposure for periods of weeks, months or even years. If the decision is taken to smother a fire with a layer of inert material consideration should be given to ways of minimising the insulating effect of the smothering layer.

2.9.3 To decide which options, or combinations of options, is appropriate you should take account of the:

- Scale and nature of the environmental hazards on your site and the activities that take place on it
- Risks posed to people, the environment and property
- Type of materials you store on site, the form they are stored in and the length of time and the best strategy needed to extinguish a fire involving them
- Availability of firewater containment facilities
- Local topography and different weather conditions and fire scenarios that could be reasonably expected

2.9.4 The containment facilities and pollution equipment you need will depend on the size of your site, the amount of material you store and the fire fighting strategy. CIRIA C736 (see further reading appendix of this guidance) will help you identify the facilities and equipment you need for your site.

2.9.5 If you make a polluting discharge to the environment you will be committing an offence, unless you have a permit/consent to do so and the discharge meets the conditions of that permit/consent. Firewater discharges to sewer may also constitute a breach of sewage discharge consents and you should consult your sewage provider.

2.9.6 It is not the intention of this guidance to provide a comprehensive guide to contaminated firewater containment and management. Your environmental regulator will be able to provide you with more detail and information, and some environmental regulators have issued guidance which includes this issue.

2.10 Fire detection, alarm and suppression systems - overview

2.10.1 The specification, design, installation, commissioning and use of fire detection, alarm and suppression/extinguishing systems is a complex area. For this reason a separate appendix is provided to this guidance on the topic (see appendix 2). You should read this appendix to inform yourself of the options and issues involved. However, in general:

- For plant and equipment (such as recycling and recovery plant) fire detection, alarm and suppression should be part of the design risk assessment. For larger facilities the development of a separate fire strategy document is recommended
- Consider multiple approaches to detection and suppression rather than simply choosing a single item. For example, in some cases using more than one type of detector may be more effective than relying on a single type of detector
- Buildings systems should be compliant with the relevant building regulations, as supplemented by your risk assessment to take account of waste management use
- All fire detection, alarm and suppression systems should be maintained in good order and tested and checked as required – seek the advice of your competent person to ensure you are maintaining and testing/checking your systems as required

2.10.2 In addition to appendix 2 on fire/risk engineering, specific issues relating to detection, alarm and suppression/extinguishing systems at waste reception, waste treatment/processing and storage are included in the relevant specific sections below.

2.11 Non-waste facilities on site

2.11.1 Virtually all waste management sites have office, weighbridge and welfare facilities and other non-waste facilities. While these are not included specifically in this guidance, you should seek competent advice on fire management in these general facilities and you must ensure you comply with the relevant standards such as those in buildings regulations and standards:

- Such buildings should have a fire risk assessment, be provided with fire/smoke detection and, as required, manual break-glass points unless all areas of the building can been seen from any other area (such as a single room cabin)
- Detection and alarm systems should be connected to the overall system for the site – that is any alarm will cause an alarm across the whole site and visa-versa

- At the least fire extinguishers of an appropriate type and number should be provided, along with training for personnel to use them
- Building standards requirements must be met for all such buildings
- In general external waste stacks should be separated from such buildings by the separation distances given in appendix 1 of this guidance, option 1, or protected by other means such as fire walls/bunker arrangements. There may also be requirements in your property insurance policy, and you would be wise to check this

2.12 Fire appliance access

2.12.1 If Fire and Rescue Services (FRS) vehicles cannot get onto your site and/or cannot access all areas of your site to fight a fire then the outcome may be disastrous.

2.12.2 Access for FRS vehicles to and around your site should be unobstructed at all times and meet as a minimum the requirements in the table below. You should also consider how fire appliances can turn around and manoeuvre once they have entered your site. Points you may want to consider include:

- If the FRS cannot access all parts of your site (see distances etc in table below), can the FRS access around the edges of your site via a public highway or similar? If not, such as if your site is right against a neighbouring building, then you will need to consider stand-off between stacks and the edge of your site to allow access (and to prevent fire spread – see appendix 1)
- Is there more than one entrance to your site which Fire and Rescue Service vehicles can use? Are you restricted to one entrance and therefore have a need for easier access around your site?
- Are there on-site height restrictions, such as overhead power lines, bridges etc

Table: Typical FRS vehicle access requirements

Type of FRS appliance	Min width of road (metres)	Min width of gateway (metres)	Min clearance height (metres)	Min weight restriction (tonnes)
Water tender	3.7	3.2	3.7	12.5
High reach vehicle	3.7	3.2	4.0	24
Weight of vehicles may need to be confirmed with your local FRS as various types of vehicle are in use				

2.12.3 If you have any doubts regards how FRS vehicles may be able to access your site, you should contact your local FRS and seek their advice.

2.12.4 Note – the above distances are for access to fight a fire by FRS vehicles. They are not distances primarily aimed at preventing or reducing the risk of fire spread such as between stacks of stored wastes. For guidance on such distances in external storage see appendix 1, and for general considerations on storage (both internal and external) see the specific sections on storage below.

2.13 Communication, training and drills

2.13.1 Many fires are averted by the swift action of aware, well trained, and well drilled staff. In the development of your fire risk assessment and fire plans you should give consideration to and describe:

- How the key features of your fire assessment and plan will be communicated to your staff, and how will you ensure that they have understood this
- How frequently key messages will be reviewed and refreshed with staff through, for example toolbox talks
- What level of training staff need to play their part in the fire emergency plan, how frequently that training will need to be refreshed and renewed, and what system will be put in place to ensure that training renewal dates are not missed or overlooked
- Drills and exercises should be undertaken at regular intervals and should be varied in content to address the range of fires and circumstances that might be encountered on the site. Drills should be conducted at least once a year, and more frequently for higher-risk sites
- The effectiveness of response to drills and exercises (and real fires) should be critically reviewed to identify improvements that need to be made and any messages that need to be fed back into the communications and training systems
- If your site/plant has fixed fire suppression/extinguishing systems fitted, such as sprinklers and deluges, then your training should include these. Your operatives need to be aware of how such equipment works, what are the consequences of activating such systems, and what their limitations are
- When the Fire Rescue Service should be called, by who, how and the information to provide the Fire and rescue Service on their arrival and throughout the incident (this issue should also feed into your accident/emergency plan – see appendix 3)

3. Waste reception

Summary of changes since 2014 guidance: *Much of the section below is unchanged compared to the 2014 edition of this guidance. The exception being the replacement of the majority of the previous guidance given on fire detection, alarm and suppression/extinguishing systems. This has been replaced by a new appendix 2, with the exception of waste reception specific issues. Various smaller changes and additions have also been made based on developments in experience and knowledge since 2014.*

All waste management sites have reception facilities, such as:

- Enclosed tipping halls where waste is discharged prior to being fed into sorting or similar plant or in preparation for transfer off-site
- Split level reception areas or similar
- Reception pits, where waste may be fed into treatment processes by grab crane, conveyor or similar systems
- External reception areas for wastes such as wood prior to processing

Note – this section is aimed at the reception and temporary storage of wastes in reception for short periods of time, typically not exceeding 72 hours, or shorter, prior to treatment and/or transfer to another site (you must comply with any limits set in your environmental permit/licence). It does not cover specifically wastes stored prior to treatment or transfer for longer periods of time. If you store wastes for longer periods of time prior to treatment or transfer then you should also refer to the specific sections on the storage of wastes below.

3.1 Hot wastes and other hazards in reception

3.1.1 One of the most common causes of fires in reception areas is the receipt of ‘hot’ loads, or loads with hazardous materials in them such as gas cylinders, batteries or containers of flammable liquids, which can subsequently cause a fire. You should ensure you have robust waste acceptance procedures that prevent unauthorised waste being accepted, so far as practical, and for limiting their potential impact so far as prevention is not practical:

- Consider implementing a fire-watch at the end of the shift/operational day
- Consider not accepting higher-risk loads late in the working day, or processing such wastes quickly rather than leaving them in reception over-night

- If practical try to empty reception areas of waste at the end of each working day, or if not practical try to minimise the amount of waste left in reception overnight
- All employees in reception areas should be instructed to look for fires, hot loads, hazardous materials and items, smoke and signs of smoulders – and what action to take if they see one (such as the use of heavy mobile plant to move suspect loads to a safe area, dousing suspect loads with water from a fire hose etc)
- Consider instructing your mobile plant operators to spread wastes out when they are received to make identification of smoulders and hazardous items easier
- Consider provision of an 'emergency/quarantine area' for suspect loads. Note – this must be different from your normal quarantine area for non-conforming loads as these may contain hazardous materials which you do not want to expose to hot wastes
- Where detection of loads which may pose a hazard may be difficult, such as pit-type reception facilities, you should consider fitting deluge, water monitor or similar suppression systems to fight any fire which may occur, and good standards of containment to reduce the risk of fire spread from reception to other areas

Tip – there will be times when the delivery of hot loads will be more likely and reminders to reception staff would be useful. Examples are the increased likelihood of "hot" barbecues and ashes in wastes delivered to HWRCs and from domestic sources after bank holiday weekends or during warm weather. Plus consider the likely increase in the appearance of hot ashes and other wastes from garden burners after the first warm dry weekends of spring and the potential presence of hot ashes from bonfires and the residue from fireworks in early November or at other times of celebration where bonfires and/or fireworks may be an issue. The location of your site may also be a factor. For example, sites near coasts may receive discarded emergency flares, or those in holiday areas may have a higher risk of camping-type gas cylinders being received.

3.1.2 If you do discover a hot load, or load containing hazardous materials, you should attempt to trace this back to the customer and take appropriate action to reduce the risk of such occurring again. You should also check your environmental permit/licence conditions, and you may need to report such loads to your environmental regulator.

Note – no matter how good your waste acceptance processes are, the risk of hot and/or hazardous items in loads is unlikely to be 100% removed. This is not to say that you should not take adequate precautions, but for many waste operators fires in waste reception may well still occur, and you should plan for such an eventuality and consider fire risk in waste reception very closely.

3.2 Fire detection, alarm and suppression/extinguishing systems at reception areas – specific considerations

3.2.1 Appendix 2 of this guidance includes detail of fire detection, alarm and suppression/extinguishing systems at waste management facilities. You should read this alongside the specific waste reception issues given below.

3.2.2 In addition to the issues in appendix 2, below are some specific considerations you should take into account at waste reception areas:

- For external waste reception areas providing fire detection, suppression etc may be more difficult than for internal reception areas. However, external detection and suppression/extinguishing systems are possible. Some sites have successfully installed camera type detectors over external reception bunkers and similar, and deluge, water monitors and similar. Just because your reception area is outside does not mean that you should not consider detection and suppression/extinguishing systems in your assessment and plan
- While this section applies to wastes in reception only for short periods of time, the greater the amount of waste in reception at any one time the higher the likely consequences should a fire occur. For large waste management and similar facilities where large amounts of waste are received you should consult your competent advice regards detection, alarm and suppression/extinguishing systems provision
- At some sites incoming materials are moved from waste reception directly into processing areas using conveyors or other mechanical handling systems. In such cases you will need to consider potential fire spread by such interconnection. You should consider provision of automatic fire suppression/extinguishing systems on conveyors to processing areas. You should also consider linking fire detectors so that transfer plant emergency stops when a fire is detected to prevent the spread of a fire by mechanical transfer means: This issue is discussed in more detail in appendix 2
- In some waste reception areas items of recycling/recovery equipment are located directly in the reception area. For example, a shredder as pre-treatment before waste is fed into a main processing area. In such cases you should consider protection such as listed in section 4 on waste processing, and in appendix 2 on fire systems. For example, for a shredder located in a reception area installing a water deluge system at the shredder
- At some sites equipment located in reception areas is mobile, such as a mobile shredder. In these cases you should consider moving the equipment at the end of each day to a safe location

- One potential problem with fighting fire in enclosed reception areas is smoke, which may obscure a fire and make it difficult for the Fire and Rescue Services to place water direct to the seat of a fire. You may want to consider, subject to your risk assessment, passive or automatic smoke vents in the roof over reception areas. However, you must consider this carefully as vents can cause interaction problems with some fire detection and suppression systems resulting in a delay in activation – you should seek competent advice on this issue
- You should consider potential operational issues which may affect the effectiveness of any suppression system you have installed. For example, if you have installed a sprinkler or deluge system around your reception bunker/push-walls (in essence, a pipe with nozzles installed on top of or just above your push-walls). This is unlikely to work effectively if the height of wastes in your reception area means such systems are 'buried'. Likewise think about height for other reasons, such as waste piled to such a height that electrical lighting may pose an ignition risk

3.3 Other considerations in reception

3.3.1 If during abnormal situations, such as plant breakdowns, you need to exceed your normal reception area capacity you should put in place additional measures, such as a fire watch outside of operational hours. Ultimately you may need to cease accepting wastes so as not to compromise the fire safety of your site.

3.3.2 Finally on reception areas, your waste reception area has a finite, safe capacity and you should not exceed this. Determine during your assessment what this capacity is and stick to it (there may also be conditions in your permit/waste management licence which must be followed).

Tip – try to think of obvious visual methods to guide your operatives regarding the maximum safe capacity in your reception area. For example, painting an obvious 'max pile height' line on reception bunker walls above which waste must not be piled.

4. Waste treatment and processing

Summary of main changes since 2014 guidance: *Additional sub-sections have been added below on specific issues relating to balers and picking cabins, and sundry other changes and additions made to the text based on developments since 2014. As for other sections, much of the previous guidance given on fire detection, alarm and suppression/extinguishing systems has been replaced by the new appendix 2.*

Waste processing systems vary widely and this guidance cannot cover all technologies used. However, many recycling/recovery systems commonly include:

- Shredding, bag opening and similar devices which may themselves pose an ignition risk though friction, sparks from metal-on-metal contact, blunt blades and other similar causes. Hazardous items in wastes, such as gas cylinders, lithium batteries and flammable liquids containers, may rupture in a shredder causing a sudden and energetic fire, which may spread to other parts of the plant quickly
- Trommel, flat and other screens, air-separators and other gravity based sorting systems. While these may not pose a high ignition risk, they are often close to items such as shredders. If a fire starts in a shredder or similar it may be just a smoulder because of a lack of oxygen: When fed into a trommel, air-separator etc the waste is then agitated and receives sufficient oxygen to ignite fully. The same mechanism may also apply to hazardous items such as hot ashes which have been wrapped and are opened and exposed to oxygen by the movement of screens and similar
- Mechanical handling systems, such as conveyors, if well maintained should not pose a high ignition risk, but they can transport already alight waste rapidly around a plant so accelerating the spread of a fire. Many conveyors used in waste management are also rubber, which in itself is combustible
- De-dusting, cyclone and other similar devices – there may be a risk of dust explosion and you should seek specialist competent advice on these items
- Mains/electrical plant rooms which may pose higher-voltage electrical ignition risks and control panels for items of recycling/recovery equipment

Each of the above common types of equipment is considered below. However, there are other items of equipment used in recycling/recovery systems such as optical sorting systems, magnetic and eddy current processes and other specific recycling/recovery equipment – you should assess any specific fire risks associated with other equipment you may use. You should seek competent advice on this and consider the various fire scenarios and causes which could occur (see appendix 2 for information on plant protection).

4.1 General ignition risks in processing

4.1.1 In addition to the above specific risks, recycling/recovery plant may pose other general ignition risks (the presence of combustible waste is a given as a potential fuel source), such as:

- Electrical faults, faulty or damaged wiring causing sparks and heating
- Friction from slipping conveyors, damaged or worn bearings, damaged or worn drive motors, or metal-on-metal contact
- Direct heat from drive motors, hydraulic power-packs and other items which may generate heat
- Direct heat from specific items of equipment, such as optical sorting equipment and eddy current devices

4.1.2 For many of the above potential risks, poor maintenance and cleaning regimes can have a role to play. A poorly maintained drive motor is more likely to overheat, a poorly maintained bearing, or one that has not been replaced to schedule, is more likely to collapse causing mechanical heat risk etc. Likewise, if dust and detritus is allowed to accumulate on items which are normally 'hot' then the risk of ignition will be higher, in particular if dusts etc become contaminated with oils, forming a readily ignitable mixture. Good maintenance, repair and cleaning can go a long way towards reducing the risk of a fire in processing plant.

4.1.3 You should seek advice from your competent person as to what fire suppression and management measures may need to be taken (and see appendix 2 for fire system advice). However, the following sub-sections offer some specific considerations for the common items of recycling plant.

4.1.4 At some sites processing equipment may be located outside, such as a mobile wood shredder in an open yard, and the fire suppression etc systems listed below may not be practical in such applications. However, this type of equipment often already comes with its own fire–fighting/suppression/extinguishing system installed, such as an automatic extinguisher system built-into a shredder. You may want to consider this type of system. At the least you should consider how you would fight a fire in such equipment. For example, would your fire hoses reach such equipment located in an open yard, and where is the nearest hydrant or other water source?

4.2 Shredders, bag openers and similar

4.2.1 This type of equipment poses a higher risk of ignition from friction and/or metal-on-metal and similar contact, or hazardous items in wastes, such as a gas cylinder or battery going through a shredder. The rupture of such hazardous items in shredders and similar is a common cause of fire at waste management plants.

4.2.2 In addition, as shredders etc are often well enclosed for valid machinery safety reasons, fighting a fire may be more difficult as it may not be easy to get at. You should consider installing water deluge or sprinkler type systems either in permanent shredder etc housings, or above shredder feed hoppers, as practical, to extinguish fires, and/or at conveyor outputs from shredders etc to prevent fire spread. Detection systems linked to such deluges or similar will need to be fast-acting if they are to be effective (see appendix 2 for detail)

4.3 Trommel screens, other screens, air-separators and similar

4.3.1 While trommel screens and similar may not pose a high ignition risk they can aerate wastes resulting in a smoulder turning into a full fire. For example, a carelessly disposed of disposable barbeque containing hot ashes which is ‘bounced’ open in a trommel screen. You should consider installing water deluge or sprinkler type systems either in trommel etc housings to extinguish fires, and/or at conveyor outputs from trommel screens etc to prevent fire spread.

4.4 Mechanical handling systems, conveyors etc

4.4.1 Conveyors and similar mechanical handling systems may carry a fire rapidly through your plant, and they may be an ignition source themselves as a result of friction:

- Consider conveyor water deluge/sprinkler systems, as identified by your risk assessment. These can be under-conveyor, over-conveyor or to the side of conveyors with deflection plates to divert water onto the conveyor. Under-conveyor systems may pose issues such as being more open to damage and/or causing a restriction to maintenance activities and will likely need protecting. Also see issues with under-conveyor/gantry sprinkler and similar systems with regard to ‘shaded’ areas under plant in appendix 2
- Consider installing slip sensors on conveyors to determine if a conveyor is slipping on its drive roller – the friction caused by such slippage may pose an ignition risk

- Fire alarm and detection systems should be connected to plant control systems so that if a fire is detected the plant stops quickly, so preventing burning wastes being transported through your plant

4.5 Balers and similar

4.5.1 Balers and similar equipment are common in many recycling plants. In general these are robust and encased in steel, for machinery safety and other reasons. This generally makes then fairly resistant to fire. However:

- Aerosols, gas cylinders etc may rupture in balers. The baler itself may take the forces involved, but significant energy can escape via baler output areas, feed chutes etc and inspection doors to baler chambers may be 'blown-off' if the energy released is high enough. Baler operating positions and platforms should be away from such potential danger zones to protect the baler operator and others in the area
- Baler output areas should be kept clear, so far as practical, of detritus. Energy emitted from a baler output area if a gas cylinder of similar ruptures can result in fire spread, and the presence of detritus will only make this more likely
- You may want to consider suppression/extinguishing systems at areas such as baler feed chutes and hoppers, dependent on design and practical considerations

4.6 De-dusting systems, cyclones etc

4.6.1 The separation/ventilation of dusts and fines using extraction systems, cyclones and similar may pose dust explosion risks. For some of this type of equipment parts of the system such as at bag filters etc may be classified as hazardous areas (commonly called 'zoning'):

- Such systems should be subject to an assessment under the DSEAR (Dangerous Substances and Explosive Atmospheres Regulations) and may require hazardous area classification (zoning) – you should seek competent advice on this
- Where required by a DSEAR assessment, controls such as spark detection/suppression, pressure release systems (such as blast panels) and water deluge or sprinkler systems or similar should be installed
- Any hazardous areas (zones) must be identified and signed – and employees should be aware of any such zones and the precautions to take

- The standards for electrical and other equipment in such systems are likely to be higher than for general electrical systems (ATEX rated) and you should seek competent advice on this
- Maintenance of DSEAR compliant systems should only be undertaken by a competent person, you may need to check on the competency of contractors or others undertaking this work – a general industrial electrical contractor may not have the knowledge required
- Ductwork associated with de-dusting and similar systems may provide an easy pathway for a fire to spread – that is through the ductwork. You may need to consider suppression systems in ductwork to prevent such fire spread, and you should clear ducts etc of detritus and dusts frequently (ducts full of dust have been implicated in fire spread at various waste management site fires)

4.6.2 De-dusting and similar systems are often aimed at the beneficial control of dusts around a plant. However, such systems may also concentrate the hazard posed and de-dusting and similar systems need careful consideration and very likely specialist competent advice on their operation, maintenance and repair.

Tip – the materials transfer points at the end of conveyors are often a significant generator of dusts and also often the first areas to be enclosed as part of dust control measures. Such enclosures typically encompass the conveyor end bearings, which can become hot and pose a source of ignition. Suitable measures to address these risks need not be expensive if considered as part of the design and installation of the enclosure.

4.7 Mains/electrical plant rooms and control panels

4.7.1 Mains/electrical plant rooms and control panels pose specific issues, largely associated with the electrical ignition risk they pose:

- Mains/electrical plant rooms should be enclosed and constructed to appropriate fire resistance standards (consult your competent advisor). For critical installations you may want to go beyond the usual standards applied for property and business interruption risk reasons
- Points where cables leave and enter mains rooms via ducts, tunnels etc should be appropriately sealed to prevent fire spread via such ‘holes’ in the integrity of the room
- Thermal imaging cameras used in regular surveys can be of use to detect electrical faults early and reduce the risks involved

- Mains/electrical plant rooms should be supplied with suitable (usually CO_2) hand-held extinguishers and doors should have vision panels to allow a fire to be seen before entry. You may want to go beyond this into fixed fire systems (see appendix 2)
- Control panels should either be located in enclosed rooms or constructed to a suitable IP (protection) standard to prevent dust ingress
- Electrical rooms should be fitted with automatic fire detection and manual call points. Depending on business criticality, such rooms or specific panels may also be fitted with automatic fire suppression

4.8 Picking cabins

4.8.1 Many general recycling plants include one or more 'picking cabins'. These pose specific issues, in particular for life-safety:

- Picking cabins, control rooms and similar should be provided with appropriate fire extinguishers. You may also want to consider sprinklers or other suppression equipment in, and under, picking cabins
- Exits from cabins and similar should be provided with manual break-glass points
- Picking cabins should be provided with suitable smoke/heat detection systems – and these must not be turned off during operational hours
- Picking cabins are often in the centre of processing plant. Escape in the case of a fire is critical – picking cabins are often the only fully-occupied location in processing areas. How would your employees escape from a picking cabin in the case of a fire which generates smoke making vision difficult? Escape routes from cabins need to be clear, signposted, lit and obvious and not convoluted and/or difficult to follow

4.9 General considerations in processing areas

4.9.1 General considerations for fire management in waste processing areas include:

- Housekeeping in process areas needs to be of a good standard. Dust should be cleared from electrical conduits and systems, hydraulic power packs and similar and drive motors (and any other item of equipment which may produce heat or be an ignition source, such as optical sorting equipment)
- Thermal imaging cameras may be used to detect hot-spots around your plant, such as slipping conveyors, over-heating drive motors, faulty electrical systems etc. Such thermal imaging surveys need not be conducted every day, but can be part of routine maintenance and inspection regimes

- Hydraulic systems, including hydraulic oil tanks, may generate significant heat. In addition, most hydraulic oils are flammable and leaks from hydraulic lines and systems may result a fire which can spread quickly to wastes. In particular if the waste has been doused in hydraulic fluid from a leak first. Fires in mists and sprays of leaking hydraulic oils are a particular risk and can be highly dangerous. You should include hydraulic systems in your routine checking, testing and maintenance systems and you may want to consider installing fire suppression systems at/above hydraulic power packs, or using non-flammable hydraulic oils. Detection systems should be linked to hydraulic systems to produce shut-down and de-pressurisation of the system in the event of a fire detection

4.10 Fire detection, alarm and suppression/extinguishing systems in processing areas – specific considerations

4.10.1 Appendix 2 contains specific advice, much of which is specifically aimed at waste treatment and processing systems. You should read appendix 2 for information on the issues, considerations and options available, and match these to your specific treatment plant – this is not an area where 'one-size-fits-all'.

4.10.2 Processing areas of waste management sites typically contain items of plant etc which have the highest asset value on the site. A simple steel construction building may only have an asset value of <£1 million, but the processing plant and equipment in the building may have an asset value far in excess of this, often many £ millions. In addition, the loss of processing plant may result in substantial business interruption until plant can be replaced. Loss of plant may be catastrophic to your business.

4.10.3 The issue of fire detection and suppression/extinguishing in processing plant is discussed in detail in appendix 2. The approach taken in processing plant is likely to be different than that followed in reception and storage areas. Detection is likely to be required to be quicker, extinguishing systems are likely to be preferred over suppression systems, and plant actions such as emergency stopping of the plant if a fire is detected, may be critical. If you have invested £ millions in costly processing plant, you would be wise to consider fire protection closely in processing areas.

Tip – it is not the intent of this guidance to provide in-depth insurance advice. However, your insurer is most likely to be interested in in how you are protecting your plant than any other aspect, because loss of plant often equals the largest loss of assets and therefore highest claim level. Take the time to discuss this issue with your insurer.

4.10.4 One potential problem with fighting fire in enclosed treatment areas is smoke, which may obscure a fire and make it difficult for the Fire and Rescue Services to place water direct to the seat of a fire. You may want to consider, subject to your risk assessment, passive or automatic smoke vents in the roof over treatment areas. However, you must consider this carefully as vents can cause interaction problems with some fire detection and suppression systems resulting in a delay in activation – you should seek competent advice on this issue.

4.11 Protecting your plant by separation/segregation

4.11.1 You should consider how your processing area is separated by distance and/or segregation by appropriately constructed barriers, such as walls, from waste storage and reception areas. In fire safety terms such separation/segregation of areas of a building is often called splitting into 'compartments' (although true compartments are rare in waste management plants), the aim of which is to prevent or reduce the risk of fire spread. This issue is discussed in appendix 2. Protection should be two-way:

- If a fire occurs in your waste storage and/or waste reception, how is your processing plant protected from fire spread?
- If a fire occurs in your waste processing area, how is fire spread to waste storage or waste reception controlled?

4.11.2 For example, you may want to consider the use of walls and/or push walls of an appropriate construction and height (both in terms of fire spread and robustness to withstand day-to-day waste management use) to segregate waste reception from waste processing to prevent fire spread, or to locate waste storage well away from waste processing. Or, you may need to consider other compartment techniques such as installation of wall-protecting deluge systems, automatic extinguishing systems in transfer conveyors to and from processing areas and similar. The principle being to provide a physical barrier between compartments, or where this is not 100% practical protect compartments in other ways.

Tip – your insurer is likely to place much importance on the integrity of the compartments in your building, in particular if a compartment contains expensive plant which should a fire occur may result in a high-value insurance claim. This may be difficult at waste management sites where wastes need to travel between compartments for the process to work, such as holes in walls to allow conveyors to pass through. Discuss this aspect with your insurer and consider how you will prevent fire spread between compartments.

5. Waste storage – general considerations

Summary of main changes since 2014 guidance: *The results of the waste burn trials conducted in late 2015 and through 2016 have resulted in extensive changes to this section, and the following specific sections 6 and 7 on external and internal storage of wastes. In addition, and for the same reasons, extensive changes have also been made to the appendices on storage previously included in the 2014 guidance. As a result, information on the use of the appendices included in this section in the 2014 guidance has been removed, and significant changes made to content. Guidance on the calculation of waste storage stack volumes has also been removed, as the simplification of storage advice allowed by the results of the waste burn trials has rendered this largely irrelevant. Sundry other changes and additions have also been made as the result of other developments in experience and knowledge since 2014. Finally, in common with other sections of this guidance, previous advice on fire detection, alarm and suppression/extinguishing systems has largely been replaced with the new appendix 2 to this guidance.*

Many waste management sites store combustible wastes: Either wastes brought to site and awaiting processing and/or transfer or wastes/products which have already been processed and are awaiting transport off site. Examples of such wastes include, but are not limited to:

- Baled recyclates such as baled paper, cardboard and plastics
- Baled and wrapped SRF/RDF and other waste fuels
- Loose wastes such as wood, hard plastics, plastic bottle, tyres etc

Note – this section is not aimed at the temporary storage of wastes in reception for short periods of time, typically not exceeding 72 hours or shorter, prior to treatment and/or transfer to another site, or wastes in treatment. Rather it covers longer-term storage of wastes. For guidance on waste reception areas see section 3 above.

Waste storage at waste management sites can be internal (inside a building) or external (such as in stock yard). This section covers general considerations applicable to both external and internal storage. The following sections 6 and 7 cover issues specific to external storage and internal storage respectively. These specific sections should be read together with this general storage section to gain an overall picture of what is required.

5.1 Definitions of terms used in storage sections

5.1.1 For consistency, the following terms are used in all sections/appendices on storage:

- **Stacks** - stored accumulations of all forms of stored wastes, whether baled, as loose materials or otherwise stored
- **Bunkered/enclosed stacks** – wastes (either loose or baled etc) stored in a bunker or enclosure, such as a three-sided enclosure, where the walls of the enclosure are of an appropriate construction and height resulting in an effective fire shield/wall
- **Open stacks** – wastes (loose or baled etc) which are not stored in bunkers / enclosures, such as an open stack of paper bales or open stacks of loose wood
- **Loose** – wastes which have not been baled/wrapped, such as stacks of loose wood, tyres, plastic bottles etc. Such loose wastes could be either bunkered, or open (such as an open pile of loose wood)
- **Baled/wrapped** – wastes which have been baled and/or wrapped, or similar, as discrete 'packages/items'. Such baled/wrapped wastes could be either bunkered or open stacked

5.2 Safe storage capacity

5.2.1 The total amount of combustible waste stored at your site and how it is stored will influence the likelihood, size, duration, and impact of a fire should one occur. As part of your assessment you should assess the maximum safe amounts of waste you can store. This assessment should include:

- For external storage the stack sizes and separation distances given for option 1 in appendix 1, or from your assessment if your site falls into option 2 in appendix 1, and the considerations in section 6 below
- For internally stored wastes, the considerations given in section 7 below, and the general information in appendix 1 as guidance (see section 7.3)
- For all storage, safe access requirements, such as those given above in section 2 for Fire and Rescue Services vehicle access, and safe evacuation routes
- For bunkered wastes, the safe capacity of your storage bunkers, including freeboard to take account of flame height (see appendix 1 and 2)
- As applicable, quarantine area/s (of little use if full of wastes already)
- Any other restrictions relating to your site, such as the need for safe traffic movements around the site

5.2.2 If you store various different types of waste you should consider whether you need to include specific storage limits for each type of waste, in particular if a specific waste type poses a higher fire risk, such as plastics and rubber wastes.

5.2.3 You should also take account of any restrictions on amounts permitted and storage times in your site's permit/licence, or other similar regulatory permissions. These may be overall limits, or limits by waste type.

5.2.4 Based on the above you should be able to determine the maximum safe volumes of waste you can store at any one time, and in any one storage location. You should then compare this maximum volume with your waste inputs and processing capacity. Your management system should then be arranged so as to ensure that waste is transported off site before you reach your maximum safe capacity.

5.2.5 If the wastes on your site are subject to seasonal variation in demand and/or supply, it is important that you manage these variations to restrict waste volumes stored on site to within their safe levels. Such seasonal variations should be included in your management system. The same principles apply when variations in off-take markets lead to a build-up of stock levels. Seasonal and/or market factors are not a valid reason for exceeding safe storage capacity.

5.2.6 Ultimately your site, and each storage area of your site, has a finite safe, storage capacity. You should not exceed this capacity and your site management systems should manage waste inputs and outputs to achieve this end.

5.2.7 All of the stack dimensions and stack separation distances quoted in this guidance, and in appendix 1, are for 'standard' storage of wastes on the ground: For example, a stack of stored bales of waste on the ground in a storage yard, or in a bunker or an open 'pile' of wastes on the floor in a building. They do not apply to specialised storage systems such as enclosed silos used to store wood chip or similar or treatment systems such as a large drying hall at a mechanical, biological treatment (MBT) plant, or other similar specialised system. For this type of specialised system competent advice should be sought, and for many it is likely that enhanced fire suppression/extinguishing systems will be required.

5.3 Bunkering/enclosing wastes with firewalls as an alternative to limiting fire spread by distance

5.3.1 Reducing the risk of fire spreading from one storage stack to another is a critical component of any site's fire management strategy (see appendix 2 for more detail and examples). This can be achieved in two main ways:

- Leaving a physical, ‘free-air’, gap between stacks (often also called a ‘fire break’) so that fire is less likely to spread between stacks
- Placing a firewall between stacks to achieve the same end (this is commonly achieved on waste management sites by bunkering/enclosing stacks, such as by using three-sided enclosures/bunkers).

5.3.2 Overall the enclosure/bunkering of wastes may provide improvements both in terms of segregation between combustible wastes and overall storage capacity. For example, providing bunkered storage will mean that the free-air separation distances in option 1 of appendix 1 of this guidance for externally stored wastes will not apply, provided that the walls used are of an appropriate construction, that stored waste height does not exceed wall height (including freeboard to account for flame height) and that stored waste does not spill out from the bunker/enclosure. However, there are also potential disadvantages and you must consider these before making a decision.

- Bunkering wastes does not remove the need to consider stack size. The combustible occupancy (how much combustible material there is and how energetically it will burn) is not affected by simply placing wastes in a bunker. In addition, bunkering wastes (or other uses of fire walls) does not completely remove the risk of fire spread, it only reduces the risk
- For very small particle size wastes, such as fines/dusts, and those where self-combustion may be an issue stored in bunkers stack size is particularly important. For example, for combustible ‘fines’ the stack sizes given in appendix 1, option 1, are unlikely to be appropriate because of the risk posed
- Consider stock rotation to remove older wastes – bunkers should be cleared to remove old waste from the back of the bunker frequently to reduce the risk of self-combustion (see below)
- Temporary wall/side structures for bunkers (such as mobile ‘A’ concrete frames or blocks, or bales of metal and other non-combustible wastes) need to be considered closely. If there are any gaps between blocks or frames they will be ineffective at stopping fire spread. Permanent walls of a suitable construction are likely to be better at resisting fire spread, although tight blocks may also be effective
- Using combustible materials, such as using bales of paper to enclose loose stored paper, as the walls of a bunker is unlikely to be effective in preventing fire spread – if you choose to use bales to separate wastes then use non-combustible materials such as metals (but, see the information in appendix 1 regards plastics and rubber wastes because of their higher burn temperatures). In addition, achieving a tight and gap-free fit using bales may be difficult and such bunker walls will be less effective than block or permanent bunker walls

- Using steel walls to segregate waste stacks is an option. However, you should consider heat transfer through the steel, and in external storage that materials such as steel can heat-up in direct sunlight
- Using railway sleepers in bunker construction is also an option. However, sleepers are combustible (in particular if they have been treated), albeit they will resist fire, but will be less effective than concrete or similar walls. In general, sleepers cannot be considered as fire walls
- Whatever construction method is used you will need to ensure that the walls are high and thick enough to stop fire spread from heat radiation. The Society of Fire Engineers Handbook 3rd edition (or updates of this), explains how to do this (see further reading and useful links appendix SFPE Handbook)
- You should have in place inspection/checking processes to ensure that wastes do not exceed wall height at any point (including freeboard), and that wastes do not spill out from bunkers/bays so defeating any segregation provided to resist fire spread. This also needs to include flame height and freeboard between waste height and bunker/wall height (see appendix 1 for detail on this consideration)
- Access issues around bunkers should be considered. The ability of the Fire and Rescue Services to fight or contain the fire may be more difficult if access is impeded

Tip – when storing wastes in multiple three-sided bunkers why not plan your bunker layout with fire spread in mind? For example, if you have three bunkers in a row, two of which have combustible wastes in and one with non-combustible wastes, then put the non-combustible waste bunker in the middle so separating the two combustible waste bunkers.

Tip – for ease of stock rotation, why not have two smaller bunkers rather than one larger? Two smaller bunkers will mean that you can completely empty one bunker while still accepting wastes into the other.

5.3.3 Bunker (and any fire) walls should be sufficiently robust for the use they will be put to. The activities of heavy mobile plant when placing and removing wastes from bunkers, and during pushing-up of wastes, can cause damage to bunker walls, and they may suffer damage from other causes. Any holes, splits, cracks and similar in bunker walls will significantly reduce their effectiveness as fire walls. In addition, such cracks, holes etc in bunker walls may promote local air-flows which in some circumstances may increase the risk of self-heating for some waste types or in the event of a fire introduce more air through ‘chimney type’ effects resulting in a more energetic burn. You should inspect bunker (and fire) walls routinely for damage and repair any such promptly (or take the bunker out of use).

5.3.4 An extreme form of enclosing wastes is to store them in enclosed containers, such as ISO containers. For example, the storage of wastes in containers at a dockside waiting for transport. In these situations stack size will not apply as such containers intrinsically restrict stack size. Likewise separation distances will not apply completely as wastes are enclosed on all sides. This type of approach may be particularly suitable for higher-risk materials such as very small (fines) sized combustible wastes.

5.3.5 However, storing wastes in containers does not completely remove the risk of fire spread. For example, if you store wood, plastics etc in an open-top steel container right next to a building and a fire starts in the container, do not be surprised if the fire spreads to the building. When using open-top containers a gap should still be left between containers and between containers and other items such as buildings.

5.4 Self-combustion and storage times

5.4.1 Some materials can spontaneously combust, and the risk generally increases when materials are stored for prolonged periods. In addition, and in general, the smaller the particle size the higher the risk, although this may not always be the case. Self-combustion is not a well understood phenomenon. Data is available from various sources, and more information becomes available frequently. However, much of this is contradictory, or at least inconsistent. It is known that self-combustion occurs, and that it does cause fires at waste sites (one larger waste management company's fire data indicates self-combustion to be the second most common cause of fires at its sites), but the risk factors involved are complex and variable.

5.4.2 In general the storage time limits shown below should be used to inform your stock rotation. These are based on experience and take account of the known risk factors in self-heating of particle size and density.

Combustible waste type	Maximum storage time
Non-shredded or similarly treated wastes (that is wastes whose particle size has not been reduced)	6 months
Baled and compacted wastes	6 months
Shredded and similarly treated wastes (that is wastes whose particle size has been reduced)	3 months
Combustible fines/dusts and very small particle size wastes	1 month

5.4.3 The above time limits are starting points for your considerations on storage. For some wastes the above storage times may be too long and you should consider your waste types carefully for self-combustion risk. You may also wish to consider whether enhanced fire monitoring and suppression/extinguishing systems may allow you to extend waste storage times. But, you should seek competent advice before making this decision, and be prepared to prove that your thinking is sound and supported by good technical evidence rather than opinion or general experience (self-heating is not currently predictable and previous experience may not be an adequate indicator of future events).

5.4.4 If baled wastes seem likely to exceed the above time limits you may consider breaking the bales and re-baling them to reduce fire risk. Likewise, you may want to consider if the turning of loose stockpiles would reduce the risk of self-heating. However, care should be taken when breaking bales or turning loose piles/stockpiles.

- Breaking bales and turning loose stacks may itself cause a fire. Self-heating may be occurring within a stack, but because of the lack of oxygen a fire has not occurred as yet. When you open the bale/turn the stack you may introduce sufficient oxygen to the waste to result in a fire
- When breaking bales and turning stacks you should have fire-fighting equipment, such as hoses, at the scene so that you can deal with a fire more quickly if one occurs (hand-held extinguishers are unlikely to be sufficient)
- Likewise, you should consider breaking bales away from any combustible wastes, such as in a quarantine area, and for loose stacks moving other wastes away from the area before turning them
- If you have one on site, the use of a thermal imaging camera when breaking bales or turning stacks may assist in being able to identify any rapid rise in temperature which may indicate a fire is about to start

5.4.5 Considering the potential risks associated with breaking bales and turning loose stacks, the best approach may be to simply ensure that waste are stored for the minimum practical time on your site.

5.4.6 You should also communicate with your waste off-takers as appropriate. If a waste is stored at your site for a period of time and is then transported to an off-taker site (or other site), how long will it be stored at the off-taker's site? The risk of self-combustion may not cease if a waste is transported from one location to another.

5.4.7 In general on the risks of self-combustion and how you may seek to minimise these:

- You must use a clear recording method to show and record how long all wastes have been on site for, and this recording system should be updated frequently to ensure that it reflects current stock levels
- You should rotate stock to ensure older wastes are not retained for excessive periods. For example, taking older bales from the rear of a stack before newer bales at the front and emptying storage bunkers to ensure that older waste is removed
- Moisture level may be a factor and you may need to monitor this, as practical for the type or waste you are storing and how it is presented (loose, baled etc)
- Keep material in its largest form prior to processing for its end market, for example keeping waste wood in bulk storage and only chipping it prior to transport off site
- Visually inspect stored wastes frequently (at least once a week as a minimum)

5.4.8 If you are storing wastes for any prolonged period of time, even if you are within the timescales noted in the table above, you may want to consider monitoring the temperature of the wastes being stored. There are various methods for doing this, such as thermal probes, thermographic cameras and fixed heat detecting systems. If you decide to monitor temperature, the method you use will depend on the types of waste you are storing and their configuration, such as loose or baled. In particular, you should consider temperature monitoring if you are storing smaller particle size wastes such as SRF, RDF, wood chips and similar.

Tip – temperature probes and thermal cameras can be used to check on stacks, such as to identify whether hot spots are starting to occur. Equipment such as probes must be used correctly. For example, probing to the centre of a stack (difficult and may be impractical for denser wastes such as bales) to determine temperature rather than just at the surface where temperatures may be lower. A starting point for how often you need to check temperature will be risk assessment, including inputs such as your previous experience and advice from a competent supplier of such equipment or similar. The exact method you use to measure temperature will depend on the waste type and how it is presented (loose, baled etc). But, be aware that most methods of temperature measurement, including those which 'look' inside a stack, are not 100% reliable as indicators of actual internal temperatures, and that one part of the interior of a stack may be cool when the very next portion may be much hotter making your measurement potentially unreliable. Likewise, if you break a bale or turn/excavate a stack to determine internal temperature, it will likely start to cool as soon as you break it, also making any temperature measurement potentially unreliable.

Tip – experience from some waste operators is that self-heating fires are more prevalent in summer than winter (that is during warm weather). This is likely the result of warmer ambient temperatures resulting in energy already being in the 'system'. If you do monitor temperature, you may want to do this more frequently during warm weather than cold.

5.4.9 Smaller particle sized wastes may be more prone to self-combustion and there may also be a relationship with density, although this is not well understood: That is the less dense the waste the more possible an oxidising mechanism and self-heating may occur (although for larger particle size wastes lower storage density may be an advantage as air may be able to circulate through the stack more easily allowing heat to be shed). If you are storing wastes, such as RDF/SRF and/or smaller particle size wastes in open storage you should consider this – you may need to seek competent specialist advice. Other more specialised wastes may also have self-heating properties which you may need to be aware of and take account of in your controls.

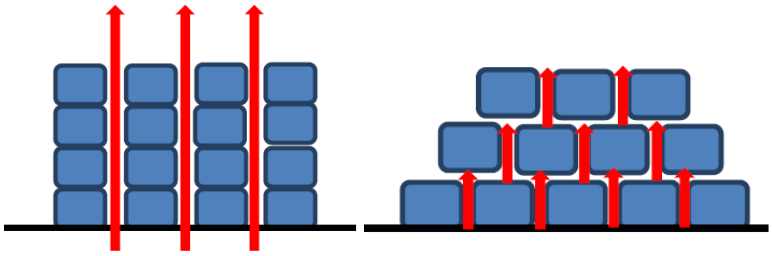
5.4.10 Overall, self-heating is a complex issue with various potential parameters such as density, particle size, overall size of stack and ability to shed heat etc. The relationship between these factors is not well understood, and currently no firm guidance can be given regards predictions as to whether self-heating will occur to the extent that a fire starts. However, it is known that self-heating has been a common factor in various waste fires and you should be aware of the risks and plan for them.

5.4.11 The document Spontaneous Heating of Piled Tyre Shred and Rubber Crumb (Health and Safety Executive – see further reading section) provides further advice on how you can control the risk of spontaneous combustion. Although written for the operators of tyre recovery facilities much of the guidance is applicable to the storage and treatment of other materials that can self-combust.

5.5 Baled wastes storage configuration issues

5.5.1 Baled wastes when stored may pose a specific fire risk issue associated with the configuration of storage. Typically bales of waste are stacked directly on top of each other. This results in continuous vertical air gaps between bales – in effect the creation of 'chimneys' between individual 'towers' of bales. If a fire occurs, these chimneys can result in energetic air-flows between bales so promoting a more rapid and energetic burn. This issue was identified during the waste burn trials in 2015 and 2016 on baled wastes:

- You should consider interlacing bales to break-up these chimneys – arranging bales in the same way as bricks in a wall rather than directly on top of each other
- In particular you should consider this for baled plastics/rubber where burn temperatures are higher than for other types of wastes (see appendix 1), interlacing bales may reduce burn temperature and how energetically a fire may burn



Far left: Standard bale storage may result in chimneys between bales promoting air-flow during a fire. Left: Interlacing bales may disrupt this chimney effect reducing air-flow and fire intensity

5.5.2 The above assumes that your bales are 'square', as is typical for bales of paper, plastics etc. However, there are other types of balers, such as those used to bale and wrap RDF and similar waste derived fuels. Bales produced by such equipment may be cylindrical rather than square. Typically such cylindrical bales are stacked interlaced for stability reasons, and so any chimney effect may already be mitigated.

5.5.3 The effect of interlacing bales in storage will depend on various factors, and generally interlacing bales did not affect maximum heat output once a fire had fully developed (see below on fire growth). Because of this interlacing bales would not generally affect the separation distances and stack size information given in option 1 of appendix 1. However, you may want to consider this form of storage, in particular for higher-risk waste types such as plastics and rubber.

5.5.4 What the fire trials did indicate is that interlacing bales slows fire growth within the stack itself. This could allow a fire to be tackled more easily in its early stages before it develops fully. Future waste burn trials will include assessing the effects of interlacing of bales, and future versions of this guidance may be revised based on such research.

5.5.5 While not directly a fire issue, interlacing bales may also have stability benefits. Bale stack collapses have resulted in serious and fatal injuries in the past and bale stack stability is a significant risk area. In addition, during a fire bale stack collapse may itself result in fire spread.

6. External waste storage

Summary of main changes since 2014 guidance: *As for the general section on waste storage above, this section has been extensively revised based on the results of the waste burn trials conducted in 2015 and 2016, as has its associated appendix 1 (in particular stack dimensions and separation distances data). The three options for external storage previously given in the 2014 guidance have been reduced to two simpler options. This simplification has been made possible by the results of the waste burn trials. As for other sections of this guidance, much of the advice given on fire detection, alarm and suppression/extinguishing systems has been replaced by the new appendix 2. In addition, sundry other more minor changes have been made based on developments in experience and knowledge since 2014.*

Note – readers should read appendix 1 of this guidance on stack dimensions and separation distance information for externally stored wastes in conjunction with this main text. Appendix 1 gives the detail, and includes an overview of the two main options available to waste operators when planning their external waste storage.

Typically more wastes are stored outside than inside buildings. This is for various reasons, such as greater available space and lower cost compared to internal storage. External storage has advantages and disadvantages, such as:

- Fires may be easier to fight than with internally stored wastes because of likely better visibility and easier access, provided that adequate stack size limits and stack separation distances are in place
- Conversely, fire suppression/extinguishing equipment, such as sprinklers and deluges, may be typically harder to design and install
- Fire detection equipment may also be more difficult to arrange

You should consider the merits of internal and external storage when compiling your storage plan for your site.

6.1 Externally stored wastes – overall considerations

6.1.1 One of the potential disadvantages of external storage is that, in general, the volumes of waste stored are much higher than for internally stored wastes. A lack of adequate separation distance (or fire walls) and excessive stack size combined with the typically higher overall volumes of waste stored externally can have serious consequences. Some of the largest waste fires experienced have been in external storage yards – some of these fires have burnt for days or even weeks or months and have been extremely difficult to control and extinguish. Many of these fires have been exacerbated by the Fire and Rescue Services (FRS) not being able to access the fire adequately, and the spread of fire because there has been little in the way of stack separation or physical segregation, such as with fire walls etc. Conversely, well organised external waste storage stacks of reasonable size and with adequate separation (or fire wall provision) can be one of the safest forms of waste storage.

6.1.2 If you store wastes externally you must consider stack size and separation between stacks, and the use of fire walls/bunkers. Appendix 1 gives guidance. You should use the guidance in appendix 1 to plan your external storage.

6.2 Detection, alarm and fire systems at external storage

6.2.1 For external storage areas the use of automatic detection systems poses practical problems, although some types of detection system can be fitted externally and you should consider these if practical. Some sites have fitted camera type detectors at external storage stacks and just because your storage is external this does not mean that you should not at least consider detection systems.

6.2.2 For external storage you should at least visually inspect stored wastes frequently. Frequency should be determined by your risk assessment, but you should start with no less than once a week and you may want to increase frequency during the summer months. As noted above, you may also need to consider the use of temperature probes or thermal imaging, as practical to the types of waste you store and the form it is stored in (loose, baled etc).

6.2.3 As for detection, external storage areas pose challenges for fire suppression systems. You should at least consider whether on-site fire hydrants are required and whether you have an adequate water supply with which to fight a fire. You may also wish to consider drench, sprinkler or other systems for external storage areas as part of your assessment. For deluge and similar systems these can sometimes be fitted to external waste storage bunker wall tops.

6.2.4 For specialist storage systems the options for fire suppression will depend on the specific situation. For example, a drench system fitted to a silo for storing wood chip, or a foam suppression system. For specialist storage systems you should seek competent advice.

6.2.5 Appendix 2 gives more detailed guidance on fire detection, alarm and suppression/extinguishing systems, including for external storage of wastes.

6.3 Arson, vandalism and other specific ignition risks

6.3.1 Some ignition risks may be lower for external storage. However, others may be higher. In particular the risk of arson/vandalism may be higher. It is often more difficult to protect external areas of a site from trespass than it is for buildings:

- You should include arson/vandalism risks (for example, the nature of the location your site is in) and security arrangements in your fire assessment for external storage
- If your site has a history of trespass, theft and/or vandalism you should consider enhancing your site security arrangements

6.3.2 Arson/vandalism may not be the only ignition threat externally stored wastes face:

- Are there any specific ignition risks posed by neighbouring premises, such as sparks from welding conducted outside and/or at your site boundary? Consider these and arrange your storage accordingly. For example, one known recycling plant is next door to a firework factory which tests fireworks in an external area not far from the recycling plant's boundary – the recycling plant operator only stores wastes at the opposite end of their site to provide as much of a stand-off distance as possible
- There may be other ignition sources external to a site. If you know of any which may be applicable to your site you should include these in your assessments

7. Internal waste storage

Summary of main changes since 2014 guidance: *As for the above sections on general waste storage issues and external waste storage, this section has been extensively revised. The waste burn trials carried-out in 2015 and 2016 were conducted on externally stored wastes. Consequently, the results of these tests may not be directly applicable to internally stored wastes, which may burn differently because of factors such as air-flow. However, sufficient information has been gained from the external waste burn trials to cast doubt on some of the information given in the 2014 guidance relating to stack sizes and separation distances for internally stored wastes, which was based on older and typically non-waste research and information. As a result, appendix 2 of the 2014 guidance has been removed, and this section substantially revised. Further burn tests on internally stored wastes may be conducted over the coming years, and any results from such tests will be fed into future revisions of this guidance. However, as some issues such as air-flow may be dependent on specific building internal layout, size etc this may remain an area for site specific assessment.*

In general less waste is stored inside buildings than outside, although this can vary from site-to-site. At many sites internally stored wastes are contained in walled bunkers and similar. However, some waste sites do store baled and other wastes inside buildings in 'open' storage and not contained in bunkers and similar. Internal storage has some advantages, but also has disadvantages:

- Fires may be harder to fight than with externally stored wastes because visibility may be impeded by smoke and access for Fire and Rescue Services (FRS) to fight fires may be more difficult
- Because of the above, if life is not at risk the FRS may decide (understandably) to simply contain a fire and let it burn itself out – this may well result in the loss of your building and/or any plant and equipment contained in it
- Conversely, fire suppression/extinguishing equipment, such as sprinklers and deluges, are typically easier to fit than at external storage areas
- Fire detection equipment may also be easier to arrange
- The risk of property and asset loss is likely to be higher than for externally stored wastes. A fire in internally stored wastes may spread to buildings and plant more easily than for externally stored wastes (provided externally stored wastes are adequately separated from buildings)
- While not a fire risk issue, storing wastes internally protects them from the weather, which for some waste types may be a quality issue, and at some sites storage of wastes internally may be a permit/licence requirement for nuisance control reasons

7.1 Internally stored wastes – overall considerations

7.1.1 If you store wastes internally you must consider stack size and separation between stacks, or the use of fire walls/bunkers. The information contained in appendix 1 may not be directly applicable to internally stored wastes, but the overall approach may be, and many of the principles are (see sub-section 7.3 below). You should consider the data in appendix 1 as a starting point, but in some cases not as absolute guidance, for the internal storage of wastes.

7.1.2 Separation between internally stored wastes and building walls, plant and other equipment within buildings also needs to be considered. Experience in the industry is that fires in internally stored wastes are far more likely to spread to buildings and plant than for externally stored wastes.

7.1.3 As above, fires in internal storage areas may be more likely to spread to waste processing areas, and damage or loss of buildings and plant is always a risk. As a result, your insurer is likely to place more emphasis on internal storage than external storage fire management. You should seek advice from your insurer to ensure that you have met any requirements they may impose.

7.1.4 If you are storing wastes internally in large quantities, such as in warehousing, then you should seek competent advice on the precautions to be taken. These will depend on the type of building used, the types of waste being stored and what fire precautions are already in place. This is a specialised area, and the general standards applied to the warehousing of goods may not be appropriate to the internal storage of wastes.

7.1.5 Overall, for internally stored wastes:

- The best approach ideally may be not to store wastes internally: If practical, within your permit/licence and compatible with any waste product quality issues. Or, failing this to limit the amount of waste you store internally (or limit type of waste – see below on plastics and rubber wastes). Or, at least move wastes which will be stored externally to their allocated external storage areas as quickly as practical
- If practical, larger volumes of internally stored wastes should generally be stored in bunkers, or separated by fire walls – in general the restrictions on space in internal storage situations and the ‘free-air’ separation distances required would tend to make the use of bunkers and/or fire walls the most practical option in any case

- You may want to consider the use of fixed fire detection and suppression/extinguishing systems more carefully at internal waste storage areas (see appendix 2 for details)
- In particular for plastics and rubber wastes, the higher burn temperatures involved are likely to pose a higher risk of fire spread to buildings and plant. Enhanced and high-specification fire detection and suppression/extinguishing systems should be given careful consideration if you store plastics or rubber wastes internally. The most practical approach may be to not store plastics and rubber wastes internally
- The approach you take to fire risk in internally stored wastes will be dependent on a range of factors, including the layout and size of your building, its construction materials, the configuration of your storage and other factors specific to your building and how you are operating. This is a matter for site specific assessment, and you may need competent advice

7.2 Detection, alarm and fire systems at internally stored wastes

7.2.1 General guidance on fire detection, alarm and suppression/extinguishing systems is given in appendix 2. For internally stored wastes you should read this guidance carefully to ensure that if you do store wastes internally you have mitigated the risk adequately.

7.2.2 At some sites materials are moved from waste treatment/processing directly into internal storage areas using conveyors or other mechanical handling systems. In such cases you will need to consider the potential for fire spread by such interconnection. In such cases you should consider the provision of automatic fire suppression/extinguishing systems on the conveyors etc leading to internal storage areas.

7.2.3 One potential problem with fighting fire in internal storage areas is smoke, which may obscure a fire and make it difficult for the Fire and Rescue Services to direct water direct to the seat of a fire. You may want to consider, subject to your risk assessment, passive or automatic smoke vents in the roof over internal storage areas. However, you must consider this carefully as vents can cause interaction problems with some fire detection and suppression systems resulting in a delay in activation – you should seek competent advice on this issue.

7.2.4 You should consider potential operational issues which may affect the effectiveness of any suppression system you have installed. For example, if you have installed a sprinkler or deluge system around an internal storage bunker (in essence, a pipe with nozzles installed on top of or just above your bunker walls). This is unlikely to work effectively if the height you are storing wastes at means such systems are buried. Likewise think about height for other reasons, such as waste piled to such a height that electrical lighting may pose an ignition risk.

7.3 Application of appendix 1 on externally stored wastes to internally stores wastes

7.3.1 The stack separation distance information in appendix 1 is only directly applicable to externally stored wastes, because it is based on data from the waste burn trials conducted in 2016 which were conducted on externally stored wastes. However, there is some application to internally stored wastes (see 7.3.5 below) and the general principles involved are the same.

7.3.2 The maximum stack heights and widths given in appendix 1 are applicable in outline to internally stored wastes. These heights and widths are based on stack stability and effectiveness of fire-fighting using standard hoses. These factors apply to internally stored wastes as much as externally stored wastes.

7.3.3 Deviations from these stack heights and widths (as discussed in option 2 in appendix 1) are likely to require enhanced fire systems if the risks associated with internally stored wastes are to be mitigated. This is a matter for site specific assessment.

7.3.4 At its top end, the stack length information given in appendix 1 is unlikely to be appropriate for internally stored wastes, if for no other reason than those of building size and available space (but, see below on separation distances related to length). This is an issue for site specific assessment, although the data in appendix 1 can be viewed as a starting point and guidance.

7.3.5 The ‘free-air’ separation distances between stacks, and stacks and buildings, and their relationship to stack length given in appendix 1 for externally stored wastes may not be directly applicable to internal storage. However, they are unlikely to be factors of magnitude out. As a result, the practical approach for internally stored wastes is likely to be the use of bunkers and/or fire walls between stacks. As for all stored wastes in bunkers and similar, bunker wall construction and height are critical factors.

7.3.6 The mechanisms for fire spread given in appendix 1 will apply to internally stored wastes, although the detail may vary. However, with internally stored wastes other fire spread mechanisms may be important. For example, hot combustion products are unlikely to dissipate to the extent they may with externally stored wastes, and the risk of fire spread through mechanisms such as ‘flash-over’ are likely to be higher. You will need to consider these other fire spread mechanisms more carefully with internally stored wastes, and you may need to seek specialist advice.

8. Disclaimer

Nothing in this guidance constitutes legal or other professional advice and no warranty is given nor liability accepted (to the fullest extent permitted under law) for any loss or damage suffered or incurred as a consequence of reliance on this guide.

The guidance is not a substitute for duty holder judgment and/or professional safety or other advisor's judgment. Notwithstanding the good practice in this guidance, duty holders are responsible for ascertaining the sufficiency and adequacy of their procedures for verifying and evaluating their organisation's compliance with health and safety law.

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This guidance is issued by the Waste Industry Health and Safety (WISH) Forum to help control the safety and health risks associated with fires. Following the guidance is not compulsory, unless specifically stated, and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Some parts of the guidance represent good practice and may go further than the minimum you need to do to comply with the law.

Appendix 1: Managing external storage stacks

Notes

Please read this appendix carefully, rather than simply turning to its summary tables. The principles in the text are important if you are to interpret this appendix correctly. This appendix applies to the external storage of wastes in stacks. It does not cover the internal storage of wastes in buildings directly, although some of the principles given below will apply (see section 7.3 of the main text for guidance on this issue). In addition, this appendix applies to the storage of wastes, and not directly to wastes in short-term reception areas, in treatment and similar. However, as for internal storage, some of the principles will apply. Internal storage of wastes and waste reception and treatment are covered specifically in other parts of this guidance.

Contents

1. Introduction

One of the most read parts of the 2014 WISH waste fires guidance was its appendix 1 on the management of external waste storage stacks, and in particular the maximum stack sizes/dimensions and minimum separation distances the appendix contained. This is not surprising because of the potential impact these parameters can have on waste site operations. This revised appendix 1 of the 2017 WISH fires guidance differs significantly from the previous 2014 version. This is largely because knowledge and experience on waste fires has developed significantly since 2014, and in particular the results of the waste burn trials conducted in 2015 and 2016.

In some areas the developments which have taken place since 2014 have allowed a simplification of this appendix. For example, the three storage stack management options given in the 2014 guidance have been reduced to two options. In other areas developments have complicated this appendix. For example, the simple separation distances given in the 2014 WISH guidance have been replaced with a variable distance (a 'sliding-scale') dependent on stack length and burn face dimensions (see below). However, even this complication can have benefits in terms of the flexibility waste site operators can exercise to customise their storage layouts.

One common item of feedback from readers of the 2014 WISH fire guidance was for an explanation of how stack size/dimensions and separation distances are derived. This revised 2017 version includes two new sections (2 and 3 below) which provide such an explanation, outline what factors are relevant to stack size/dimensions and separation distances and, perhaps as importantly, what factors can be used practically to determine these parameters (not all potential factors are useful or practical).

Section 4 of this revised 2017 appendix covers standard stack sizes/dimensions and separation distances, and replaces the 'option 1' information in the 2014 guidance. Section 5 covers bespoke stack sizes/dimensions and separation distances, and replaces the 'options 2 and 3' in the 2014 guidance. Section 6 provides examples of storage stack layout to assist waste site operators in interpreting this appendix and applying it flexibly to their specific site.

It seems likely that this revised 2017 appendix 1 will remain the most-read part of the WISH fires guidance, and likely will receive the most feedback. Stack size/dimensions and separation distances are critical to good levels of fire management at waste management sites. This 2017 revised appendix 1 is based on the best and most up-to-date information available on these key aspects.

1.1. Storage stack fire risks and developments since the 2014 WISH fires guidance

Some of the largest waste fires in recent years, and those which have taken the longest to extinguish or bring under control, have been in external waste storage stacks. This is not surprising as typically greater volumes of waste are stored outside than in buildings. These large waste fires have attracted the greatest amount of publicity, and potentially pose the highest risks to the environment and human health and safety because of their size. The adequate management of external waste storage stacks is critical to reducing these risks, and in particular stack size/dimensions and separation distance between individual stacks are key factors. For example:

- The larger an individual storage stack of waste is the more fuel it will contain and the greater the potential for a larger and more long-lasting fire. In addition, the larger an individual waste stack the more difficult it may be to fight a fire, such as not being able to focus fire-hose water streams at a fire effectively because of the size of a stack
- A fire in one individual storage stack of wastes, provided the stack is of a reasonable size, may be manageable. However, if the fire spreads to other adjacent stacks then the likelihood of a larger and potentially uncontrollable fire increases. In addition, if a stack is too close to a building then fire may spread to the building, or other combustible object

To mitigate the above risks, limits on stack size/dimensions and standards for separation distances between stacks, or buildings etc, are required. However waste management sites are finite in size, and stack sizes/dimensions and separation distances can have a direct effect on how much waste can be stored, and consequently on site operability. Stack size/dimension limits and separation distance standards need to achieve good levels of fire safety and management, and be cautious and prudent, without going unreasonably beyond what is needed to achieve these good and prudent levels of fire safety and management.

The 2014 WISH fires guidance, and much other similar guidance, used various and typically non-waste data sources to arrive at stack sizes/dimension limits and separation distance standards: They used the best information available at the time. This was acknowledged in the introduction to the 2014 WISH fires guidance which stated: *“As knowledge on the burn properties of specific wastes improves, experience of real fires accumulates and as better information becomes available, revisions of this guidance will be made to keep it up to date.”*

Specifically on waste storage, the consultation letter accompanying the 2014 WISH fires guidance (included in the guidance as an appendix) stated: *“There is little available fire testing or science specific to wastes to provide a firm under-pinning for the available information on stack sizes and separation distances… There is data on raw materials. Much of this indicates that the separation distances in table 1 in appendix 1 are conservative and separation distances in excess of those currently available for wastes may be required at sites with no fire prevention measures.*

"For example, data on virgin, raw paper and plastics suggests separation distances between 10 - 11 metres and 18 - 27 metres respectively – that is well in excess of those distances quoted in table 1 of appendix 1. Whether this data for raw materials can be applied direct to wastes is not known - real testing on wastes is required."

This real testing on wastes was undertaken in 2015 and 2016 (a non-technical summary of the results of the tests is available on the WISH web-site). In addition, a review was undertaken of developments in other factors which may be used to inform the setting of waste stack size/dimension limits and separation distance standards. This review included the collation and pooling of knowledge and experience on the practical aspects of fighting waste fires. The aim of the tests, and review, being to provide a basis for waste specific stack size/dimension and separation distance standards which would achieve good levels of fire safety and management, without going unreasonably beyond this. A summary of the factors considered during the above review and input of the waste burn tests is given in sections 2 and 3 of this appendix.

Note – the alternative to free-air separation distances between stacks of using fire walls/bunkers is also considered in the sections below.

1.2. External waste storage stack management options

As was the case for the 2014 WISH fires guidance, this 2017 revised guidance aims to be flexible and offer options to waste operators. The 2014 WISH waste fires guidance gave three options for the management of external waste storage stacks. As a result of the above review and the waste burn tests, and increasing knowledge in other areas, it has been possible to simplify this appendix down to two options:

Option 1: Standard separation distances and stack sizes/dimensions
Option 1 applies to waste management sites with only basic fire-fighting provision, such as hand-held fire extinguishers and 'standard' fire hoses (sites which largely rely on the intervention of the fire and rescue services should an incident occur), and operators who do not wish to have bespoke fire engineering calculations performed.

Option 2: Modified/bespoke separation distances and stack sizes/dimensions
Option 2 would apply to sites with enhanced fire-fighting provisions, such as fixed fire extinguishing/suppression equipment (for example automatic water deluges, oscillating water monitors or other similar equipment), and operators who do wish to have bespoke fire engineering calculations performed on their specific situation and/or wastes.

Sections 4 and 5 below describe these options and their application to stack sizes/dimensions and separation distances in more detail, and section 6 gives examples of site storage layout to illustrate the use of the stack dimension and separation distance information given.

2. Factors affecting separation distances and use of fire walls/bunkers

Fire spread has been a major factor in many large fires in externally stored waste stacks. Obviously, fire will tend to spread within any individual stack of wastes. However, fire spread between stacks, or between stacks and buildings etc, is also an important issue. There are two main methods of reducing the risk of fire spread between stacks/stacks and buildings:

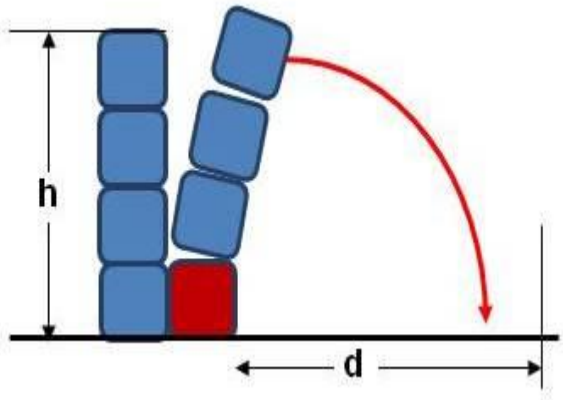
- Provide an adequate free-air gap (separation distance/fire break) between stacks
- Place an effective fire barrier (wall/bunker wall) between stacks

How wide a free-air separation distance needs to be, or what would be an effective fire wall/bunker wall, will depend on fire spread mechanism. In addition, some mechanisms of fire spread are more useful than others when setting separation distances.

2.1. Fire spread mechanisms

Fires can spread between stacks via various mechanisms. For externally stored waste stacks the most significant potential fire spread mechanisms include:

- Flying/blown ‘brands’: Burning detritus blown from one stack to another (or building etc). This mechanism is unpredictable and depends on factors such as wind strength and direction, and active fire management can reduce the risk, such as by tackling any flying brands with hoses or similar. Flying brands do pose a risk of fire spread, but because of their unpredictable nature it is not practical to use them as a guide to separation distances
- Stack collapse: The collapse of a stack on fire resulting in burning wastes falling, rolling and coming into contact with a second stack. How far wastes can ‘roll’ as the result of a collapse varies dependent on the nature of the stack and the wastes, and waste configuration (shape of bale for example). As for brands variability makes this mechanism impractical as a guide to separation distances



Example of a stack collapse mechanism, assuming a bale at the base of the stack collapses first. The distance any bale, or part of a bale, will ‘roll’ is dependent on a range of factors making stack collapse too unpredictable to use as a guide to separation distances between stacks

- Thermal energy transfer: Heat produced by a stack which is on fire resulting in the temperature of a nearby stack (or building etc) being raised to its ignition point and setting on fire. This mechanism is capable of measurement and can be used as a guide to separation distances

This is not to say that flying brands and stack collapse should be ignored. Site emergency response plans should include mitigations against these fire spread mechanisms. But, they are not useful as a practical guide to determining separation distances between stacks to reduce the risk of fire spread. Thermal heat transfer does provide a practical guide. The waste burn trials conducted in 2015 and 2016 provided data which can be used to calculate separation distances based on thermal heat transfer.

2.2. Use of thermal emission data to determine separation distances

When an object, such as a waste stack, burns it emits heat (it becomes an ‘emitter’ of thermal energy). Unless this heat is ‘blocked’ by an item such as a fire wall, the thermal energy will travel through the air. If another combustible object, such as another waste stack, is placed in the path of this thermal energy it becomes a ‘receptor’. The temperature of the receptor will increase, and if it reaches its ignition point (the temperature at which it will burn) this second object will set alight.

The above is obvious, but can heat transmitted in such a way really pose a serious risk of fire spread? During the waste fire burn tests the heat emitted by a burning stack of bales of waste plastic was sufficient to melt a data-logger ten metres away, and blister the paint on a porta-cabin nearly 30 metres away. Heat transfer between an emitter and receptor is a common cause of fire spread, and a tried and tested method for determining separation distances between combustible objects/materials.

One of the main outcomes of the waste fire burn tests was to determine how much heat energy various types of waste emit when they burn. Research has been conducted in the past on this aspect, both on some waste types and more commonly on raw materials which may behave like wastes in a fire. However, such research typically used small scale laboratory type testing. The waste burn trials moved beyond this laboratory type testing and involved much larger scale burn tests aimed at replicating what actually happens when a waste storage stack is on fire.

The non-technical summary of the results of the waste fire tests, available on the WISH web-site, goes into this topic in more detail. However, the tests resulted in a good set of data on thermal heat emissions for waste storage stacks. In terms of their heat outputs, the wastes tested during the waste burn tests can be split into two broad categories:

- Plastics and rubber: These waste stack types exhibited higher heat outputs when burnt during the tests. Surface temperatures during burns in some cases exceeded 1,200 degrees centigrade, and were consistently higher than for other waste types

- Other combustible wastes stacks, such as SRF, RDF, wood wastes, paper etc: These waste types exhibited lower relative heat outputs when burnt. There were variations in surface temperatures, but within a practical range of 850-950 degrees centigrade

The temperatures quoted above are for the most frequent 'worst case'. These two broad categories form part of the basis for the standard separation distances information in option 1 below. However, there are other factors to be taken into account:

Receptor ignition properties: From the waste burn tests we know the levels of thermal heat produced when different types of waste stored in stacks burn. But, there is limited information available on the ignition properties of receptors. The receptor could be another waste stack, a building, a wooded area next to a site etc. For the purposes of the standard separation distance information given in option 1 below, two receptor ignition property figures have been used:

- Research into the ignition properties of wastes has been conducted, in particular Swedish research on the ignition properties of baled RDF. This research indicates that a heat input of 10 Kw/m^2 is required to ignite baled RDF
- The accepted national standard for buildings protection regards ignition is a heat input of 12.6 KW/m^2 for solid unprotected surfaces

The above provides a practical range: That baled RDF requires less heat input to ignite than a typical building is not surprising. However, different types of waste may have different ignition properties. If you believe that your waste may have a different ignition property then you could have your waste tested (see option 2 on bespoke distances below).

Angle of emitter and receptor: The angle between emitter and receptor is an important factor. Heat transfer between two surfaces parallel to each other will be more effective than between two angled surfaces of the same dimensions. In fire science this issue is accounted for by use of a 'configuration factor' (discussed in the 2014 WISH fire guidance, appendix 1, option 3).

Because of the results of the recent waste fire burn tests, this issue can be simplified in practical terms for standard separation distances information without a waste site operator needing to perform such calculations themselves, likely via a consultant. The separation distance information given in option 1 below takes account of configuration factor for loose stacks. This is the reason why separation distance information for loose pile stacks with an assumed angle of repose of 45 degrees is quoted, in addition to 90 degree (vertical) baled and similar stacks and buildings.

The separation distance information in option 1 below takes account of the above issues, and translates much complex fire science into practical separation distances. However, it is accepted that there are variables still be to fully understood, and there is nothing to stop anyone performing their own calculations rather than relying on the standard parameters given in option1.

Finally on factors which can affect separation distance to reduce the risk of fire spread, the potential fire spread mechanisms of stack collapse and flying brands are discussed above, and noted as being too variable to provide a practical basis for determining separation distances. However, the separation distances quoted in option 1 are such that they are also likely to provide a reasonable degree of protection from these other potential fire spread mechanisms. Issues such as stack collapse do, however, provide input to stack height (see section 3 below).

2.3. Use of fire walls and bunkers to replace free-air separation distances

An alternative to using 'free-air' separation distances between waste stacks, or stacks and buildings etc, is the use of fire walls. The intent being to provide a 'block' to the heat produced by a burning waste stack so reducing the risk of fire spread. Fire walls can be linear, to separate two objects, or arranged as bunkers, typically in waste management applications three-sided.

The topic of fire walls and bunkers is discussed in more detail in the main body of this guidance and in the fire/risk engineering appendix (section 6.5 of the fire/risk engineering appendix). Readers should study these sections before deciding on the use of fire walls/bunkers in external waste storage. However, specific to this appendix on external waste storage:

- When used to protect buildings height of fire wall needs consideration. Heat does not only travel horizontally - walls need to be high enough to protect upper portions of buildings
- Three-sided bunkers only protect from fire spread on the three sides where walls are installed. For the open side the full free-air separation distances need to be used
- Fire/bunker walls need to extend at least 1 metre above stored waste height to take account of flame height, and wastes should not spill/extend beyond fire/bunker walls. Please note that in some of the waste burn tests flame height exceeded 1 metre: The 1 metre above is aimed at achieving a reduced risk of fire spread

In addition, there are some practical aspects associated with fire wall/bunker use:

Fire walls/bunkers can be useful in reducing the space required to store wastes, by removing the need for wide free-air separation distances between stacks. However, access to fight fires is a consideration. What you do not want is to create a 'maze' of fire walls making access to fight a fire difficult, and potentially hazardous. Consider access issues when planning fire walls/bunkers, including what actions you can take on site in the event of a fire, such as using heavy mobile plant to remove wastes from bunkers/the other side of fire walls adjacent to where a fire has started.

It is fairly common practice in external storage at general waste recycling plants to use rows of metal wastes bales to separate stacks of combustible waste bales. The recent waste fire burn tests showed a significant difference between the heat emitted by most combustible wastes when they burn and plastic and rubber wastes, plastics and rubber burning at much higher temperatures. For example, during the plastic baled waste stack burn test maximum temperature measured at the surface was in excess of 1,200 degrees centigrade. This is above the melting point of aluminium. The use of metals bales to separate bales of paper or similar may still be valid, but their use to separate plastics/rubber bales or similar may be ineffective. A 'fire wall' constructed of waste metals bales will be of little use if it starts to melt and falls-over.

Readers of this appendix may be surprised by the free-air separation distance information given in option 1 below. For sites with restricted space, the use of fire walls/bunkers in external waste storage may be the most effective option to provide an adequate degree of protection from fire spread while maintaining reasonable space requirements on site. In particular for plastic and rubber wastes where separation distances in free-air are wider, because of their higher burn temperatures. However, fire walls/bunkers require good planning to be effective and careful thought should be given to their construction, use, configuration, maintenance and layout.

From left: Smaller scale laboratory burn tests, the 'porcupine' thermal sensor array used in larger scale stack burns, plastic bales burn test, RDF loose stack burn test, bale burn test general view.

3. Factors affecting stack size and dimensions

Some of the most difficult, long-lasting and largest waste fires experienced in recent years have been in large undifferentiated individual external waste stacks. Such ‘mega-stacks’ are clearly not acceptable because of the risks they pose, and the difficulties faced by the fire and rescue services when attempting to fight such fires. Limits are required on stack size/dimensions, but as for separation distance what factors such limits are based on needs consideration.

As outlined in section 2 above, thermal heat transfer can provide a basis for calculating separation distances. This section considers the factors which may be used, and which may be practical to use, to determine limits on stack size/dimensions.

3.1 Burn-time, self-heating and stack volume as potential considerations

The more waste in a stack the longer a fire may potentially last for: How long, is a function of how much waste there is and the rate at which the fire burns at. During the recent waste fire burn tests the rate of mass loss during burning was measured for various waste types. That is, when left unattended how long do various wastes take to ‘burn-out’ by exhausting their available fuel. The result were variable: Rate of burn varied between 1 tonne of some waste types taking only a few hours to burn-out to other waste types taking more than 24 hours.

For many waste fires the fire and rescue services will fight the fire rather than letting it burn-out. But, in others a strategy of containment (controlled burn) may be used, such as to prevent contaminated firewater from fire-fighting entering a nearby watercourse. For controlled burn, setting a time limit of a few hours, or even a day or two, for waste fires to burn-out and applying this to determine standard maximum stack size would result in maximum stack sizes of only a few tonnes for many waste types.

In addition, assuming that the fire and rescue services do fight a fire actively, how long this may take will depend on a range of variables such as how advanced a fire is, available water supplies, how quickly they can mobilise, what fire appliances are available at any given time etc. Installing fixed fire systems such as water deluges and oscillating water monitors will increase the likelihood of a fire being brought under control/extinguished more quickly. However, fire/risk engineering is not based on distinct time limits against volumes of material stored, such systems are not common currently in external waste storage, and would in any case likely move a site out of the standard approach of option 1 into the bespoke approach of option 2 as given below.

With the current level of knowledge, setting a distinct time limit to burn-out or extinguishment and using this to try to determine standard maximum stack size is fraught with problems, and unlikely to be practical. The only practical statement that can be made is that plans should be made to extinguish waste fires as quickly as possible.

Self-heating is another potential parameter to consider. However, self-heating is not well understood and is dependent on a wide range of variables, from particle size and density to waste type, ignition mechanism and external environmental conditions.

Surface area to mass ratio is likely to have a role to play in self-heating: In general for cone or similar shaped stacks, the larger the stack the lower its surface area to mass ratio becomes, and the less able it is to shed heat caused by self-heating. But stack configuration is also a factor. A longer thinner stack may contain many hundreds of tonnes of waste and still largely maintain a surface area to mass ratio which allows heat to be shed, and larger particle size wastes may allow sufficient air-gaps within a waste stack to allow heat to be shed other than at the stack's surface. For example, a bale stack of 50 metres length x 20 metres width x 4 metres height when compared to a smaller stack of 20 metres length x 10 metres width x 4 metres height loses less than 30% of surface area to mass ratio, despite having five times the volume.

Self-heating is a significant factor in waste fires, and waste operators need to account for this in their storage management, such as in good standards of stock rotation. However, current knowledge of the phenomenon is insufficiently advanced to allow its practical use to determine standard stack sizes. Self-heating is covered more generally in section 5.4 of this guidance.

When a stack of waste is on fire it will emit heat. The greater the amount of heat emitted, the wider the separation distance between the stack and another combustible object, such as another stack, needs to be to avoid fire spread by thermal radiation. However, it is not primarily the volume of a stack which determines this. It is the dimension of the 'burn-face' of the stack (see 3.3 below). For example, following the waste burn trials calculated separation distances were modelled for two stack volumes (450 m^3 and 750 m^3), but with the same burn-face dimensions. The difference between the two sets of separation distances arrived at was not significant.

With the current state of knowledge, the most practical method of determining standard stack sizes is likely to be a combination of practical fire-fighting experience, stack stability and stack configuration/dimensions relating to burn face dimension. This may change in the future as knowledge in this area develops, and in that case a revision to this appendix would be required.

3.2 Practical fire-fighting and stability considerations

Most external stack fires are likely to be fought using manual hoses and similar, in the first instance perhaps by site staff and then by the fire and rescue services. This poses practical considerations: If the fire and rescue services are confronted by a 20 metre high x 60 metre diameter individual waste stack they are unlikely to be able to apply water over all parts of the stack using standard equipment. The fire and rescue services have been pooling their knowledge and experience of waste fires in recent years, and WISH has been involved in this process. Based on this knowledge and experience, standard maximum height and width for waste stacks can be set based on practical fire-fighting considerations. These dimensions are included in option 1 below.

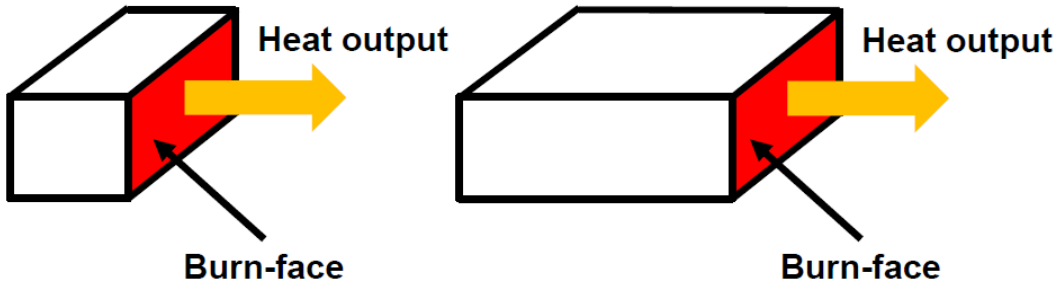
- Maximum stack height = 4 metres (for baled waste stacks no more than four bales high or 4 metres whichever is the lower – note this is subject to overall stability of bale stacks and three bales high may be more appropriate dependent on risk assessment)
- Maximum stack width = 20 metres if adequate access can be arranged from both sides of a stack, or 10 metres if access is only adequate from one side

If a fire persists for a longer period of time, more specialised equipment may be brought to the scene, such as high-volume pumps (if there is a water supply which can feed such equipment effectively). However, it must be assumed in a fire's earlier stages that standard equipment will be all that is available. The aim must be to extinguish waste fires quickly as the best option. Stack sizes set by using practical fire-fighting considerations reflect this aim.

In addition, stack stability is an issue. Stack collapse is a valid potential fire spread mechanism, and stack stability has other non-fire safety aspects such as falling materials or bales striking a person. While the maximum height of 4 metres is set based on practical fire-fighting considerations, this height should also mitigate against stack stability issues.

3.3 Heat transfer and stack dimensions

As noted above, when a stack of waste is on fire it will emit heat. If the separation distance between the stack and another combustible object is insufficient then this heat may cause the second object to ignite. However, the amount of heat emitted in any one direction will depend on the dimensions of the 'burn-face' of the stack facing the second object, and not primarily its overall volume. The diagram below illustrates this. The two waste stacks shown are of different volumes, but the burn-faces are the same dimension, and the heat output (represented by the amber arrows) in any one direction will likewise be largely the same.



Separation distance is largely a function of the amount of heat emitted per unit of area of a burn-face, and the dimensions of the burn-face. As noted above, wastes can practically be split into two categories: General wastes such as wood, paper, RDF etc which exhibit maximum burn temperatures of some 850 - 950 degrees centigrade and plastics and rubber wastes with temperatures of up to some 1,200 degrees centigrade. We know what the heat emissions per unit of area for these two temperatures are, which leaves burn-face dimension as a variable.

Maximum stack height = 4 metres and maximum width = 20 metres (or 10 metres dependent on access). The 4 metre height is a constant, and width will be known up to a maximum of 20 metres. The only dimension remaining as a variable is length. The longer the burn-face (stack length) the higher the heat output, and the wider the separation distance required to avoid fire spread. There is a 'sliding-scale' relationship between burn-face length and separation distance. This is not a straight-line equation. As length increases the effect on heat output at any given point on a receptor declines. This is reflected in the separation distance graphs provided in option 1 below.

NOTE – the terms 'width' and 'length' are used above. Obviously if a waste storage stack is 10 metres by 10 metres, its width and length are the same, and the terms stop making that much sense. In addition, if a waste stack is on fire its 'width' will emit heat and well as its 'length' – both the width and length will have burn-faces. This issue is covered in more detail in option 1 below.

3.4 Other considerations

There are some other considerations which support the practical factors noted above:

- As above, stack collapse is a fire spread risk. The higher the stack the greater the risk that falling wastes will travel further. A maximum height of 4 metres/no more than four bales high mitigates against this risk by reducing the kinetic energy falling wastes may have
- Stability of stacks is a fire and non-fire safety consideration. Slips in loose waste stacks may engulf personnel and bales toppling may strike persons in the area posing a risk of severe or fatal injuries. This would include fire and rescue services personnel tackling a fire
- Stack collapse may impede the fire and rescue services and delay access for fire-fighting
- One technique used during waste fires is to remove unburnt wastes from a stack which is on fire using mobile plant. This is easier if a stack is not too high or too wide

In summary:

- Maximum stack height of 4 metres (or maximum of four bales high whichever is lower) based on practical fire-fighting and stability considerations
- Maximum stack width of 20 metres (provided access is available from both sides – if not maximum of 10 metres) based on practical fire-fighting considerations
- Stack length a variable based on the separation distance which is achievable at any specific site, so allowing flexibility to account for site dimensions and layout

Between these three parameters the separation distances provided in option 1 below can be arrived at, based on practical considerations and fire science from the waste burn trials.

4. Option 1: Standard separation distances and stack size

As noted in the introduction to this appendix, two options for stack sizes and separation distances are given. This section covers standard stack sizes and separation distances information, and the alternative use of fire walls/bunkers. Option 2 in section 5 covers bespoke and modified cases.

4.1. Introduction to standard separation distances and stack size option 1

The standard stack sizes and separation distances information, and information on the alternative use of fire walls/bunkers, given in the tables below for option 1 are based on the factors and considerations described above, including the results of the 2015 and 2016 waste fire burn tests. This option 1 is aimed at waste management sites which only have a basic level of fire provision, such as hand-held fire extinguishers and standard fire hoses, and operators who do not wish to have bespoke fire engineering calculations performed. If your site has fixed fire protection systems at external storage such as water deluges or automatic oscillating water monitors, or you wish to have bespoke fire engineering data calculated, then option 2 may be more applicable.

The data given in the tables below has been split:

- Information and standards for general wastes (typical maximum burn temperature of circa 950 °C), **excluding** wastes which are predominantly plastics and rubber. These are again split into tables for loose waste stacks and baled waste stacks
- Information and standards for waste which are wholly or mostly plastics and rubber (typical maximum burn temperature of up to circa 1,200 °C). These are given separately because of the significantly higher thermal outputs these types of waste exhibit. As for general wastes, tables are split again for loose storage stacks and baled storage stacks

Please read the notes and information given on the various scenarios in the tables below, and on the separation distances graphs, to ensure you understand fully what each means. Please also read the above sections so that you are aware of how the information and standards in the option 1 tables below were derived, and the limitations to their use.

Fires in external waste storage stacks have been some of the largest, most long-burning and most difficult to fight.

4.2. Information and use of the tables and graphs

Some of the standards set in this appendix for storage stacks are simple, such as stack height and width. However, separation distances will vary dependent on the length of the stack (see 3.3 above) on a sliding-scale. Because of this separation distances are shown as graphs.

Two graphs are provided:

- **Graph 1.** Shows stack lengths and separation distances for general wastes, such as RDF, wood, paper etc (950 °C typical maximum burn temperature – see 2.2 above). Four lines are shown on the graph: Loose stack to loose stack distances, loose stack to buildings distances, baled stack to baled stack distances and baled stack to buildings distances
- **Graph 2.** Shows stack lengths and separation distances for plastics and rubber wastes (1,200 °C typical maximum burn temperature – see 2.2 above). Four lines are shown on the graph: Loose stack to loose stack distances, loose stack to buildings distances, baled stack to baled stack distances and baled stack to buildings distances

To determine your separation distance, mark your stack length on the horizontal axis of the graph and draw a line up to the relevant graph line (stack to stack, to buildings etc). Then draw a horizontal line across to the vertical axis and read-off separation distance. This can also be done in reverse. For example, at your site separation distance may be constrained by site size. This distance can be marked on the vertical axis and maximum stack length read-off on the horizontal axis (see section 6 on example stack layouts below for illustration of this use).

The terms stack length and width are used in the tables and graphs. However, when considering separation distances based on thermal heat transfer a burn-face could be on the long-side (length of a stack) or the short-side (width of a stack), or length and width could be equal. Both need to be taken into account. Section 6 gives examples of the approach to be taken.

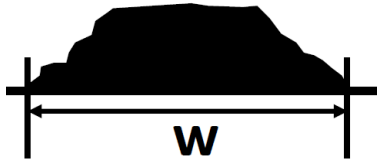
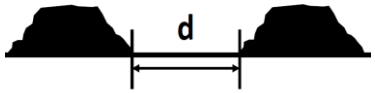
The aim of the tables and graphs below is to give waste site operators practical and standard guidance they can use without the need to employ a specialist fire engineer to calculate bespoke separation distances. As a result assumptions have been made to avoid complicating the issue and a need to have ‘hundreds’ of graphs and scenarios. The main assumptions made include:

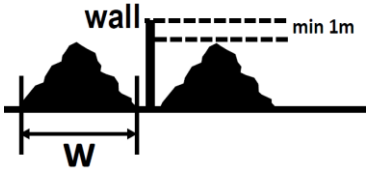
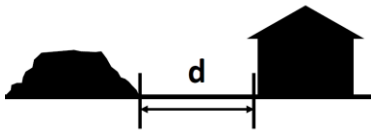
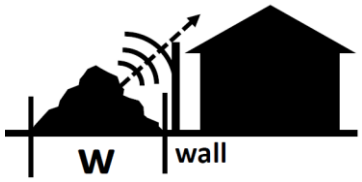
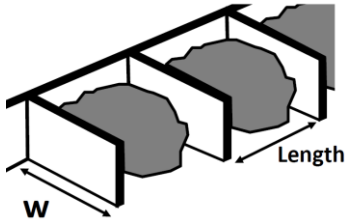
- That emitter (waste stack) and receptor (other waste stack or building) are parallel to each other. If this is not the case then separation distance may reduce – this is a matter for bespoke calculation by a competent fire engineer
- That loose waste stacks (piles) have an angle of repose of 45 degrees. If your loose waste stack has an angle of repose steeper than this then separation distance may increase, or if shallower distance may decrease – again this is a matter for bespoke calculation

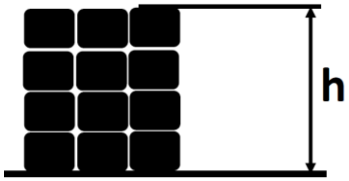
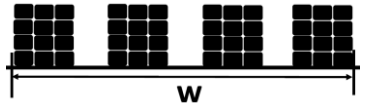
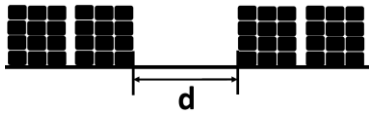
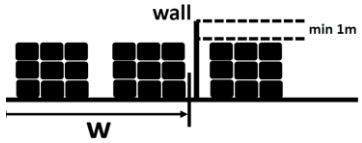
- Typical maximum burn temperature for the two broad categories of waste types noted (general wastes and plastics/rubber wastes) have been used. These reflect the typical worst case fire scenarios observed during the waste burn trials, such as 'inside-out' loose stack fires and bale 'chimney effect' fires (see the non-technical summary of the waste burn trials on the WISH web site for details). This a cautious and prudent approach aimed at good standards of fire safety and management. In addition, the 2015 and 2016 waste burn trials tested 13 different types of waste, but could not test all possible combinations – please see the note after the tables for plastics and rubber wastes in option 1 below for details and further guidance on this issue
- A receptor ignition property of 10 kW/m^2 has been used for waste stacks, based on research into the ignition properties of baled RDF. If you believe your wastes have a different ignition property you could conduct testing to prove this, and in which case separation distances may be different than those shown in option 1
- A receptor ignition property of 12.6 kW/m^2 has been used for buildings. This is the value commonly used for buildings with unprotected surfaces. For example, if your building is of concrete block construction with no doors, windows or other openings in its face opposite your waste stack then the value of 12.6 kW/m^2 may be too low, and therefore the separation distances in the graphs below too wide. However, this is a matter for specialist assessment. For example, many steel clad buildings use a composite cladding with insulation between the sheets. The type of insulation used (combustible or non-combustible, and its rating) will affect the assessment. It is unlikely that you will be able to perform such an assessment without specialist assistance, and you will then need to employ a fire engineer to calculate a bespoke separation distance
- Graphs 1 and 2 assume a stack height of 4 metres (the maximum taking into account practical fire-fighting issues and stability). If your waste stacks are significantly lower than this you could employ a competent fire engineer to calculate bespoke separation distances for your site. However, small differences in stack height are unlikely to have a significant effect, and you would need to be confident that your stacks are consistently lower
- To avoid over-complicating the tables and graphs given in option 1 a limited number of scenarios have been used (those most common at waste sites). There are other potential scenarios, such as a bale stack next to a loose stack. Further detail can be found in the non-technical summary of the waste burn trial results available on the WISH web site

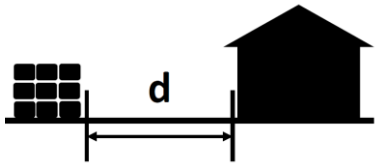
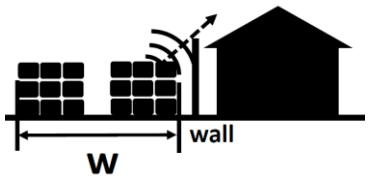
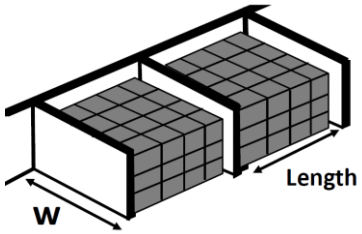
Finally, when using the graphs below take a practical and cautious approach. Separation distances obtained from the graphs should be rounded-up to the nearest whole number. Measuring stack length or width or height down to the last millimetre is unlikely to have any substantive effect, and would not replicate actual conditions on a waste site, which will vary from day-to-day and week-to-week – if in doubt err on the side of caution and prudence.

4.3. Summary tables of standard stack separation distances and stack sizes: OPTION 1

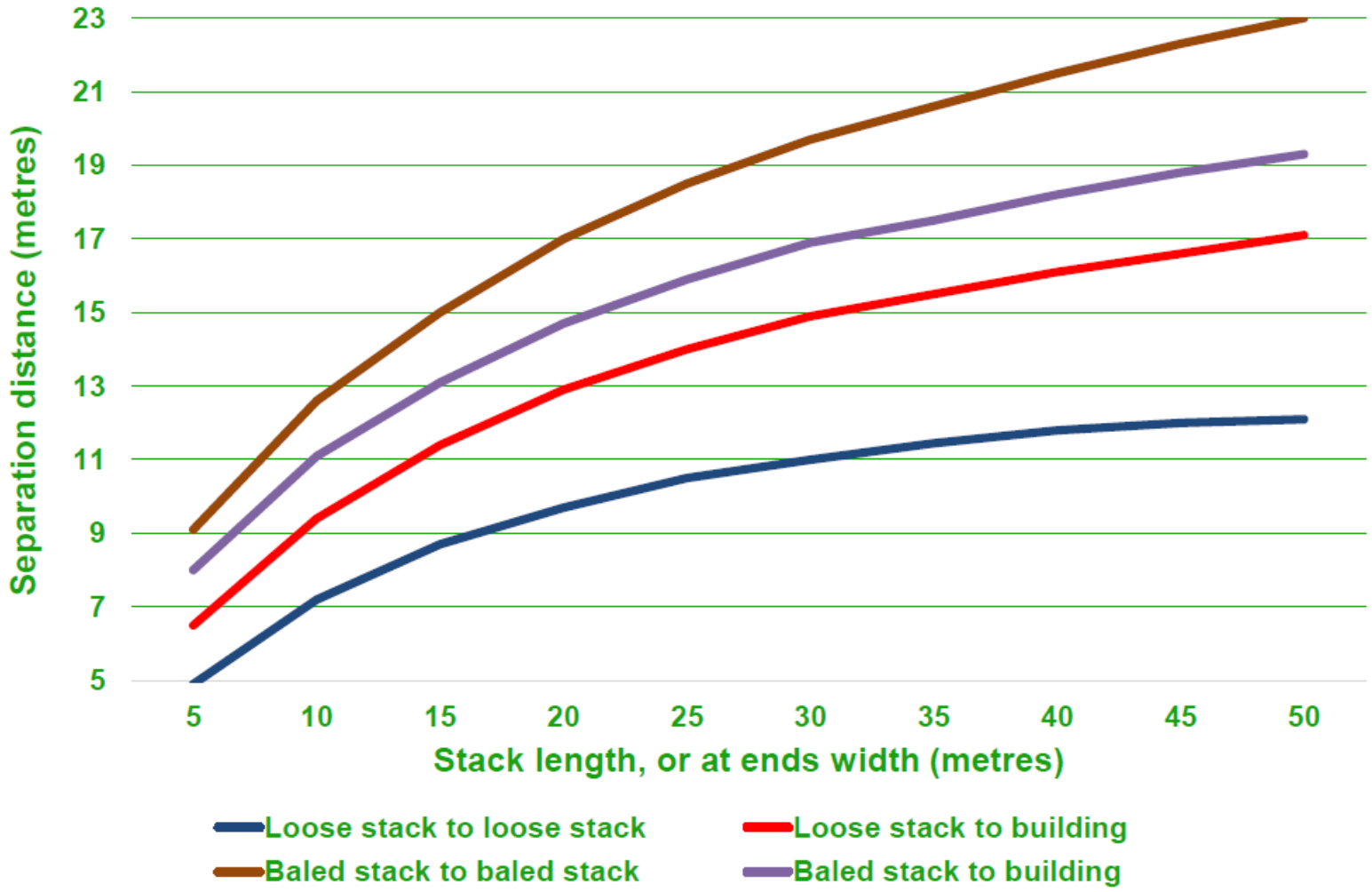
A. General combustible wastes (typical max burn 950 °C), EXCLUDING plastics/rubber	
Parameter and standard	**Commentary**
Note: *The graphics used below are indicative only and should not be considered as being to scale or a guide to stack layout or configuration, number of bales suggested in a stack etc. They are for illustrative purposes only and should be treated as such.*	
1. Loose waste stacks: General wastes (typical max burn 950 °C), EXCLUDING plastics/rubber	
 **Max height (h) of stack = 4 metres**	Maximum height (h) of 4 metres is based on practical ability to fight fires using manual means such as standard hoses, and stability of stack to reduce the risk of fire spread from falling/rolling wastes.
 **Max width (w) stack = 20 metres (10 if access one side only)**	Maximum width (w) of 20 metres is based on practical ability to fight fires using manual means such as standard hoses. **NOTE** – 20 metres assumes good access from both sides of the stack to fight fires. If this is not the case then maximum width = **10 metres**.
 **Min 'free-air' separation distance between stacks (d) = See graph 1**	Separation distance will depend on stack length (or at their ends width) – the longer the stack the wider the separation distance required. See graph 1, **blue** line to calculate separation distance for your stacks.

	**Alternative fire wall between stacks. Max stack width (w) = 10 metres**	Walls must be of suitable construction, and a minimum freeboard of **1 metre** left between waste and wall height to account for flame height. Stacks could be 'butt' against walls, but access to rear of stacks may be required for stock rotation and similar – this is a matter for site specific assessment. **NOTE** – access for fire-fighting will not be from both sides. This means maximum stack width = **10 metres**
Note: *Readers may look at the option above and ask: "Why would I do this as stack width is reduced to 10 metres and I might as well just have one 20 metre wide stack". When considered as a fire wall between the length-sides of stacks this is a valid point. However, use of fire walls between the width-sides of stacks may have benefits. See the example stack layouts in section 6 below.*		
	**Min distance to buildings (d) = See graph 1**	Separation distance will depend on stack length (or at their ends width) – the longer the stack the wider the separation distance required. See graph 1, **red** line to calculate separation distance for your stack to buildings.
	**Alternative wall between stacks and buildings. Max stack width (w) = 10 metres**	Heat does not only travel horizontally. A wall height which is too low may result in heat radiated upwards and outwards travelling to an exposed upper portion of a building. Wall height should be sufficient to avoid this. A gap between wall and building should be left for general access. Unless this gap is substantive, access for fire-fighting will be from one side only and max stack width = **10 metres**.
Note: *Buildings can be on-site (such as a recycling plant waste hall) or off-site (such as a nearby industrial unit). The separation distances and/or fire wall information given above applies in both cases, including at site boundaries (heat does not stop at a site boundary).*		
	**Bunkered wastes. Max width (w) of bunker = 10 metres**	Maximum width (w) of bunkers = 10 metres (for reasons of practical fire-fighting as access is unlikely to be from both sides). Length of bunker is for site specific assessment based on stock rotation etc. A minimum of 1 metre freeboard should be left between waste and bunker height. **NOTE** - if open (length) side of bunker/s faces a building/other waste stack then see graph 1 for separation distance.

2. Baled waste stacks: General wastes (typical max burn 950 °C), EXCLUDING plastics/rubber		
	**Max height (h) = 4 metres or no more than four bales high, whichever is lower**	Maximum height (h) of 4 metres, or four bales high whichever is the lowest, is based on practical ability to fight fires using manual means such as standard hoses, and stability of bale stack to reduce the risk of fire spread from falling/rolling waste bales.
	**Max width of stack (w) = 20 metres (10 if access one side only)**	Maximum width (w) of 20 metres is based on practical ability to fight fires using manual means such as standard hoses. **NOTE** – 20 metres assumes good access from both sides of the stack to fight fires. If this is not the case then maximum width = **10 metres**. **NOTE** – within an individual bale stack adequate gaps for access for stock rotation should be left between rows of bales.
	**Min 'free-air' separation distance between stacks (d) = See graph 1**	Separation distance will depend on stack length (or at their ends width) – the longer the stack the wider the separation distance required. See graph 1, **brown** line to calculate separation distance for your stacks.
	**Alternative fire wall between stacks. Max stack width (w) = 10 metres**	Walls must be of suitable construction, and a minimum freeboard of **1 metre** left between waste and wall height to account for flame height. Stacks could be 'butt' against walls, but access to rear of stacks may be required for stock rotation and similar – this is a matter for site specific assessment. **NOTE** – access for fire-fighting will not be from both sides. This means maximum stack width = **10 metres**
Note: *Readers may look at the option above and ask: "Why would I do this as stack width is reduced to 10 metres and I might as well just have one 20 metre wide stack". When considered as a fire wall between the length-sides of stacks this is a valid point. However, use of fire walls between the width-sides of stacks may have benefits. See the example stack layouts in section 6 below.*		

	**Min distance to buildings (d) = See graph 1**	Separation distance will depend on stack length – the longer the stack the wider the separation distance required. See graph 1, **purple** line to calculate separation distance for your bale stack to buildings.
	**Alternative wall between stacks and buildings. Max stack width (w) = 10 metres**	Heat does not only travel horizontally. A wall height which is too low may result in heat radiated upwards and outwards travelling to an exposed upper portion of a building. Wall height should be sufficient to avoid this. A gap between wall and building should be left for general access. Unless this gap is substantive, access for fire-fighting will be from one side only and max stack width = **10 metres**.
Note: *Buildings can be on-site (such as a recycling plant waste hall) or off-site (such as a nearby industrial unit). The separation distances and/or fire wall information given above applies in both cases, including at site boundaries (heat does not stop at a site boundary).*		
	**Bunkered wastes. Max width (w) of bunker = 10 metres**	Maximum width (w) of bunkers = 10 metres (for reasons of practical fire-fighting as access is unlikely to be from both sides). Length of bunker is for site specific assessment based on stock rotation etc. A minimum of 1 metre freeboard should be left between waste and bunker height. **NOTE** - if open (length) side of bunker/s faces a building/other waste stack then see graph 1 for separation distance.

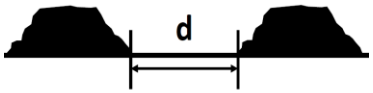
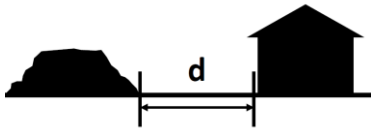
Graph 1. Stack lengths and separation distances general wastes (typical max burn 950 °C)

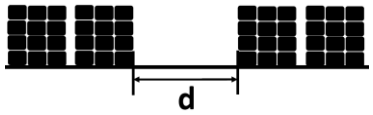
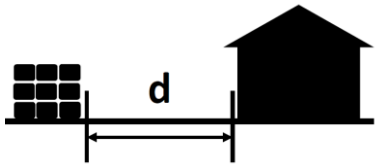


To determine your separation distance, mark your stack length on the horizontal axis of the graph and draw a line up to the relevant graph line (stack to stack, to buildings etc). Then draw a horizontal line across to the vertical axis and read-off separation distance. This can also be done in reverse. For example, at your site separation distance may be constrained by site size. This distance can be marked on the vertical axis and maximum stack length read-off on the horizontal axis (see section 6 on example stack layouts below for illustration of this use).

B. Plastics/rubber wastes (typical max burn 1,200 °C)

The waste fire burn tests showed that burning plastic and rubber wastes have higher burn temperatures and thermal emissions. As a result, separation distances are wider than for general wastes. Graph 2 below note these wider distances. Other information, such as relating to fire walls/bunkers, stack width and height, as given for general combustible wastes, are the same and are not repeated below.

Parameter and standard	Commentary/rationale
Note: *The graphics used below are indicative only and should not be considered as being to scale or a guide to stack layout or configuration, number of bales suggested in a stack etc. They are for illustrative purposes only and should be treated as such.*	
1. Loose waste stacks: Plastics/rubber wastes (typical max burn 1,200 °C)	
 **Min 'free-air' separation distance between stacks (d) = See graph 2**	Separation distance will depend on stack length (or at their ends width) – the longer the stack the wider the separation distance required. See graph 2, **blue** line to calculate separation distance for your stacks.
 **Min distance to buildings (d) = See graph 2**	Separation distance will depend on stack length (or at their ends width) – the longer the stack the wider the separation distance required. See graph 2, **red** line to calculate separation distance for your stack to buildings.
Note: *Buildings can be on-site (such as a recycling plant waste hall) or off-site (such as a nearby industrial unit). The separation distances and/or fire wall information given above applies in both cases, including at site boundaries (heat does not stop at a site boundary).*	

2. Baled waste stacks: Plastics/rubber wastes (typical max burn 1,200 °C)		
	**Min 'free-air' separation distance between stacks (d) = See graph 2**	Separation distance will depend on stack length (or at their ends width) – the longer the stack the wider the separation distance required. See graph 2, **brown** line to calculate separation distance for your stacks.
	**Min distance to buildings (d) = See graph 2**	Separation distance will depend on stack length – the longer the stack the wider the separation distance required. See graph 2, **purple** line to calculate separation distance for your bale stack to buildings.
Note: *Buildings can be on-site (such as a recycling plant waste hall) or off-site (such as a nearby industrial unit). The separation distances and/or fire wall information given above applies in both cases, including at site boundaries (heat does not stop at a site boundary).*		

NOTE: *Wastes are variable. The data above, and in graph 2 below, for plastics and rubber wastes are based on wastes which are wholly or mainly plastics or rubber. Some of the waste types included in the general wastes section and graph 1 above will contain a proportion of plastics/rubber, such as SRF and RDF. However, the proportion of plastics/rubber in such wastes is typically limited. If your waste type is a mixture, but contains a substantial proportion of plastics/rubbers you may want to consider using the data above as for plastic/rubber wastes, or you want to have your waste tested to determine its burn temperature and thermal heat emissions. The 2015 and 2016 waste burn trials were conducted on 13 different types of waste (see the non-technical summary of the tests available on the WISH web site). The wastes tested were selected to be the most typical, but your wastes may vary from those tested. If you do decide to have your waste tested, WISH would be grateful if you could provide the result to it for the benefit of the waste management industry and future revisions of this guidance.*

Graph 2. Stack lengths and separation distances plastic/rubber wastes (typical max burn 1,200 °C)

To determine your separation distance, mark your stack length on the horizontal axis of the graph and draw a line up to the relevant graph line (stack to stack, to buildings etc). Then draw a horizontal line across to the vertical axis and read-off separation distance. This can also be done in reverse. For example, at your site separation distance may be constrained by site size. This distance can be marked on the vertical axis and maximum stack length read-off on the horizontal axis (see section 6 on example stack layouts below for illustration of this use).

5. Option 2: Modified/bespoke separation distances and stack sizes

As noted in the introduction to this appendix, two options for stack sizes and separation distances are given. This section covers bespoke options for sites with enhanced fire systems at external storage areas, and those waste operators who wish to have bespoke fire engineering calculations performed on their specific situation or wastes. Option 1 above covers standard stack sizes and separation distances for sites with only basic fire systems in place, such as hand-held extinguishers and standard fire hoses, and operators who do not wish to have bespoke fire engineering calculations performed.

5.1. Introduction to bespoke separation distances and stack sizes - option 2

This section considers the factors which may move a site from option 1 (standard sizes and separation distances) to option 2 (bespoke sizes and distances). 5.2 covers enhanced fire-fighting provision which may move a site from option 1 to option 2. 5.3 covers bespoke fire engineering calculations for those operators who wish to consider these.

In terms of physical fire-fighting improvements, this appendix restricts itself largely to the common configurations of external waste storage, such as open stacks and stacks with fire walls or in three-sided bunkers etc. It does not consider specialised systems, such as enclosed silo storage of wood chips. This type of specialised storage is a matter for specific assessment. In the case of silo storage this may include fixed water deluge systems within the silo, activated by fire detection systems such as those which monitor for the presence of early-stage fire combustion products. If you have a specialised storage system you should consult with competent fire/risk engineers to decide upon the fire systems you will need (see appendix 2 of this guidance for more information).

5.2. Potential factors for inclusion in bespoke options: Fire-fighting provision

To move away from the standard stack sizes and separation distances given in option 1 above, any additional fire-fighting provision should address one or more of the under-pinning considerations which led to the standard parameter being set.

For example, stack width and height in option 1 are based on practical fire-fighting considerations, in particular using standard fire hoses. To move away from option 1, any additional fire-fighting provision needs to be aimed at these practical fire-fighting considerations.

For illustration: You may have a three-sided bunker at your site containing combustible wastes in storage. Option 1 gives a maximum width ((w) in the diagrams in option 1 for bunkers) of 10 metres. This is based on the practical aspects of fighting a fire using standard hoses. You may install a dry fixed water deluge system on the walls of the bunker (pipework with spray heads directed into the bunker). This deluge being fed by a pipe which ends in a 'dry-riser' connection. In the event of a fire the fire and rescue services can connect their hoses to this dry riser and introduce water into the system, so allowing the application of water across the bunker area. This may overcome some of the practical restrictions of fighting the fire using standard hoses, and allow you to increase the width of waste (w) in the bunker to beyond 10 metres.

However, the above illustration does not overcome potential water supply issues. The fire and rescue services may be able to 'plug-into' the dry-riser, but do they have sufficient water or pumping capacity to sustain the effective use of the deluge over a period of time which is sufficient to fight a fire adequately?

To overcome this issue you may install your own on-site water supplies, such as a fire water tank and pumps, to feed your deluge system. This would remove the need for the fire and rescue services to supply water to the deluge. It would also allow a quicker application of water to any fire as the deluge could be activated before the fire and rescue services arrive at the scene. You may decide on manual activation of this deluge system, such as a button located in a safe place which operative push to activate the system.

Ultimately, you may decide to install fire detection at the bunker which would automatically activate the deluge system. This is likely to be quicker acting than a manual activation, in particular if your site is not occupied 24/7 (manual activation obviously requires someone to activate the system).

The illustrative examples above tackle the under-pinning reason for setting a standard 10 metre limit as given in option 1 above – that is practical fire-fighting considerations. Having a deluge at all aims at the ability to place water over the area of a bunker, and not rely completely on the use of standard hoses. Having an adequate water supply to feed a deluge system aims at the practical limitations of the volume of water the fire and rescue services can carry in their fire tenders (most fire tenders only carry 1,800 – 6,000 litres of water dependent on the type of tender). Having automatic activation of the deluge system from fire detection aims at the practical issue of how long the fire and rescue services may take to attend your site, and set-up, and that your operatives are not on a 24/7 dedicated fire-watch at the bunker.

The above are examples of the types of systems and approach which may move a site away from the standard specifications set in option 1. The degree to which a site can move away from the standard specifications in option 1 is a matter for technical fire/risk engineering assessment and will depend on a wide range of factors such as combustible occupancy (in the above example of the wastes in the bunker), technical specification of the fire system chosen (in the above example a deluge system) and other factors. For most waste operators this is unlikely to be a process they can pursue without competent fire/risk engineering advice.

Note: *All fire suppression/extinguishing systems, such as deluges, must be specified, designed, hydraulically balanced, installed and commissioned to appropriate fire/risk engineering standards. This is not a matter of purchasing a length of hose, putting some holes in it and attaching it to a bunker wall. See the fire/risk engineering appendix of this guidance for more details.*

Detection systems are mentioned briefly in the examples above. Fire detection systems are not currently in common use at external waste storage areas. This is largely because many types of detector do not work that well in external environments. However, there are detector systems which do work in external environments, and are in use at some waste management sites.

Having a detection system may allow better early warning of a fire, provided it is reliable and capable of detecting a fire effectively in an external environment. However, on their own having a detection system in place at external waste storage is unlikely to be a reason for a site moving from option 1 to option 2, unless they are used in combination with other measures such as fixed fire suppression/extinguishing systems.

5.3. Potential factors for inclusion in bespoke options: Bespoke calculations

The separation distance information given in option 1 above is based on the 2015 and 2016 waste burn trials and other research. For reasons of practicality and ease of application it is also based on a series of assumptions (see 4.2 above).

The data given in option 1 is partially based on the results of the waste burn trials conducted in 2015 and 2016, and also includes an assumption on the ignition properties of waste based on other research (the 10 kW/m^2 figure used). If you believe that the burn properties of your waste/s when stored in your specific stack configuration or their ignition properties are different then you always have the option of having your own tests conducted. If you do decide to do your own testing you should consider all of the factors involved, including that small-scale laboratory type tests may not provide realistic data for real-life waste storage stacks (see non-technical summary of the waste burn trials available on the WISH web-site).

One of the main reasons you may wish to conduct your own testing is that you may believe that your wastes differ in composition from those tested during the 2015 and 2016 waste burn trials, and therefore will have different burn properties. For example, in option 1 above SRF and RDF are included in the general waste category (maximum burn temperature of some 950 °C) rather than the plastics and rubber wastes category (maximum burn temperature of some 1,200 °C). This is because of the results of the waste burn trials. However, if your SRF, RDF or other waste mixture contains substantive proportions of plastics/rubber then its burn temperature may be higher.

In addition, there are various assumptions made in option 1, as listed in 4.2 above, such as on building construction, orientation of stacks to stacks or to buildings, loose stack angle of repose etc. These assumptions have been made based on knowledge of typical waste sites, and aimed at operators who do not wish to have bespoke calculations conducted and simply want a 'standard solution'. If you believe that your specific site situation is different you have the option of having specific bespoke fire engineering calculations conducted to give you bespoke separation distance information.

NOTE: Such bespoke fire engineering calculations as noted above very likely need to be carried-out by a competent fire engineer. Not many waste operators will have the required competence to perform such calculations in-house.

However, you should consider this route carefully. Unless your site specific issues, waste types and storage configurations etc are significantly different than those outlines in option 1 you could spend a lot of time, trouble and resource on bespoke calculations with little return.

WISH would appreciate that if you do conduct your own tests or have bespoke fire engineering calculations conducted that you provide the information to WISH – such data may benefit the wider waste industry and inform future revisions of this guidance.

From left: Water deluge head mounted above external waste storage bunker wall (example only – deluge etc systems can be mounted lower or direct on walls), camera-type detector in external use above a waste bunker, standard bale storage ('A' frames in place for use as fire walls as required)

6. Examples of stack layout

6.1. Introduction and factors when planning stack layout

The graphics below are examples to illustrate how the stack dimensions and separation distances included in option 1 above are used and can be applied to stack layouts, including the use of fire walls/bunkers. The principles would also apply to bespoke dimensions and separation distances.

For reasons of simplicity only stack dimensions and separation distances are used in the graphics. However, there are other factors you may need to take into account when deciding on your stack layout. These include the below examples (you should consider your specific site conditions):

- Location of potential ignition sources on your site
- Location/s of occupied buildings and high-asset value equipment and plant
- Escape and evacuation routes – must not be compromised by stack layout
- Location of flammable and/or hazardous substances kept on site, such as gas cylinder cages, diesel tanks, quarantine areas which may contain non-conforming wastes etc
- Locations of on or off-site fire hydrants, other water supplies and fire-fighting equipment – you do not want to block access to these with your stack layout
- Proximity and location/s of any infrastructure which may be affected by a fire, such as overhead power lines, major roads, rail lines etc
- Proximity and location/s of any off-site, third party buildings which may be affected by a fire
- Permitted amounts of wastes, and types of waste, allowed on site
- Provision of a 'quarantine' area, as appropriate to site specifics
- Operational practicalities such as movements of vehicles
- Stock rotation requirements, seasonality of supply/off-take etc

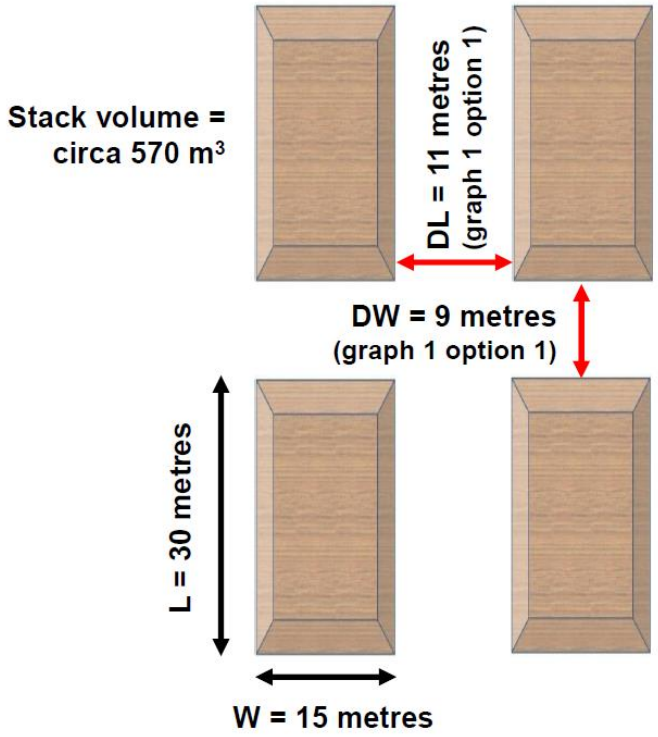
You are also likely to require a scale map of your site, and of the surrounding area (the one/s in your emergency response plan may be suitable).

Tip – you may want to cut-out 'shapes' from card or similar, representing items such as storage stacks (to scale). Plus, lengths of card representing separation distances etc (again to scale). You can move these around the map of your site to experiment with different layouts. Once you have settled on your layout you may also want to mark stack boundaries on the ground, such as with yellow road markings or similar, as an aid to operatives, and so you can see easily your storage plan is being obeyed.

Once you have decided on your storage stack layout you should record this, and review it if anything changes. You should also induct your employees on your plan.

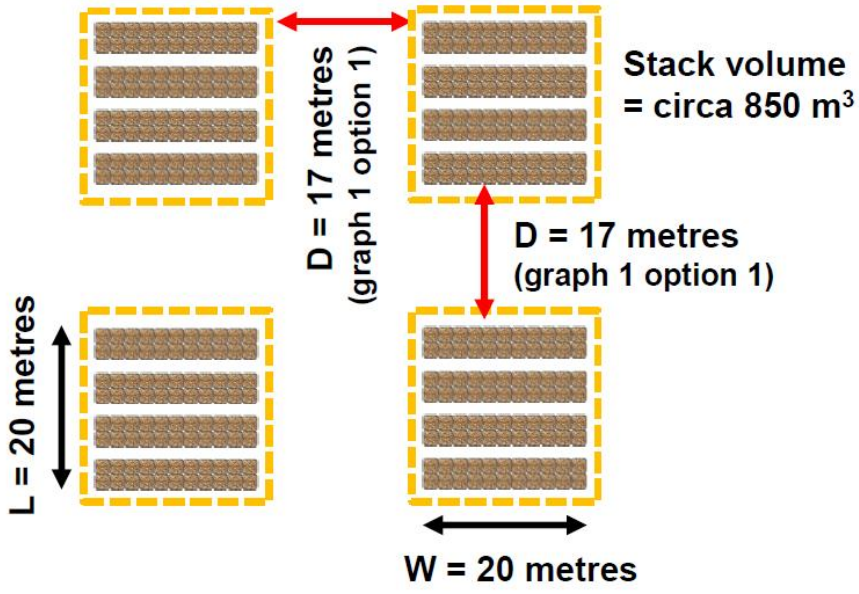
6.2. Examples of stack layout

A. Simple loose stack layout, pre-crush wood using free-air separation distances



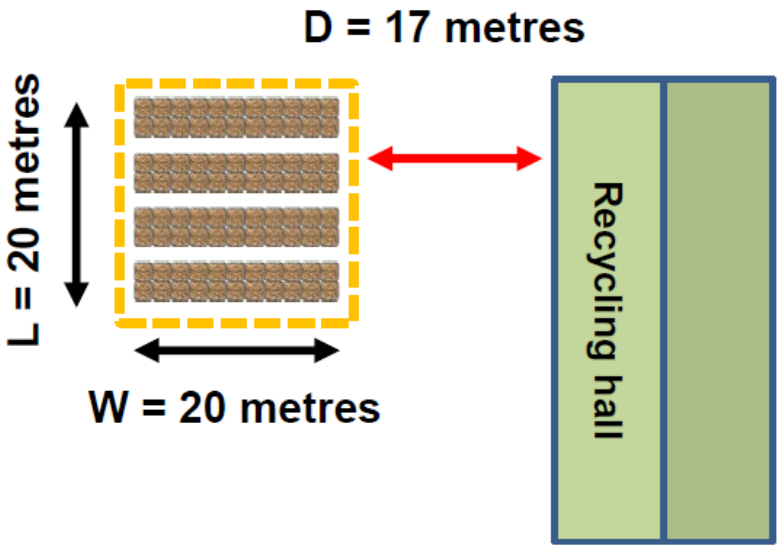
This example is pre-crush wood stored in loose stacks with free-air separation distances used to mitigate fire spread. Each stack is 30 metres long and 15 metres wide. As wood is a general waste for purposes of option 1, using graph 1 blue line (loose stack to loose stack distances) gives a separation distance on the length side of each stack of 11 metres (DL) and on the width side of 9 metres (DW). Each stack has a volume of circa 570 m^3, with total volume across all four stacks shown of circa 2,280 m^3 (equivalent to circa 450 – 500 tonnes density dependent).

B. Simple bale stack layout, baled paper/card using free-air separation distances



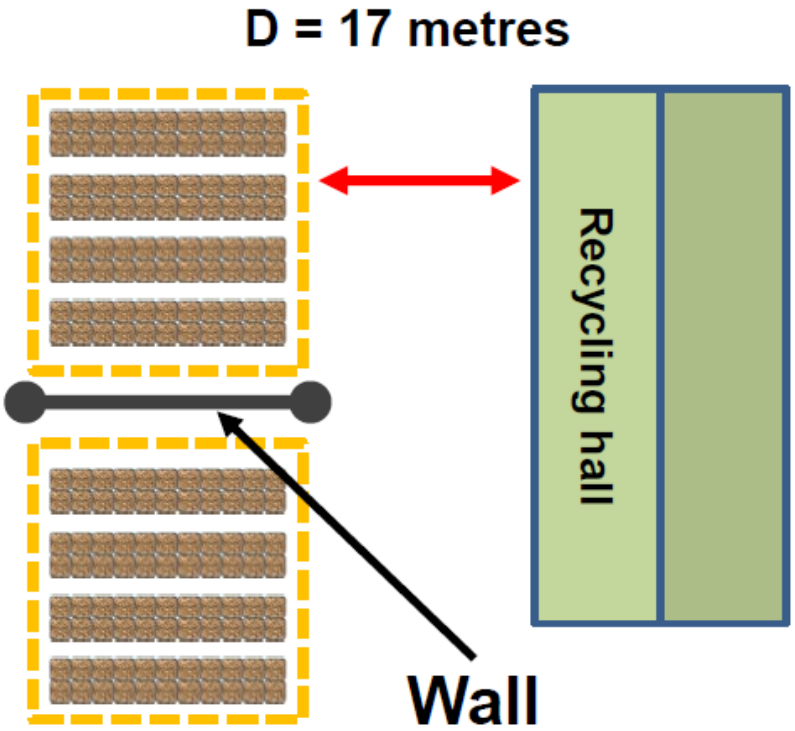
This is similar to above, but using paper/card bales (each individual stack of rows of bales demarked by amber dotted line). These are general wastes, so graph 1 applies. Stacks are 20 metres square, giving a separation distance from the brown line in graph 1 of 17 metres each side. Excluding the gaps between bale lines for access, stack volume is circa 850 m^3, with a total volume across all four stacks of circa 3,400 m^3.

C. Example of restricted separation distance determining stack dimension



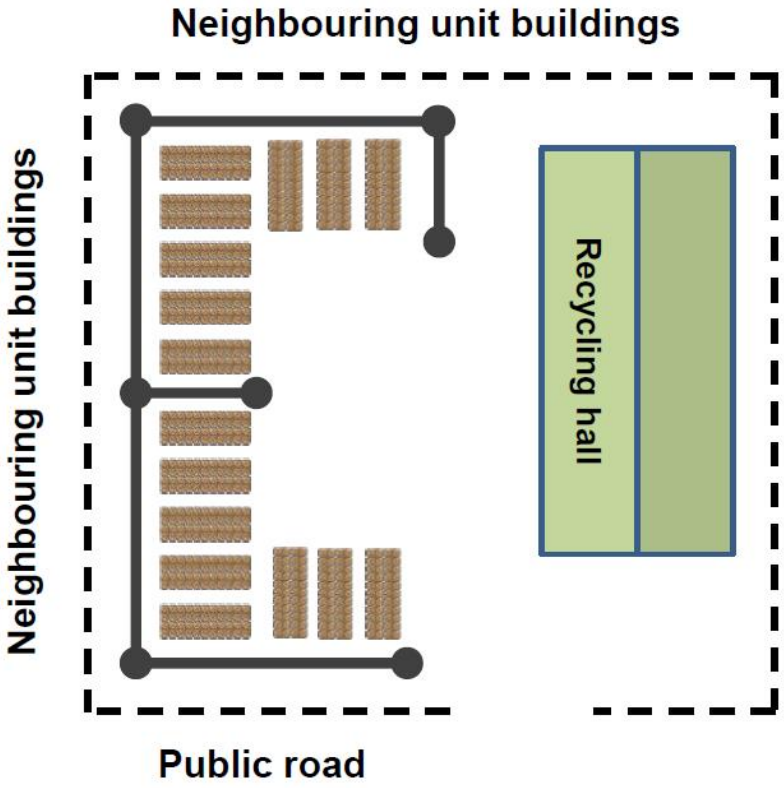
Limited space at this site means the maximum separation distance which can be achieved between recycling building and stack is 17 metres (D in graphic). Using paper/card bales as for example B above, graph 1 purple line gives a maximum stack length of 20 metres (mark 17 metres on the vertical axis of graph 1, draw a horizontal line across to the purple line, and then a vertical line down, giving stack length at 20 metres). This is an example of a reverse use of the data in graphs 1 and 2.

D. Use of a single fire wall to extend storage capacity



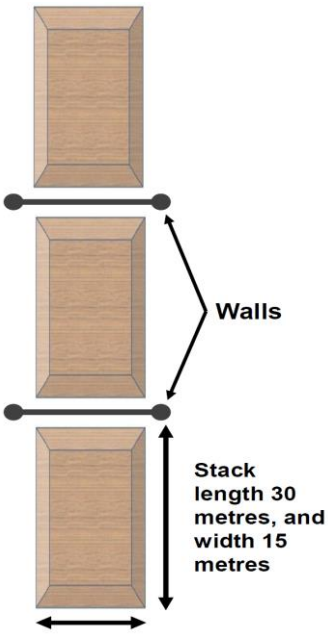
This is the same as C above, but the operator wishes to increase overall storage capacity in a limited space. Adding an appropriate fire wall as shown removes the need for a free-air gap at the width ends of the bale stacks. Each stack still has a length of 20 metres, and is still in line with graph 1, because the separation distance is determined by the burn-face of each of the stacks. Obviously the integrity of the fire wall is critical – if it fails to prevent fire spread and both stacks ignite then overall burn face will be 40 metres, which would require a wider separation distance. Note – maintaining the 20 metre width of stacks in this example assumes good access for fire-fighting from both sides of stacks.

E. Use of a bunkers/fire walls to extend storage with buildings at site boundary



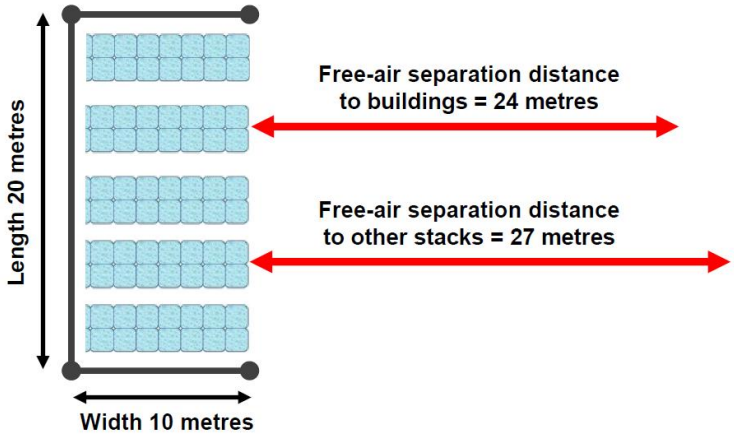
All of the above examples assume there is nothing at the site boundary. This example is the same site as example D above, but assumes the waste site is on an industrial estate and has neighbouring industrial unit buildings close to its site boundary. Installation of additional walls to form bunkers around the storage stacks provides protection for these neighbouring units without free-air separation distances (a reasonable level of stand-off is still required). However, because access for fire-fighting is not available from both sides, stack width is decreased to 10 metres. In this example, extending the walls has allowed the operator to reduce the loss of overall site storage capacity to only circa 12% compared to the capacity of example D above.

F. Use of fire walls with loose stacks



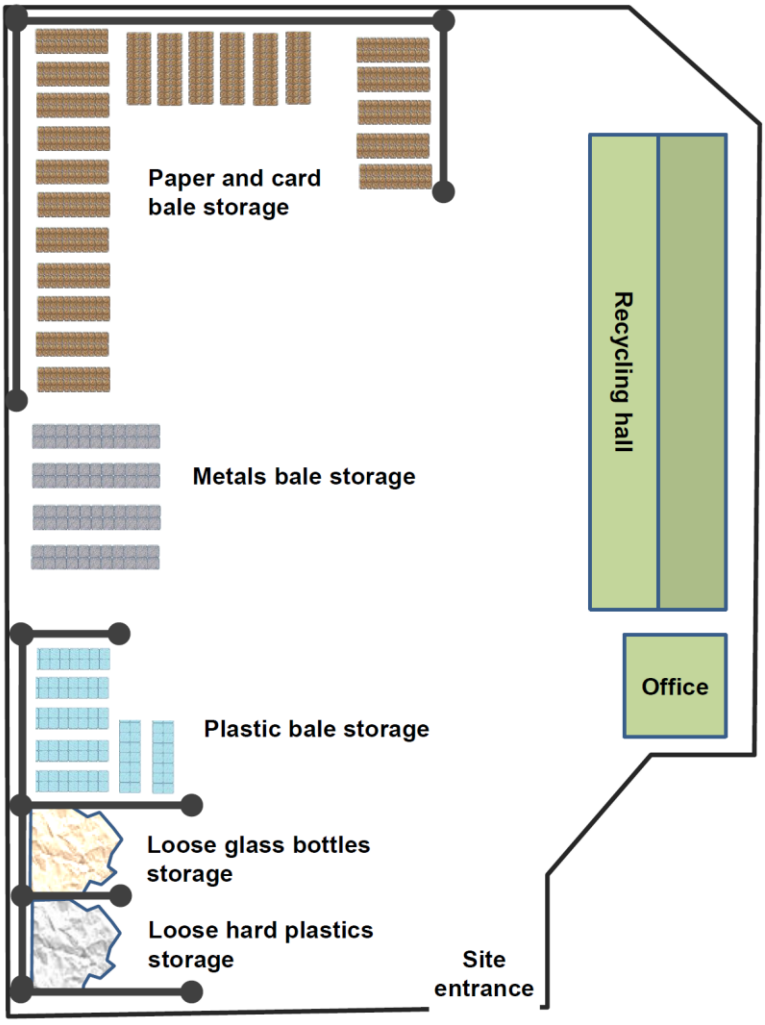
The use of fire walls is not restricted to bale stacks. This example shows a loose stack layout using fire walls to remove the need for free-air separation distances at the width ends of the stack. Assuming good access for fire-fighting is available from both sides stack width is not affected (shown at 15 metres, but could be the 20 metre maximum). This type of ‘sausage link’ layout may be suitable for ‘long and thin’ waste sites and allows space to be maximised.

G. Plastic and rubber wastes



All of the above examples are for general wastes. For plastics and rubber wastes free-air separation distances are wider because of their higher burn temperatures (see graph 2 option 1 above). Use of bunkers is likely the practical option with this type of waste, such as the example of baled plastics shown here. However, an appropriate free air separation distance still needs to be left at the open side of the bunker (from graph 2 using stack dimensions shown).

H. Overall site storage example



For more complex sites overall site storage layout will require careful thought, either to be in line with the standards in option 1, or any bespoke solutions under option 2. The example shown here simply an example, however: Paper and board bales are partially bunkered to preserve separation distances, but not on one side as distance is not an issue to the bunkered baled plastics bunker or baled metals, which are themselves not bunkered. Plastics bales are bunkered, with adequate free separation distance at the open side of the bunker. Loose glass (non-combustible), stored in a bunker for non-fire reasons has been placed between the plastic bales bunker and loose plastics bunker as a further precaution.

Appendix 2: Fire/risk engineering for waste management plants/sites: Detection, alarm and suppression/extinguishing systems

Introduction

Note – this appendix covers a wide range of issues, many of which may not be relevant to smaller waste management operations. However, some of the basic principles may still apply. Treat this appendix as a guide to fire systems, and issues with these in waste management use, which may be relevant to your site.

Even the smallest waste management site is likely to require some basic form of fire detection, alarm and extinguishing/suppression, such as standard fire hoses, or at least quick access to a good water supply such as a public hydrant. The larger and more complex a site/plant is, the more complex and comprehensive the fire strategy and planning required. As a result, the more likely that more advanced fire systems may be required, such as sprinklers, deluge systems, water monitors, complex detection systems, and similar. For very large and complex plants multiple systems are likely.

You may already have some fire systems in place at your site. However, what is acceptable to regulators and insurers has changed significantly over the years, and continues to change. A small open-air civic amenity site is still very unlikely to require sophisticated fire systems, but increasingly these are being required at even fairly basic transfer and recycling/recovery sites, and for large and complex plants higher standards are very likely to be expected.

There are various drivers behind this shift. The industry's fire record is an obvious driver, which has led to an increasing focus by regulators and the imposition of tougher guidance on the application and enforcement of fires issues in permitted activities. One of the other main drivers is asset protection and insurance: Waste management is not a popular industry for property insurers because of fire risk, and the standards being required by insurers are increasing. Your insurer is a key stakeholder: Waste management companies which fail to satisfy their insurers are likely to find insurance increasingly difficult and costly to obtain. Insurability to one side, if you have invested significant funds in a complex recycling, recovery or similar plant/site it makes good business sense to protect your investment.

All of this moves waste management operators into the area of fire/risk engineering – a specialised and complex discipline. Unless you work for a very large company with its own in-house competent fire engineer, you are likely to need an external competent advisor to help you identify what type, specification and design of detection, alarm and extinguishing/suppression system/s would be effective and practical.

Please note that the term ‘fire engineering’ has lost credit in the eyes of some and the term ‘risk engineering’ is now becoming more common. For the purposes of this appendix the term ‘fire/risk engineering’ is used.

- You do not need to be a fire/risk engineer, but the more you know about the principles the more likely it is that you will end-up with systems which are effective and match with your needs. This is the same as if you were purchasing a new loading shovel. Simply asking a supplier for a loading shovel is not enough. What size, what wastes will it handle and how, what attachments are required, are there any site restrictions relevant, what controls will I need to have in place when using it etc? Just asking a fire consultant/supplier for a sprinkler system without having an ongoing engagement with them and their design thinking risks you ending-up with a system which may be ineffective or does not fit with your needs
- Waste management sites are not warehouses, offices or shops. Wastes are not standard stored products. Applying standard fire systems to waste management sites/plants risks any system fitted being ineffective in the event of a fire
- Knowledge on how wastes burn and types and specifications of fire systems are effective with waste fires is a rapidly developing area. What was acceptable five years ago is unlikely to be acceptable today. You will be able to identify fire engineering guidance and standards which apply to your waste management operations, but you must ensure that these are up to date and relevant still. The rapid development of understanding in this area means that standards may be based on older assumptions that are no longer considered valid

This appendix is not comprehensive and will not make you a fire/risk engineering expert, and it is not intended to be a technical document or provide all of the information you may need to ensure your fire systems are adequate. It does intend to give you a basic level of information on some of the issues involved. You should always seek competent advice and assure yourself that your systems are effective, appropriate, and that they will work in the event of a fire.

***Tip** – many larger insurance companies and insurance brokers have in-house fire/risk engineers. You should liaise with your insurer to gain access to this advice, and to ensure that any fire systems you install are to your insurer’s requirements. What you do not want to do is to install an expensive system to find-out that your insurer will not accept it and that further systems and/or work is required.*

Note – while your insurer may be a critical stakeholder, there are others. Environmental regulators will also have requirements, as will your local fire and rescue services (FRS). You will need to satisfy all of these stakeholders, and accept at times that they may have differing priorities, standards and requirements. Your insurer may be a good place to start, but you should also consult with your environmental regulator and local FRS to ensure whatever systems you decide on satisfy all stakeholder requirements.

Note – this appendix does not cover the issue of contaminated firewater run-off and control in any detail. When deciding on what fire systems you may want to install you should consult with your environmental regulator and available guidance on this issue.

Note – the main body of this WISH guidance is arranged in sections covering waste reception, waste treatment and waste storage. In each of these sections specific fire systems issues relating to reception, treatment and storage are discussed, plus a reference to this appendix. You should read the specific mentions in the main guidance under reception, treatment and storage alongside this appendix.

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1. Design of fire systems

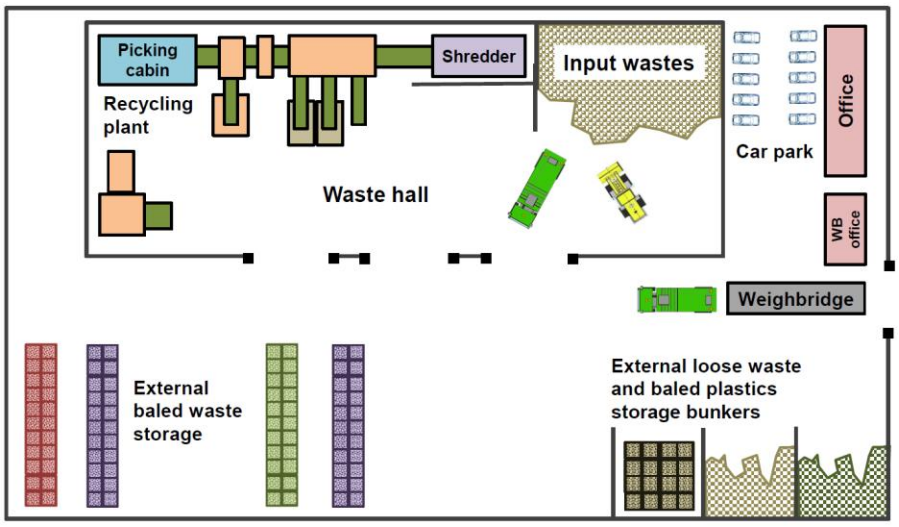
Note – if you are familiar with the basics of fire/risk engineering, such as the differences between sprinkler, deluge, water monitors, detector systems, suppression and extinguishing systems etc, you may want to read this section first. However, if you are not, you may want to skip this section and read the rest of this appendix first, then return to this section. Throughout this section the example of a basic recycling plant is used to illustrate the issues raised. This is simply an example and should not be considered any form of recommendation as to what systems may be appropriate for your plant/site. Please also note that the graphics used are not to scale and are intended simply as illustration.

1.3. What do you want your fire system to achieve?

You have decided that you want to install fire systems at your plant/site, or you may have existing systems which you want to upgrade. A starting point is to consider 'what do you want your fire systems to achieve'. This may seem an obvious question, but one which is often missed-out.

Life safety is paramount and you must ensure the safety of your employees and others on your site. It is not the intent of this appendix to repeat guidance on fire life safety, which is freely available elsewhere. But, in all of your decisions life safety must be your top priority. Beyond life safety, you will likely want to protect the parts/components of your site which have the greatest value to your business. This may be capital cost of replacement/asset value, and also business interruption impacts.

The illustration below shows an example recycling operation, consisting of a waste hall, waste reception area within the hall, recycling plant (shredder, screens, over-band magnets, baler etc) and external storage for baled and loose recyclates. Ancillary facilities such as offices and weighbridge are also shown. This will be used to illustrate the principles you may want to follow.



1.4. Factors for design and design process

Asset value, cost and time of replacement and business interruption

For most recycling facilities it is the recycling/recovery equipment/plant itself which represents the highest asset value. Total or partial loss of equipment/plant as the result of a fire may cost £ millions. Loss of plant is also likely to represent the highest business interruption risk. Even fairly minor damage to a recycling plant as the result of a fire can result in significant downtime, extending to weeks or even months.

In addition, within your plant there may be items of equipment which are more critical than others. 'Standard' parts such as conveyors and drive motors may be capable of replacement fairly quickly. But, a bespoke shredder, optical sorting array or similar may take far longer to replace. What within your plant is critical, and which items would take the longest to replace? A start here would be your asset list, which should list all components of your plant, and their values. However, please remember to include control systems, cabling etc – this may not be identified on your asset list, but may be costly and take a significant period of time to replace.

At the other end of the scale, a fire in an external waste storage bunker may be spectacular, but may not involve significant asset damage or business interruption. Your environmental regulator may take a completely different view of this, and this is one of those areas where you may need to satisfy the differing demands of different stakeholders.

Often buildings may not be as critical as plant and equipment. For example, if you lost part of your waste hall from fire could you continue to operate (subject to permission from your environmental regulator)? What temporary arrangements could you put in place if you lost part or all of a building?

- List the asset/replacement values/cost of plant and equipment on your site – try to be as specific as possible and drill-down to details such as individual critical components
- Consider likely timescales to replace, in particular for critical and/or bespoke items of equipment which may take longer to replace. Do not forget the control systems associated with your plant as these can take significant time to replace
- List the asset/replacement value/cost of buildings and other ancillary facilities on your site and likely replacement times, including porta-cabins and similar and possible temporary arrangements you may be able to enact

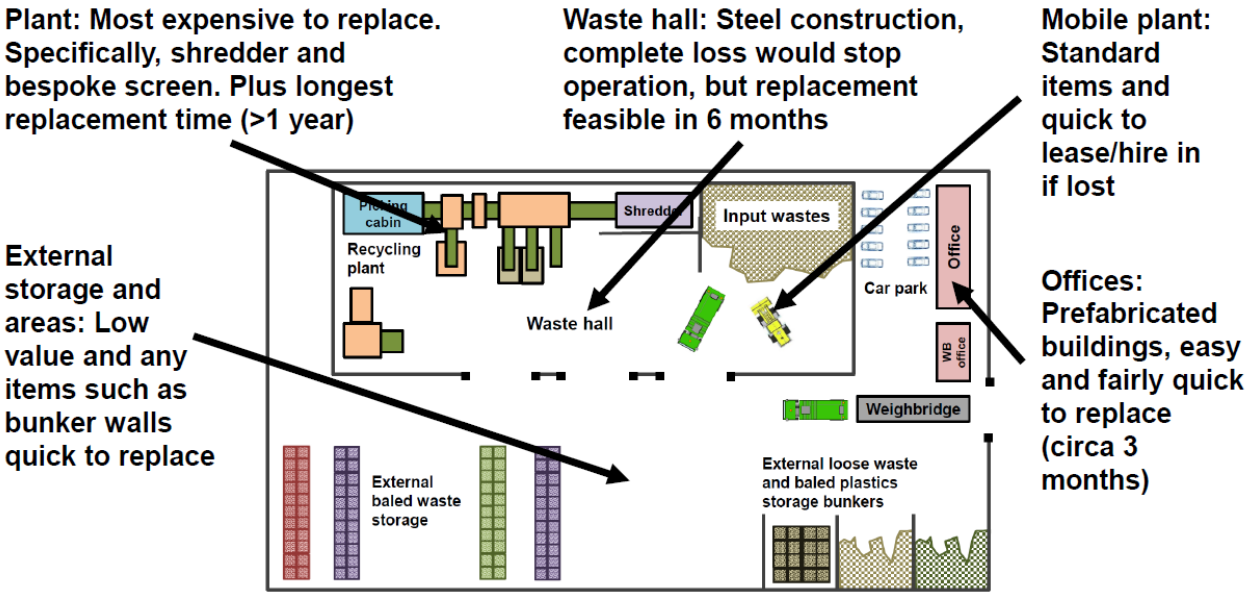
Note – the asset values you have listed may not be replacement cost. If your plant is old, then you should factor in inflation. If your plant was supplied from abroad, have currency exchange rates changed? Would installation, design and similar processes be more expensive today?

- Based on replacement times, consider what your business interruption costs might be for any loss of an item of plant, building etc. It may be that a fairly minor or cheap component poses a higher business interruption risk than a larger or more expensive item (if this is the case, you may want to hold such a component in stock rather than have to wait for order and replacement times)
- Consider what you would do if you lost your plant. For many waste management operations this would include diversion of wastes to alternative waste management facilities. What would this cost you in terms of transport and gate price? Even complete loss of a facility for a time would often not result in total business interruption, as the wastes would be diverted elsewhere – the cost would be the 'increased cost of working' during diversion

The above process should give you a good idea of which parts of your site you want to protect the most. And, potentially those parts which you can 'ignore' (at least partially) in terms of protection as they would be easy, cheap (or at least less expensive) and quicker to replace.

Do not forget the contents of buildings, such as ICT equipment, or plant control systems. It is often the case that replacement of a plant control system and its associated wiring and ancillaries takes just a much time as replacing the plant itself. In addition, if your plant control systems are old they may not still be supported and a complete redesign of control systems may be required – this can take time.

You should now be in a better position to answer the question: 'what do I want to protect'. However, answering the question: 'what do I want my fire systems to achieve' requires thought.



Combustible occupancy

To add to the above, you may then add what combustible occupancy (what will burn and how much of it is there) you have at your site/plant and where this occurs. Wastes are the obvious combustible occupancy at waste management sites. For example, the wastes at the reception area in the above illustration, wastes being processed by the plant etc. But, do not forget other combustible occupancy:

- Not only wastes burn. Rubber conveyors, wiring, hydraulic oils in power packs etc also have substantial combustible occupancy
- Do your buildings contain combustible items, such as insulation? If you are planning a new site/plant then specifying non-combustible wall and roof panels would be a good start
- Diesel and other flammable materials stores

Fire scenarios and risks

Next you may want to consider what the likely fire scenarios and impacts at your site may be. Industry data indicates that the most common causes of fires at waste management facilities are hot/hazardous materials in wastes (such as lithium batteries, badly extinguished hot ashes etc) and self-heating. There are other causes, such as mechanical heat and friction, electrical faults and the 'usual suspects' of discarded smoking materials and hot works such as welding and grinding. Management controls, site procedures and rules etc should be targeted at these ignition risks, but in terms of fire systems likely scenarios should be considered as an input to design. There may be other potential sources at your site – think about these.

Apply this thinking to your assessment of asset values, replacement costs and business interruption and/or increased costs of working. Overlay potential fire scenarios with combustible occupancy and the information you have listed regards asset values and replacement times and costs.

For example, if you lost your weighbridge (a critical and fairly expensive component of your site) to fire it is likely that you would not be allowed to continue to operate until it was replaced. But, how probable is this? Debris under the weighbridge may accumulate, and a discarded cigarette from a driver may ignite this. But, how likely is this to damage the weighbridge substantially, and provided you control debris build-up by housekeeping and enforce site smoking rules, how likely is this scenario anyway? In addition, a temporary weighbridge could be hired-in fairly quickly.

Conversely for example, a hazardous item such as a lithium battery, a can of petrol or gas cylinder may ignite wastes being fed into the shredder at the start of your recycling process, and such a fire could spread quickly to the rest of your plant via the action of conveyors. The outcome of such a fire could be disastrous in terms of asset value and business interruption. Likewise self-heating or discarded ashes could cause a fire in wastes in your reception area, and such a fire could spread to the waste hall, and recycling plant.

Consideration of fire scenarios will inform the nature and specification of fire systems.

Under-pinning design concept

At this point you will almost certainly want some external input, such as from a competent fire/risk engineer/consultant. But, you will have the basic information you need to conduct a meaningful and effective conversation with the fire/risk engineer, and you should be able to start to answer the question: 'what do I want my fire system to achieve?'

The job of the engineer/consultant is to start turning your aspiration into a working and practical 'under-pinning design concept'. You may already have some basic ideas of what you want, but these may not be practical, would not be achievable within standards, or may be very expensive – you may need to consider alternatives and go through several iterations before you have something which is workable, represents good risk management, and is cost effective and compliant with standards.

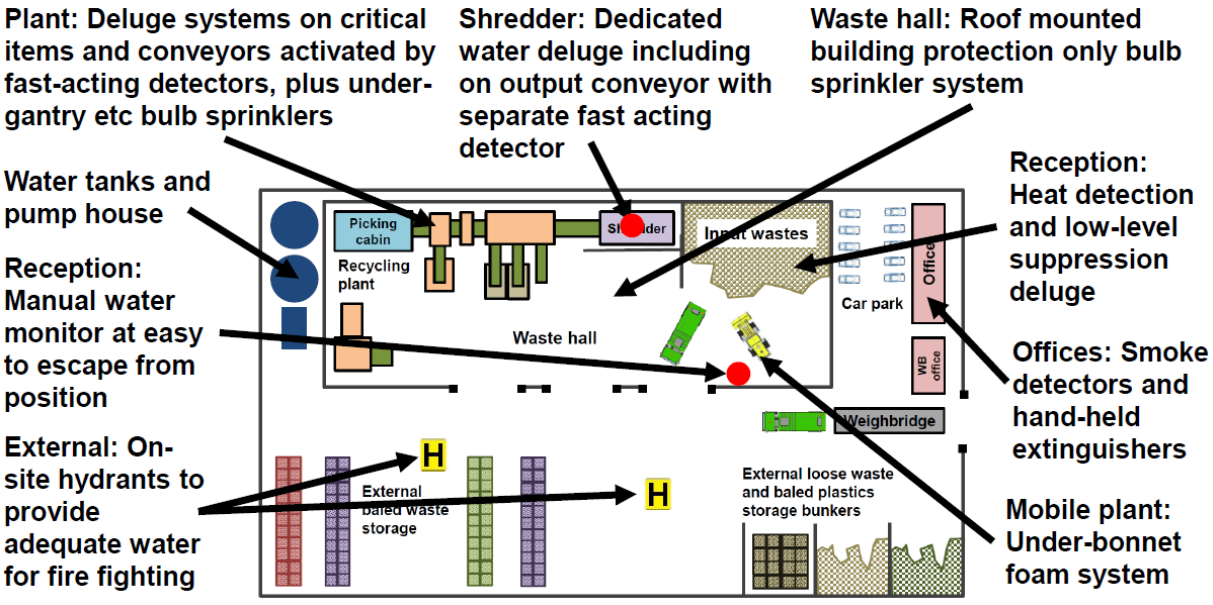
For example, you may decide that you want to protect against a fire in your shredder, as described above. One option may be installing a water deluge system above the shredder (this is simply an example, and there other options). Such a deluge would need to extinguish any fire, rather than only suppress it – so informing the specification, water density requirements etc for the deluge. The deluge would need to activate rapidly, so you would need a fast acting detection system such as IR/triple IR. And, the detector would also need to emergency stop the plant to prevent any fire being spread via the movement of its output conveyor. You may also want a deluge system over the shredder output conveyor as a back-up, activated by the same detector as activates the shredder deluge.

Likewise, for example, you may want to install a heat-detecting type detector system at the waste reception area, to give early warning of a self-heating or other smouldering fire before it becomes an open-flame fire. You may decide that you would only want to suppress a fire in this area to allow time for your local fire and rescue services to arrive and tackle the fire, and for your operatives to use the site's loading shovel to excavate the waste and take it outside to be drenched (see below on links to procedures etc). One option may be a low-level water deluge system, or oscillating water monitors. You may also decide you want a manual system, such as a manual-use water monitor for use in fighting such a fire. And, for out of hours fires (common in this type of scenario) the alarm may need to be monitored 24/7 such as by an external 24 hour responder system. Or, alternatively if your site is occupied 24/7, you may decide that you will rely on manual systems only at your reception area, such as manual hoses or water monitors.

If a fire does develop out of control, you may want to protect the waste hall itself, such as by installing roof mounted sprinklers. If this system is only aimed at building protection, a suppression sprinkler system may be adequate and its specification and water density requirements may be fairly low.

These are only examples and illustrations of options and scenarios. You should take the time with your competent fire/risk engineer to assess each scenario and its potential impacts across the whole of your site, including business interruption.

This should include external areas and ancillary facilities and buildings. For example, you may decide for practical, asset value and low business interruption risk reasons that you will not provide any automatic fire systems at external waste storage areas, but that you will provide on-site fire hydrants to allow such fires to be fought with an adequate water supply. Likewise, you may decide that you will install smoke detectors and alarm in site offices but no suppression/extinguishing systems and that you will rely on hand-held extinguishers in offices.



Part of your under-pinning design concept should certainly include likely water demand requirements for the options you are investigating. Water tanks and mains to feed fire systems are often the most expensive parts of a system, and there may be practical issues to consider, such as gaining planning permission for large water tanks. You do not want to commit to a system/s which you cannot put in place, or which would be too expensive relative to the risks posed.

This appendix is mainly concerned with fire/risk engineering as applied to fire systems such as detectors, suppression/extinguishing systems etc. However, there are other aspects of fire/risk engineering which you may want to include in your design. For example using the above illustration, having identified the risk of fire spread from your reception area to your plant, you may also want to increase the height of the separating wall between reception and plant as a physical barrier to fire spread. Or, you may want to reroute your plant control systems and cabling to reduce the risk of fire damage to this type of component.

Take the opportunity of the design process to consider wider fire/risk engineering aspects. See specific sections below on fire compartments and walls and smoke vents for examples.

Consultation with stakeholders

Your under-pinning design concept will now need testing against stakeholder needs. The best place to start is likely to be with your insurer, but you will also need to consult with your environmental regulator and local fire and rescue services. They will all have their own priorities and input. This can be a frustrating process, but one which is essential if you are to achieve a solution which is acceptable. Be prepared to change your design concept based on the needs of your stakeholders.

Detail design

Once you have acceptance from your critical stakeholders your under-pinning design can be developed to detail design, giving a scope which suppliers and installers can work to. This would include specific water densities and flows, scope of systems, hydraulic calculations etc. It should also include the standards/codes your fire systems need to be designed, procured and installed to.

Your detail design must also fit with the design of your recycling/recovery plant and, where relevant, the building it is in. There is little point in a detail fire systems design in isolation which ignores the design, layout and configuration of your plant and/or building.

Tip – different insurers sometimes have different requirements regarding approvals and certifications of fire system components, such as for detectors, suppression/extinguishing systems etc. At some point in the future you may want to change insurers. If you have committed to specific standards individual to one insurer, which other insurers may not accept, this may be difficult. Try to future-proof your design.

Installation and commissioning

Installation is a critical phase. You may have a good quality detail design document and scope, but actually transforming this into reality can be another matter. In addition, if you have specified particular standards you want to make sure that is what you get.

If your plant is a new build, then installation of fire systems will need to be co-ordinated with installation of the plant, construction of buildings etc. For example, it is usually easier to install a roof-mounted sprinkler system before installing recycling/recovery plant, but obviously gantry/low level sprinkler systems require the plant to be in place before installation. Manifolds to feed fire systems need space, pipework needs to be routed taking account of plant layout. Likewise, installation of water tanks and water mains will need to be co-ordinated with civil engineering works. Project management and managing the interface between your plant installer, buildings contractor and fire systems installer is critical.

If you are adding fire systems to an existing plant the interface between your day-to-day operations and installation will need managing. Installing fire systems takes time, and may require shut-down for phases of the installation. Night and weekend working is possible, but likely be more expensive.

If possible, try to ensure that your insurer is involved during the installation phase, such as arranging site visits during installation by your insurer's fire/risk engineer. They may well spot issues which can be addressed easily during installation, but which would be more difficult and costly to address at the end of installation. Your competent fire/risk engineer should also be involved during installation to ensure you are getting the quality and detail of what you have asked for.

For example, changing spray heads on a deluge system if they are not to standard may be fairly straightforward, assuming the pipework is to standard. But, having to dig-up a new underground water main because sectional control valves have not been installed to the correct standards and locations will be far more expensive and time consuming.

All fire systems, detectors, alarms, plant controls linked to alarms/detectors and suppression/extinguishing systems, require commissioning to ensure they function correctly. Based on this commissioning your system can be certificated. Your insurer may want to witness this commissioning, or have specific requirements for commissioning. Consult with your insurer to ensure their needs are met. You may also want to invite other stakeholders to witness commissioning.

Summary of process

Step	Comment
Asset value/replacement cost	List assets and their values and replacement costs. Include plant and equipment, control systems, buildings and ancillary items
Business interruption impacts	For the above assets identified, how long would they take to replace? What would be the lead-time for replacement?
Identify critical components	From asset value/replacement cost and replacement lead-time identify the critical components of your plant/site which you want to protect
Combustible occupancy	What do you have at your site which can burn? Waste may be the obvious items, but what other combustible or flammable materials are present?
Fire scenarios	What are the most likely fire scenarios at your site? How would these fire scenarios occur and their causes? What fire spread risks exist?
Under-pinning design concept	Using the above, and likely working with an external competent fire/risk engineer, identify options for fire systems and produce an under-pinning design concept

Consultation	Check your under-pinning design concept is acceptable to your insurer, environmental regulator and fire and rescue services
Detail design	Work-up your under-pinning design concept into a detail design and scope which a fire systems installer can work to
Installation	Install fire systems. Keep your insurer and other stakeholders involved throughout to ensure required standards are met
Commissioning	Commission your fire system to ensure it does what you expect it to do, including plant actions. Likely your insurer at least will want to witness commissioning

1.5. Links to site procedures/plans, training and employee awareness and knowledge

Emergency response, disaster recovery and business continuity planning

Elsewhere in this guidance emergency planning is covered. Your fire systems, and the process by which you arrived at what fire systems you want, should feed into your emergency plan. And, you may want to expand your emergency plan to include disaster recovery and business continuity planning.

As part of the process above you will have identified plant, buildings etc replacement costs and timescales, waste diversion plans and costs etc. These are valuable inputs into a business continuity plan. If you suffer a major fire resulting in your plant being down for a significant period of time, business interruption costs are very likely to be a major factor. Planning in advance, such as waste diversion planning, listing potential suppliers and lead-times etc for replacement plant, buildings, temporary buildings etc can save valuable time when you are trying to get back to business as usual. Every week you are down for costs money.

This type of information is also valuable to your insurer to calculate the likely costs associated with a major fire at your site. If you have under-estimated replacement costs and/or business interruption costs you may find yourself under-insured. Conversely, good planning can reduce the potential impacts, and therefore may have a positive effect on your insurance premiums.

Your emergency plan should also include information on what fire systems you have in place. For example, you may have installed a ‘dry-riser’ as part of your fire systems, through which the fire and rescue services (FRS) can introduce additional water to your systems. This needs to be included in the emergency services information part of your emergency plan so that the FRS know this option exists at your site. Likewise, if you have installed a deluge system with a manual activation point in a safe location, this needs to be marked on your emergency plan. And, you should consult with your local FRS so that they are familiar with your fire systems, such as by fire and rescue services visits to your site.

However, if a fire does occur at your site it may not be your local fire and rescue services who attend – they may be busy on another call. You should anticipate that a different FRS may attend, who are not familiar with your site. Controls for fire systems, dry-risers etc need to be clearly signed and obvious, and your emergency services information pack should include clear directions and information.

A real example shows the value in this. At a fire at a waste management site the detection and alarm system was linked to a 24/7 responder service. The local fire and rescue services were out on another call, and so the FRS from a nearby town was called to the scene instead. They had never been to the site before. They arrived before any site staff. The building the fire was in had a manually activated deluge system, the controls of which were in an obvious lean-to building next to the waste hall. But, the controls for the deluge were not clearly marked. The fire and rescue services pushed the obvious and large red button in the middle of the control panel, thinking that this would activate the deluge – it was actually the emergency stop for the deluge system pumps… Site staff arrived and wasted several critical minutes re-setting the system before the deluge could be activated (fortunately the fire was controlled and extinguished with only minor damage – this could have been very different).

Employee awareness, information and training

Your employees need to know what your fire systems are and how they work. This issue is covered in more detail in the specific sections below. However, in brief if you have manually activated systems your employees need to know what these are, how to operate them and what they are designed to achieve. Your employee procedures, rules and training should include your fire systems.

As part of your planning and design process as above you may have identified actions you expect your employees to carry-out in the event of a fire. For example, using the site's loading shovel to excavate wastes to allow them to be drenched outside a building, or to use site fire hoses to damp-down areas next to a fire to reduce the risk of fire spread. If you expect your employees to perform such actions then they must be trained, competent and aware of the risks involved. Identify where in your planning and design process you expect intervention by your employees and include in your procedures, awareness and training for employees.

1.6. Selecting the right consultant/contractor/supplier

Your insurer is very likely to have requirements for designers and installers of fire systems, such as the BRE 'red book' (search the internet for BRE red book for details). However, such accreditations may not be sufficient to ensure waste management operators achieve effective fire systems. Experience is that 'standard' fire systems may not be effective at waste management plants/sites. The reasons for this are discussed in more detail in the sections below. However, just selecting a designer, consultant, installer etc from a standard approved list may not be sufficient for waste managers.

- Your insurer may also insure other waste management operators and may be able to suggest suppliers, consultants, engineers and installers who have waste management experience
- Ask your competitors – fire safety is not a competitive event and sharing knowledge across the industry will only help in the longer-term
- Ask potential suppliers, engineers, installers etc if they have previous waste management experience and whether they can provide references
- Be wary of potential suppliers, engineers, installers etc who simply suggest a standard solution rather than taking account of your specific situation

You may also need more than one supplier. For example, a contractor who installs fire systems may not be able to also provide detail design services. For larger waste management operations it is common to have a design fire/risk engineering consultant and a separate installer, although they obviously need to co-operate and consult with each other.

2. Fire detection

2.1. Detection introduction

Detection systems typically aim to provide one or more of the consequences listed below:

- Activation of an alarm to inform people that a fire may have started to allow them to evacuate and/or take measures to fight or suppress a fire (or for more advanced systems to inform the fire and rescue services or 24 hour responder service direct via ICT link that a fire may have started)
- Early warning of a developing situation that may lead to the outbreak of fire (such as thermal imaging/heat detection, or detectors which look for combustion products before flames or other obvious signs of a fire are apparent). Typically this form of early warning is intended to allow actions to be taken to prevent an actual fire starting
- Activation of a fire suppression/extinguishing system or systems, such as a deluge system
- Plant actions, such as the emergency stop of conveyors to prevent a fire spreading
- Other actions, such as the closing of automatic fire doors and/or shutters

Often detectors will perform multiple tasks, such as a flame/visual type detector activating a water deluge system and an alarm to inform people that a fire has started.

To respond to a fire you first need to know that a fire may have started, or may be about to start. Unless you have employees in every part of your site/plant 24/7 all dedicated to watching for fires, detection systems are likely to be required.

2.2. Fire detection system types

Fire detectors come in many different types and specifications, such as:

- 'Standard' smoke' detectors – these may be acceptable in an office or welfare facility, but are very unlikely to be appropriate in an operational environment
- Beam detectors – these 'throw' a beam of light to a receptor. Typically smoke interrupting the beam activates the detector
- Aspirating detectors – typically these draw air through a network of tubes to a detector which looks for smoke and/or other combustion products which may indicate a fire has started
- UV/IR/triple IR detectors and similar 'visual' type detectors – these 'look' for specific light frequencies associated with flames, sparks and fires
- Heat sensing systems such as heat-camera type detectors which react to temperature changes – obviously these look for heat and temperature changes
- Heat sensitive wires which react to changes in temperature
- Video type systems which 'look' for smoke or other signs of fire
- Specialised systems such as carbon monoxide or other combustion product sensors

The above are only examples – there are various other types of system and variations on existing types of system. New systems come to the market all of the time. Key is ensuring that the detection system you specify will do what you want, is reliable and is effective.

Tip – fire detectors come certificated to various standards. Your insurer may have specific requirements of what they will accept. For example, your insurer may only accept detectors certificated to LPCB (Loss Prevention Certification Board) or FM (Factory Mutual). Check with your insurer before you fit a system, or risk fitting one they will not accept. That a specific detector does not have a formal certification may not result in your insurer not accepting it (it may that the detector is new and has not gained certification yet). Consult with your insurer – they may accept test data and similar as proof that a detector is effective. Conversely, a detector may have all of the certifications in the world but would not be effective in your application (see below on robustness of detectors).

Tip – more than any other area of fire/risk engineering new detection systems come to the market all of the time. The suppliers of these are naturally keen to sell their products. Beware being sold systems which are not appropriate for waste management use, or do not meet with your needs. Ask suppliers for proof that their detector is effective and reliable in waste management operations, and ask for references you can check on, such as another similar waste management plant where the detector has been installed and used reliably and effectively. Conversely, a new type or model of detector may be just what you need. Keep a balance between natural cynicism and being open to new ideas.

2.3. Factors when selecting fire detection systems

Specific assessment of potential fire scenarios and the environment detectors will be used in is required to determine the type of detector to be used, in what application, the locations of detectors etc. One size does not fit all here - different types of detector may be required in different areas of a site/plant based on the need for speed of detection and what suppression and plant control system actions etc are required.

Robustness and reliability

Waste management operations often involve dusty, moist and other forms of extreme environment. Detectors used in waste management facilities need to be robust and reliable. If they are not, the outcome is likely to be either that they do not work effectively, or that they produce frequent false-alarms and detections.

Detectors such as beam detectors and standard 'smoke' type detectors may be suitable for offices and control rooms, but are unlikely to be reliable or effective in most operational waste management applications because of dust, moisture and other factors. Experience is that many beam detectors are affected by dusts and similar and produce false alarms in waste management environments. This often results in operators turning-off beam detectors during operational hours and then turning them back on out-of-hours, or using timers to achieve the same end. This is less than ideal.

In some applications protection for visual-type and similar detectors, such as UV/IR/triple IR/camera type etc detectors, may be required. For example, air-shields may need to be fitted for reliability reasons (air shields blow clean air in front of the detector to keep it clean and effective). In other applications physical protection may be required, such as protecting a flame detector in a conveyor cover from ejected wastes.

For some types of detector air-flow may be an issue. For example, locating an aspirating detector system near to roller shutter doors that are usually open may mean that smoke from a fire never reaches the detector (or is delayed) because of the air-flow from the open door. Likewise installing an aspirating detector in a ‘dead-air’ space may also have the same effect, but for the opposite reason. This may be solved by careful consideration of location of the detector, or a different type of detector may be required.

Speed of detection

In general detectors may be fast acting (such as IR/UV, triple IR and similar), medium acting (such as aspirating systems) or slow acting (such as some carbon monoxide and similar detection systems). What actions you want the detector to produce, and therefore the type of detector chosen, will be affected by how quickly you want these actions to occur. For example, a detector above a conveyor may be intended to stop the conveyor quickly – if it does not the speed of the conveyor may result in a fire being carried along the conveyor and so spread. There is little use fitting a slow/medium speed acting detector in this type of application as by the time it alarms the fire will have already spread. Conversely, for general area use a medium acting detector may be appropriate to use.

Consider life safety also when deciding on detection. Is a slow acting detector really appropriate to inform all on site quickly that a fire has started and that they may need to evacuate? You may need more than one type of detector to satisfy different needs, and in different parts of your plant.

Tip – this is not always the case, but often quick acting detectors tend to be directional (they look for a fire in one specific area), whereas slower detectors tend to be able to cover a wider area (such as one aspirating detector system covering an entire waste hall). There is often a balance here – think about what you want the detector to cover and how essential is its speed of reaction.

Interactions and blocks

It is not unusual for a large waste management sites/plants to have more than one type of detection system in place. For example, at a recycling plant there may be a dedicated deluge system over a shredder feed hopper, activated by an UV/IR detector (quick acting). Plus an aspirating system for general alarm purposes covering the whole of the hall the shredder is in and to deploy lower-level deluges over stored wastes in bunkers in another part of the hall. A fire starts in the shredder, the UV/IR detector detects this quickly and the specific shredder deluge deploys extinguishing the fire. But, there is still smoke in the air which two minutes later is detected by the aspirating system which deploys the general deluges over the stored waste bunkers. Where different detector types are used potential interactions need considering to avoid suppression system clashes and unintended consequences (see consequences matrices below).

Interactions between detectors of the same type may also be an issue. For example, you may decide that to reduce the risk of false activations that you will install two visual-type detectors looking at the same area or item of plant which activate a deluge system, and that both detectors must activate to set-off the deluge (sometimes called a ‘double-knock’ system). This is unlikely to be acceptable. If one detector is blocked/dirty or faulty then the one remaining detector will not set-off the deluge as it needs two to do this. In this case three detectors would be more appropriate to ensure there are always two to activate the deluge.

In the same way as air-flow and dust can affect some types of detector, physical obstructions can affect others. For example, installing a visual-type detector looking at a pile of wastes in a reception area will be of little use if you routinely park a loading shovel in front of it, so blocking its 'view'. Likewise for bunker walls, and for a visual-type detector mounted over a conveyor – it cannot 'see' under the conveyor. Think about physical blocks when considering detector location and number of detectors required.

2.4. Summary table detector robustness and example applications

The table below gives detector types, comments on their likely robustness and issues, and example potential applications. It is not intended to be comprehensive, and all detector applications require specific assessment. The below is simply a guide and is not intended as a set of strict rules.

Detector type	Robustness in waste management application	Speed of response	Potential example applications
Standard smoke detectors	Very unlikely to be robust enough for operational areas	Medium	Offices, control rooms and welfare facilities
Beam detectors	Can be affected by dust/moisture and experience is that often not robust in operational areas	Medium	Internal waste storage areas where dust and moisture is not an issue
Aspirating systems	Likely need to be harsh environment systems, and not placed in dead-air areas or where air flow such as from roller doors could prevent or delay activation	Medium	Internal waste reception areas, general detection in processing areas, internal storage areas, but only if dead-air or air flow issues are not relevant
Visual IR/UV/triple IR type detectors	May need protection such as air-shields in operational areas, and beware of their 'view' being blocked by obstructions	Fast	In process areas to activate deluges over conveyors, shredders and other specific items of plant etc, or above storage bunkers
Heat sensing/thermal camera type systems	'View' may be blocked by obstructions and often require 'programming' to specific situations. May not be accepted by insurers	Medium to fast	Internal waste reception and storage areas, such as bunkers and pits

Heat sensitive wires	Prone to damage and unlikely suitable for general detection	Medium to fast	Conveyor and similar, but speed of reaction may be an issue
Video smoke and similar detectors	Fairly new to waste management	Medium	Potentially waste halls
Gas (carbon monoxide etc) sensing systems	Specialised and require specific assessment	Medium to slow	Storage silos used for treated wastes, enclosed waste treatment systems and similar

2.5. Maintenance, testing and cleaning

Whatever type of detectors you install, they also need to be accessible for maintenance, testing and cleaning. Mounting detectors in inaccessible places, or where routine maintenance requires the use of scaffold or elevating work platform is likely to result in them not being maintained correctly. Think about access when deciding on detector location.

- Read the manual for the detector and ensure cleaning and maintenance occurs to the correct frequency, content and quality. Maintenance and cleaning requirements vary. For example, aspirating systems require the blow-out of their pipework to prevent build-up of dusts etc which may impair their effectiveness (dependent on the aspirating system this may be very specific and include the use of dried compressed air as a requirement)
- Maintenance and checking applies both to the detector, and its power supply, wiring to alarms etc – the whole system needs maintenance not just the detector itself
- Ensure detectors and the associated systems are tested and checked at the required intervals by a competent person, likely an external person

3. Fire alarm

3.1. Fire alarm introduction

The purpose of a fire alarm system is to inform all on site (and in some cases off site) that a fire may have started. This is to allow people to respond to a fire quickly, such as by evacuation or seeking to fight a fire. Note – life safety is the first concern and response by employees to any alarm must be carefully considered with this in mind.

3.2. Alarm requirements

You should consider what you want to happen if a fire alarm is activated, and based on this what are your requirements for the alarm system. In general:

- Fire alarms should be clearly audible across the whole of a site, including in offices, welfare facilities, weighbridges etc. This is likely to require multiple ‘sounders’
- If your site/plant is a noisy environment, you may need visual back-up such as strobe lights or similar so that any person in a noisy area is aware that the alarm has been activated, including those in heavy mobile plant cabs which may be insulated from noise and persons who may be wearing hearing protection. This may include beacons on the outside of buildings
- If a fire starts out of working hours (and many do) and your site is not manned 24/7 who will hear the alarm? You may need to install an alarm system which is linked to a 24/7 responder, an automated call service, and/or your local fire and rescue services direct
- If you are using detection systems which sense temperature rises prior to fire breakout you need to ensure that those involved have a clear understanding of how to react to this, and to actual fire break out, and when escape becomes a higher priority than continuing to try to control fire outbreak

3.3. Alarm and detection system plant interactions

It is not unusual for fire detection and alarm to be on one system and for plant control to be on a separate system (such as a SCADA system). If you want your detection and alarm system to produce actions in your plant, such as shut-down, then these systems must be compatible. If you expect your employees to hear the alarm and then manually activate emergency stops or similar you run the risk of them not doing this exactly as you want – in extreme situations when under stress people rarely do what they may be expected to do 100% of the time.

3.4. Manual alarm points

In addition to alarms activated by detectors, the majority of sites will also have manual alarm points, such as break-glass points. These need locating in clearly visible locations and according to relevant standards. As for detector systems, they need routine testing and checking to remain effective.

Left to right: Aspirating detector (red pipework) at a waste recovery site, visual type detector in external use overlooking a waste storage bunker, specialised gas detector at a wood chip storage silo, flame detector set in a waste bunker wall

3.5. Wireless alarm systems

The use of wireless alarm systems can be attractive because they do not require extensive (and costly) hard-wiring. However, wireless systems need to be acceptable to your insurer, and can suffer from interference. They may be an option, but you should check with your insurer before fitting.

4. Fire suppression/extinguishing systems

4.1. Suppression/extinguishing system introduction

Fire suppression/extinguishing systems are aimed at either extinguishing fires or suppressing them until the fire and rescue services can attend. You should be clear what type of system you want. Do you want the system to extinguish a fire, or only suppress it? For example, for a system installed over a conveyor, shredder or similar it is likely you will want the system to extinguish a fire (and quickly), whereas for a storage area you may consider suppression to be appropriate. This is a critical decision and should be a key part of your design process (see above).

Note – you should ensure that you know what type of system you have: Suppression or extinguishing. There have been some large fires where the operator has assumed that a system will extinguish a fire, when all it was designed to do was to suppress a fire to allow other actions, such as by the fire and rescue services, to be taken, with the obvious disastrous outcome.

Systems may be manual or automatic, and may be for manual use or fixed. Examples of fixed systems would include sprinkler, deluge and foam systems. Examples of manual use systems would include manual water monitors (cannons), fire hoses etc. The sections below attempt to explain the differences between these, how they are designed and specified and how they may be applied to waste management sites. However, this is a very brief overview of what is a highly technical area and should not be considered in any way as being comprehensive or definitive. However, first it is useful to consider how fire suppression/extinguishing systems are specified, and what guidance is available on fire systems relevant to waste management.

4.2. Combustion properties of wastes, occupancy and effect on systems

One of the under-pinning factors in the design of any fire suppression/extinguishing system is the combustion property of the material which may catch fire. For example, a sprinkler system designed to suppress a fire in a warehouse storing steel motor components will need to provide less water than one designed to suppress a fire in the same situation where baled paper is being stored. The more energetically a material may burn and the more of it there is the more water (or foam etc) is required to extinguish a fire.

How energetically a material may burn is only one factor in what is often called ‘combustible loading’ (sometimes also called combustible occupancy). In brief, what is there in a building or area which can burn, how much of it is there and how energetically it will burn = combustible loading. This may seem obvious, but the more of a combustible material there is, and how energetically it will burn, is fundamental to the design and specification of fire suppression/extinguishing systems.

This fundamental issue affects the design and specification of sprinkler, deluge and similar systems. It also affects water monitors, hoses and overall water supplies. A standard fire hose which flows perhaps 100 litres of water a minute is unlikely to have much effect on a 500 tonne pile of waste on fire, and a water main capable of only providing 200 litres a minute to a water monitor is likewise unlikely to be sufficient for a large waste fire.

The standards used by fire/risk engineers to assess combustible loading typically use the system of ‘commodity class’. Some wastes fit neatly into this system. But, for mixed wastes and waste products commodity class is less easy to allocate because of their variable composition. The commodity class of a material is a critical input into fire systems design.

For example, if a waste contains less than 5% by weight or volume of specified types of plastic it is likely to fall into ‘commodity class 3’. If it contains 5% - 15% by weight or 5% - 25% by volume it would likely be ‘class 4’ (the higher the class the more energetically a material burns). If it contains more than the above of specified types of plastic it would likely fall into a specialised ‘high hazard class’. The design, specification and water flows required will vary significantly between the above three cases. As an illustration of the potential effect commodity class can have, a sprinkler system designed for a class 4 material may have twice the water demand as for a class 3 material.

***Note** – different types of fire suppression system use different types of water supply measurement. For sprinklers and deluges a water ‘density’ such as mm/minute or litres/m^2/minute is typically used, but for hoses, water monitors etc a simple flow rate such as litres/minute is typically used.*

How much (the amount) of a combustible material is present is dealt with by area of cover of a system. For example, a deluge system over a conveyor may be specified at a water density of 20 mm/m^2/minute ‘over the whole area of the item to be covered’. Using this example, if the conveyor is 1.5 metres wide and 10 metres long, a water demand of some 3,000 litres a minute would be required. If you have five conveyors each with its own deluge the total water demand if all of the deluges are activated will be significant. For sprinkler systems the ‘area’ used is different because not all sprinkler heads will activate (see below).

Combustible wastes are the obvious combustible occupancy in waste management plants. However, there are other items which can also burn, such as rubber conveyors, electrical wiring insulation, wall panel insulation etc. These are likely to be taken into account when a fire suppression system is being specified. For example, you will not help yourself by installing combustible wall panels – think about this type of issue during construction design.

In addition, dusts can be a significant issue and can affect combustible occupancy. For example, if a deluge system has been specified based on the type and amount of waste present it may be ineffective if you also allow dusts to build-up through poor housekeeping, because the overall combustible occupancy will be higher than the system was designed to cope with.

Avoiding ledges and other flat surfaces where dust can accumulate, by the installation of inclined or curved planes on such surfaces which dusts tend to 'run-off', can help to minimise dust build up.

Another issue which often affects waste management plants is that we change them… The original design for a plant may include that wood is stored in a specific storage bunker. Then after a few years this changes and plastics start to be stored in the bunker. This would significantly affect the combustible loading (plastics being a higher commodity class than wood). If a deluge, sprinkler etc system was specified over this bunker based on wood, it will very likely not be effective if asked to suppress/extinguish plastics. Similarly, if you change the layout of storage bunkers/areas, their configuration etc, you may need to reassess your fire systems to ensure they remain effective. We know that we change our plants and sites – change is one of the only constant factors in waste management. Considering this it may be wiser when specifying fire systems to assume worst case, even if this costs more.

In addition to combustible occupancy and the amount (area) of material there is, other factors also apply in system design, such as building height for roof mounted sprinkler and deluge systems. These are included in the sections below on specific types of system.

4.3. Existing guidance on fire engineering for waste management

There are existing guidance and standards for the specification of fire systems, some of which are applicable to waste management (although the majority are not). Generally, these guidance/standards documents originate with insurers, although there are other sources:

- NFPA standards, ACE guidelines and FM data-sheets – technical insurance documents (beware these often need interpretation by competent risk engineers)
- EU EN and local standards – European and national standards

- National FPA (Fire Prevention Association) guidance produced by national fire organisations, and also from the CFPA-E (EU FPA association) and LPC (loss Prevention Council)
- Industry guidance, such as this WISH guidance
- Regulator guidance, although this rarely includes technical fire engineering specific standards

Most available technical fire/risk engineering guidance/standards tend to fall into two types:

- There are under-pinning technical design standards, such as NFPA13 on sprinklers, NFPA15 on deluges etc. These describe the technical process required to design a fire system from scratch. They start with basic principles such as combustible occupancy and apply no matter the type of site or material being considered. They also often include installation, construction and other standards
- The other type of guidance tends to be sector specific, such as NFPA850 guidance on WtE plants etc. These do not give the technical process required to design a system from scratch. Rather they give guidance and 'stock' suggested specifications for fire suppression systems. For example, NFPA850 is about power generation plants, but includes suggested specifications for fire systems for the storage of alternative fuels such as RDF

For the designer of a fire system it may seem easier to look at the sector specific guidance than to use the under-pinning technical design standard to design a system from scratch – the suggested specification is given to the designer 'on-a-plate' rather than having to go through the full technical design process. However, this approach may be flawed.

When writing sector specific guidance assumptions need to be made about the material involved, design of the building etc. Most sector guidance includes caveats that the suggested specifications given are just that, and that specific site situations need to be taken into account. These caveats may largely go ignored by some suppliers and designers.

For example, a suggested specification in sector guidance may assume that the waste being stored is mixed domestic wastes. But, you may be storing plastics. Likewise the sector guidance may assume a specific type of building design and height. But, your building may be higher or of a different design. Beware designers who simply quote from an item of sector guidance.

- How old is the guidance? Knowledge of the combustion properties of wastes has developed significantly over the past few years, such as the recent waste fire burn tests in the UK
- What assumptions have been made to arrive at the suggested specifications in any guidance? Are these assumptions compatible with your plant?

The suggested specifications given in general guidance may not be correct for your wastes and your site/plant. If you simply use these suggested specifications and do not do the specific assessments and calculations for your specific situation then you risk your fire systems being under-specified (or over-specified in some situations). You may end-up with a system which costs you a significant amount of money, but which fails to perform as expected in the event of a fire.

4.4. Basic types of suppression/extinguishing system

Manual and 'fixed' (non-manual) systems

Fixed (non-manual) systems are those which do not require a person actually at the system to use it, such as sprinkler and deluge systems. Fixed is a bit of a misnomer, for example a water monitor may be 'fixed' in one location but requires a person actually at the monitor to aim and use it.

Manual systems are those where a person is required actually at the system to use it, such as a manual fire hose, or a manually aimed water monitor (cannon). Manual-use systems require a person holding/operating the suppression/fighting equipment at the location for it to work.

Manual use systems have their potential problems. If a fire hose is in an area which is actually on fire then there is little chance that anyone will be able to use it. Likewise during a fire significant amounts of smoke may be generated. If a manual-use water monitor is in the path of this smoke a person will not be able to access the monitor to use it. There are some ways of potentially reducing this issue. For example, a simple half-wall may provide sufficient protection to allow a person to stand behind it and use a water monitor fixed to the wall (please note such arrangements **MUST** be immediately next to fire escape to the outside to allow a person fighting a fire to escape easily and must not be used at any risk to human life).

Conversely, manual systems are typically flexible and can be useful to tackle smoulders and small fires before they can grow and spread. For example, a loading shovel operative at the reception area of a recycling plant notices a small amount of smoke coming from a recently tipped load. They get out of their cab, un-roll a fire hose and drench the area so extinguishing the fire. Information from waste management company fire investigation reports indicates that this is just how many smoulders and small fires are dealt with, effectively and with little risk to human health.

However, relying completely on manual systems risks not being able to access these systems in the event of a larger fire, for reasons such as smoke and heat. Fixed systems may be more appropriate and effective in the event of a larger fire.

Care must also be taken with the water supply to some manual systems. For example, deluges and sprinklers etc operate at fairly high pressures (typically 6 - 10 bar). This is not suitable for a fire hose - the operator would be thrown all over the place by the pressure. If fire hoses are supplied from a pumped water supply which is also used for deluges and sprinklers, then pressure reduction valves are likely to be required.

***Note** – if you expect your employees to use manual-use fire systems such as hoses then they **MUST** be thoroughly trained, and they **MUST NOT** use systems if there is any risk to their safety.*

Note – this appendix does not cover hand-held fire extinguishers – there is plenty of guidance easily available on types and use of fire extinguishers. You should include hand-held extinguishers in your fire plan, but except for the smallest of fires you should not rely completely on them.

Manual activation and automatic systems

Fixed systems fall into two types: Manual activation and automatic activation systems.

Manual activation systems require a person to activate them. For example, a fixed deluge system not linked to a detector which requires manual activation, such as by pressing a button in a control room. Automatic systems do not require any manual intervention, such as sprinkler systems or a deluge activated by a fire detector. In some cases systems can be both manually activated and automatic. For example, a deluge system which activates automatically from a detector, but which can also be manually activated by pressing a button should the detector fail to activate the system.

Manual activation only systems are generally less reliable because human beings make mistakes and may panic in the event of a fire and so not activate the system. Conversely, a detector may have failed or have not detected a fire before it is seen by a person, and in such cases manual activation is useful. For some systems, such as deluges, both automatic and manual activation is the likely best option. If you have manually activated systems (or automatic systems which can also be manually activated):

- At least two manual activation points should be provided for each suppression system. For example, for a deluge system a button in the control room and a second button on a panel external to the building in a safe location. If a control room is full of smoke no one is likely to enter it to activate the suppression system and an external activation point may be the only safe option
- Manual activation systems should be simple and obvious, such as a large, well signed red button in a convenient and obvious location. If an operative needs to access a computer programme, or press several buttons, or go to another room to activate a system the risk of failure will increase

Automatic systems are those which activate automatically when a fire is detected by a detector, or in the case of sprinkler systems when a bulb bursts. For sprinkler systems experience is over many years that activation is reliable: Heat reaches the sprinkler bulb, which bursts releasing water. However, for other systems such as deluges and automatic water monitors activation is via detector/s. These detectors must be reliable and located such that they can detect a fire quickly enough for the deluge, monitor or other system to activate reliably and effectively (see above on detector selection). The advantages of automatic activation systems are:

- They are more reliable than manually activated systems – this has been proven many times
- They work when no one is there to manually activate a system, such as out-of-hours, or if manual activation is via a button in a control room and no one is in the control room

Training, instruction and awareness are critical, and the more complex a system the more critical they become. Your operatives should understand your fire system, and be trained in its use. For example, a complex plant may have ten separate deluge systems installed in conveyors, shredders etc. If a fire occurs one or more of these may need to be activated manually. A fire starts in one shredder, and the automatic detection system fails to activate the deluge over this shredder. If an operative is confronted by a control panel with ten buttons (one for each deluge in the plant), which they have not been trained in and are not clearly labelled as to which button activates which deluge the outcome is predictable. The operative will push every button they can, 'letting-fly' with all deluges. This may have operational consequences, and reduce water supply to the deluge over the shredder to the extent that it is ineffective.

4.5. Specific automatic fire systems

There are many types of fire system. Typically the most common ones in use at waste management sites are sprinkler systems, deluge systems and water monitors. Some sites also have foam systems and other specific systems. The sections below give an overview of these commonly used systems, and for sprinkler systems outlines some of the issues waste management sites may have with them.

Sprinkler systems

Sprinkler systems are networks of water pipes with 'spray heads' on them. The spray heads are equipped with heat-sensitive bulbs. These bulbs burst when exposed to heat so releasing water. They can be wet systems (where water is always in the pipework system), dry systems (where water is not in the pipework and only flows into it when a bulb/s burst) or pre-action systems (where water is not normally in the system, but is allowed to flow into the system via a valve if a fire detector detects a fire - that is the pipework system 'pre-charges' with water ready for potential use if a bulb/s bursts).

Activation of wet systems is obvious – when the bulb/s burst the water in the pipework comes out of the spray head/s. With dry systems if a bulb/s burst this causes an air pressure drop in the pipework system, which activates a valve allowing water into the system which fills the system and comes out of the spray head/s. For pre-action systems (assuming the detector has worked and allowed water into the system) activation is as for wet systems.

The difference between these types of system is speed of reaction to a fire. Wet systems are quickest as there is no time delay while water fills the system. With dry systems there may be a delay while water fills the system.

Wet systems generally require more maintenance and will need to be equipped with drain down points. Wet systems need to be trace heated if they are installed in external and unheated open areas where they may be at risk of freezing. Some systems are operated wet during the summer months, and dry during the winter months (sometimes called a semi-dry or alternate system). You should know what type of system your plant has, in which areas and have an awareness of the implications.

The specification of sprinkler systems is usually given as a water density as mm of water per minute (sometimes over an area such as per metre^2). The higher the density the more water delivered over any given area. The area given varies because of factors such as the differences in speed of reaction between dry and wet systems, and combustible occupancy. The speed of reaction important: For dry systems it is assumed that a fire may have grown during the delay while water enters the dry system, so the area cover specification is higher than for wet systems.

In general, wet systems are preferred because of their faster reaction. But, in many waste plants wet systems may not be practical and dry and/or pre-action systems may need to be considered.

Normally during a fire not all sprinkler bulbs will burst, only those exposed to sufficient heat (despite what is often shown in films). The specifications of sprinkler systems are based on this premise - that is the water flows assume only some bulbs burst. However, in some cases the area specification is 'across whole area'. This is generally for smaller areas such as hydraulic power pack rooms where area specifications would not make sense.

Sprinkler systems must be ‘balanced’ to ensure that adequate water volume and pressure reaches all parts of the system. This is achieved during design by the use of ‘hydraulic calculations’. These hydraulic calculations must take account of other systems which may activate at the same time to ensure adequate water flow and pressure to all systems, and must assume worst case situations such as flows at the least favoured sprinkler head rather than most favoured (such as sprinkler head furthest away from supply rather than closest).

Sprinklers have been proven over many years to be reliable. However, they do have some limitations. In particular for waste management sites: If there is a large vertical distance between waste storage/treatment and sprinkler heads then heat from a fire will take time to reach the sprinkler head and activation may be delayed, or not occur at all. This is an issue in high waste halls (see below).

This is not to say that sprinklers in this type of situation are not effective in terms of building protection - if sufficient heat to cause building damage reaches a roof then the sprinklers will certainly activate and are likely to protect the building structure. However, in high waste halls sprinklers are unlikely to be effective in dowsing an open flame fire in the waste itself and may need supplementing by other systems, such as lower-level deluges and/or automatic water monitors.

Roof height and sprinkler systems: Sprinkler systems activate using frangible bulbs at the spray heads. When exposed to heat these bulbs burst causing the sprinkler to activate. Fundamental to sprinkler systems is that heat must reach the sprinkler head for the system to activate, and that only those heads where the bulbs burst will flow water.

Deluge systems are different (see below). They may look like sprinkler systems, but the spray heads are open and do not have bulbs. Deluge systems are activated by a separate detector, such as IR, triple IR etc. The detector sees a fire and activates the valves and pumps etc associated with the system. The same principle applies to other suppression systems such as automatic oscillating water monitors, which are activated by a separate detection system.

Because sprinkler system bulbs need to be exposed to heat for the sprinkler spray head/s to activate, the height of the building is a critical factor. The further away vertically from a fire a sprinkler head is the more time it will take for heat to reach the sprinkler head, and the longer the time delay before the sprinkler head will deploy. The longer the time delay before the sprinkler head deploys, the larger the fire will be before it deploys. The larger the fire, the more water will be required to suppress the fire. In brief, the greater the vertical distance between potential fire and sprinkler system, the greater the water density and flow required. There are other factors such as evaporation of water droplets, but time delay is the main issue.

Experience from fire/risk engineers is that vertical distances of more than around 6 or 7 metres between a fire and sprinkler head/s can result in unacceptable delays in sprinkler activation, or no activation at all (note – the 6 or 7 metres quoted above is not intended as strict guidance and will depend on specific situation and system).

A fire in 2015 at a UK waste transfer station illustrates this (this is a real example): The vertical height between the fire and sprinkler system was around 7 to 8 metres. Despite there being a substantial fire in the transfer hall for at least five hours only one sprinkler head deployed (the one directly above the fire). The water flow provided by this one sprinkler head likely had little effect. The fire was extinguished by the local fire and rescue services, with no injury and minimal property damage.

In addition to the risk of delays in sprinkler activation, high waste halls can also pose water supply issues because the higher the hall the greater the water density and flow required. The higher the hall the greater the water density required, because of the likely delay in activation. For very high waste buildings this may result in unacceptable (or at least very costly) water demand requirements.

The above does not mean sprinklers are not suitable for waste management. Sprinklers have been proven over time to be effective. However, their use in high halls may need careful consideration.

Gantry level sprinklers and 'shaded areas: Another problem for roof mounted sprinkler systems is that many recycling/recovery halls contain a lot of obstructions such as plant and equipment (conveyors, screens, gantries etc). These will block (shadow) water from a roof sprinkler system.

For example, if a fire starts under a conveyor water from a roof sprinkler may not reach it - the water hits the conveyor and runs-off rather than hitting the fire. In these situations gantry/low-level sprinkler systems should considered to supplement roof systems. These are sprinklers located under or alongside conveyors etc. Gantry/low level sprinklers have two advantages:

- They overcome the shadow effect
- They are likely to be far closer to a fire and will activate more quickly

In general (codes vary), where any gantry, conveyor, screen, conveyor etc is >1 - 1.2 metres wide gantry/low level sprinklers should be fitted. Note - careful placement of gantry/low level sprinkler systems is required to avoid pipework and sprinkler heads being damaged by plant movements, including mobile plant, and maintenance requirements should also be a factor to consider. This shadowing issue can also apply to roof mounted deluge systems.

Deluge systems

Deluge systems are similar to sprinkler systems, but they have 'open' spray heads rather than bulbs. Deluge systems activate when a fire detector detects a fire (the detector activates a valve which releases water into the deluge system). Unlike sprinkler systems, where water will only come out of the spray heads where the bulb has burst, for deluge systems water will come out of all of the spray heads in the system.

Deluge systems can cover entire areas (such as a waste storage area) or specific items (such as a conveyor, a trommel screen or a shredder feed hopper). They can be roof mounted, or mounted at a lower level, such as wall-mounted above a waste storage bunker or under conveyors. Where a deluge covers an entire area the detector cannot usually spot exactly where a fire is (most detectors simply detect a fire in an area rather than where exactly in that area the fire is). As a result, for deluges covering an entire area their specification is given as a water requirement across the whole area.

Where deluges are in conveyors, screens etc the same specification of across the whole area is given, but in these cases it is the area of the specific item being protected (such as the area of the conveyor, shredder feed hopper, screen etc). This is because the detector/s are in/over the specific items and can detect much more specifically where the fire is. Note - detectors must be specific to items for this to be the case. It is no good having one in-item detector covering five conveyors. Most of this type of deluge system has 'legs' (also called zones), such as five legs covering five conveyors (one leg for each conveyor). In these cases water calculations should take account of the worst case scenario. For example, for a seven leg system the worst case may be only that four legs would need to activate.

Deluges covering whole areas can have very high water supply needs, because the detector does not know where the fire is and the whole system is activated. For this reason deluges covering an area are often also split into legs covering different zones in the area. Each zone has its own detector which only activates the deluge leg feeding the deluge over the specific zone. This reduces water supply needs, but requires multiple and/or complex detector systems.

The specification of deluge spray heads and number of heads should be such so that the whole area is covered. This will depend on factors such as distance from deluge head to item being protected etc. Of course, deluge systems are reliant on their detector/s, and in most cases a manual activation facility should also be provided (see above on manual activation).

Oscillating and non-oscillating water monitors

Automatic oscillating water monitors function like large garden sprinklers. They are normally activated by fire detectors (in the same way as automatically activated deluges), although manual activation can also be provided. The detector detects a fire and releases water into the oscillating monitor pipework system and so to the monitor spray head/nozzle. The hydraulic pressure of the water in the system also causes the monitor to oscillate from side-to-side so spraying the water over the area covered. In the case of a manually activated system a person activates the monitor by pressing a button or similar.

Non-oscillating water monitors operate in the same way, but do not move from side to side and rather provide a directed spray at a smaller area or specific point.

Where oscillating monitors are used they must cover the entire area being protected with no 'blind spots'. If blind spots do exist they should be covered by supplementary means, such as a deluge spray head under a monitor to fill a blind spot directly under the monitor where water from the monitor cannot reach.

The assumption when designing oscillating water monitor systems should be that one monitor may fail. For example, if two monitors are installed then the whole area must be capable of being covered by the remaining one monitor on its own. If four monitors are installed then the whole area must be capable of being covered by any three monitors etc.

Water flow requirements for monitors are different than for deluges and sprinklers and are usually expressed simply as a total water flow through each monitor, or overall flow through all monitors in an area. This water flow is dependent on combustible occupancy, in the same way as water density is determined for sprinkler and deluge systems. As for deluges and sprinklers water volume and pressure/hydraulic calculations for monitors must take account of multiple suppression systems potentially being in use in any one area at any one time to ensure adequate water flow and pressure in all systems. And, that all monitors will receive adequate water flow.

Placement of oscillating water monitors should be considered in terms of maintenance requirements, potential damage from plant and equipment movements and to avoid any blocks (such as bunker walls or plant/equipment which may block the water spray from a monitor). As most oscillating monitors move from side to side design drawings often show the 'arc' of movement and water ‘throw’ - this should reach all parts of the area to be covered. Nozzle type used should also be considered - too tight a nozzle may produce a water stream which could 'blast' wastes around so promoting fire spread - wide area cover nozzles may be better for many waste management applications.

Foam systems

Foam fire suppression systems are not that common in waste management plants, but seem to be becoming more popular for reasons such as that they typically require lower water demand than equivalent deluge, sprinkler or monitor systems. Typically, foam systems include a foam storage tank/vessel for the foam suppressant concentrate. A fire detector activates the system by pumping water into the system, which mixes with the foam concentrate, producing the foam which is sprayed onto a fire through spray heads/nozzles or similar.

Foam suppressants come in different densities and types, and foam ‘mix’ and delivery systems come in different types – this is a complex area and it is essential that the correct foam type and mix/delivery system is used for the specific application at your site.

Foam systems depend on smothering a fire so excluding oxygen from a fire to work effectively. For piles/stacks of wastes the foam must cover the entire surface of the waste including any irregularities and dips, or the foam must 'cling' to sides of any pile to effectively exclude oxygen. This can be difficult to arrange in waste management applications. Foam systems were originally designed for liquid fires, and as a matter of physics liquids are always flat – this is not the case for most wastes.

In addition, another potential issue with foam is that large open-flame waste fires tend to generate lots of heat and thermal air turbulence, which may blow foam away and/or evaporate it.

Foam systems can also be used in enclosed conveyor systems, or with other similar enclosed recycling and recovery equipment. The foam 'floods' the enclosure to exclude oxygen. As for other uses, the density and type of foam and delivery system type used should be tailored to the application.

Foam suppression systems have been used in many industries to good effect, and have been used in some waste management applications effectively. Set against this, they are typically more complex than simpler water suppression systems and require detail design and tailoring to specific applications. The benefit is that they use less water, which on large systems may be a significant factor.

If you are considering a foam system you should consult with your environmental regulator as run-off from a fire may contain contaminants which require specific attention in terms of pollution.

Tip – some insurers have very specific requirements for foam systems, and some may not accept foam systems at all. You should liaise with your insurer to ensure that any foam suppression system you are considering will be acceptable to them.

Water mist, gas, and aerosol etc suppression systems

The above are the most common types of suppression system found at waste management plants. However, there are other systems such as gas, water mist and aerosol systems. Typically, these may be installed where there is a perceived risk of damage to equipment being caused by the use of high-flow water suppression systems such as sprinklers. For example, MCC (motor control) or electrical equipment rooms, or with hydraulic power-pack enclosures. Water mist, gas and aerosol systems, and other similar, require very careful and specific design – they are limited and specialist applications and you would be well advised to consult with your insurer before considering such systems. They must be completely tailored to their application and environment. In addition, they are typically more complex and have higher maintenance and check/test requirements. They can be a valid alternative to high-flow water systems, but if you decide you need gas, water mist etc systems then you need to accept this likely higher design cost and complexity and higher maintenance resource. And, ensure that required maintenance is actually carried-out, or you risk the system becoming ineffective.

Tip – many insurers are not that keen on gas, water mist, aerosol etc systems, or they require some specific design criteria to be met. If you decide you want gas, water mist, aerosol etc then you should liaise with your insurer to ensure you do not end-up with a system your insurer will not accept.

4.6. Sprinkler, deluge, monitor, foam etc system design

Sprinkler, deluge, water monitor, foam etc suppression system designs are not generic. For example, the design of a sprinkler system can change based on factors such as: The commodity class of the waste, the storage height of the waste and distance to the sprinkler heads, the storage configuration of the waste (where and how stored), the building height/clearance (distance between waste and ceiling). In addition, the area of operation of a sprinkler system can change based on factors such as whether the system is a wet, dry or pre-action system, roof slope etc. These factors are very likely to be different from site to site. This is a case of one-size-definitely-does-not-fit-all. Fire systems are not standard and you should ensure that whatever system/s you decide to install are designed and specified for the wastes you store or process, the building they are in and the specific requirements and environment of your site/plant. And, if you change the types of waste you store or process, their storage locations, the layout of storage etc you will need to reassess your fire systems.

4.7. Summary table automatic fire systems, issues and example applications

The table below gives automatic system types, comments on their use in waste management, and example potential applications. It is not intended to be comprehensive, and all system applications require specific assessment. The below is simply a guide and is not intended as a set of strict rules.

Automatic system	Comments/issues	Example waste management applications
Roof level sprinklers	Robust and reliable, but if vertical distance between wastes and sprinklers is circa >6-7 metres may suffer delayed or no activation in high waste halls	Lower waste buildings where vertical distance wastes to sprinklers is less of an issue, above plant/equipment systems (where distance to sprinkler head is not an issue) and as building protection
Gantry level sprinklers	Removes problem of shaded areas under plant (conveyors, gantries etc) which water from roof level systems may not reach. May be prone to physical damage and may need protection	Under conveyors, access gantries, screens and similar which may block water from roof level systems

Roof level deluges	As for roof mounted sprinklers, but activated by detector. Delayed or no activation less of an issue. But, water demand can be high (sometimes very high) leading to multiple deluges zones to reduce water demand and complex multiple detector systems to activate individual zones	General use waste halls, above wastes stored internally, waste bunkers etc
Lower-level deluges	Water demand may be less than for roof deluges, and may be easier to target specific areas, but multiple/complex detector issues may remain	At waste storage areas and bunkers, under conveyors and similar
Dedicated deluges	Deliver water direct to where it is needed, but can be difficult to arrange in some plant, and higher water demand may result in complex, multi-leg systems. Typically require fast detector systems to be effective	Above shredder input chutes, in conveyor systems, in/above trommel and other screens
Oscillating or fixed water monitors	May have lower water supply needs than equivalent deluge systems, but must be capable of covering whole of area within their operating arc. Obstructions (plant, gantries etc) may block water stream from monitors, and nozzle type may need careful selection to avoid burning wastes being 'blasted' about promoting fire spread	Larger waste reception, treatment or storage halls/areas where roof sprinklers may not be effective and where obstructions from plant and walls is not an issue. Note – some oscillating water monitor systems are in use in outside applications and may be an option for external storage of wastes
Foam systems	Lower water supply needs than equivalent water sprinkler, deluge etc systems, but foam itself and systems may be costly. May not be effective if all of the waste cannot be 'enclosed' in foam, and may be affected by thermals from large fires ('blown away' or evaporated)	In-conveyor systems or other enclosed items of plant, applications where wastes are fairly 'flat' so that foam can enclose whole of surface
Water mist, gas, aerosol etc systems	Specialised, may be expensive and have expensive maintenance and check requirements. No standards in place and insurer acceptance critical. But, can pose less of a risk of damage to electrical etc systems when activated	MCC and electrical rooms, subject to insurer acceptance

Summary: There are multiple options when choosing fire suppression/extinguishing systems. The critical factor in choice must be effectiveness. But, other factors such as water demand and cost may also be valid. Beware any consultant or supplier who 'jumps' quickly to a single option without careful consideration of use, environment and other specific aspects of your site/plant.

5. Water demand, supply and water mains

5.1. Water demand, supply and water mains introduction

The principle aims of any water supply to a fire system are that the supply is reliable and adequate. Most fire suppression and fighting systems consume large volumes of water. Sufficient water supplies must be available on-site to fight a worst-case scenario fire. Dependent on various factors, insurance standards require on-site water supplies to last typically for 90 to 120 minutes (examples only and may be higher).

Some people ask why for so long, stating that water supply would only be required until the fire brigade arrives. The average fire brigade tender only carries some 1,800 - 6,000 litres of water, depending on type of tender - enough to supply a reasonable size sprinkler system for perhaps a minute or two... Unless you have a water main, tank or alternative supply which can be fed into the fire and rescue services vehicles and pumps they will be of limited use. In addition, and understandably, the fire and rescue services may not want to enter a smoke-filled and hazardous building to fight a fire if life is not at risk.

In general water supplies can come from three sources:

- Water tank/s on site with pumps feeding a water main
- A non-tank fed fire/water main on site, such as from a commercial supply main
- Alternative water supplies such as a near-by river, canal, lake, lagoon etc (in some rare cases wells can be used, but their capacity and recharge characteristics must be adequate)

Left to right: Large foam system under test at a waste recovery plant, sprinklers in action at a recycling plant, manual-use water monitor at a waste site, under-gantry sprinkler head and pipework at a recycling plant

Water supplies can be either pumped (typically from on-site water tanks or from alternative water supplies) or un-pumped (typically from site fire/water mains).

When calculating total water supply requirements for your fire systems the worst-case must be assumed. Generally, this is all fire suppression/fighting systems in the highest water flow requirement area/compartment of the site being active at any one time. The exception would be for in-conveyor and similar deluge systems where a worst-case scenario may not include all of the legs/zones of the deluge. Plus, allowance should be made for manual hoses/monitors etc.

For example, the highest water flow requirement area of a site may have in place a sprinkler system, a seven-leg in-conveyor/screen deluge system and manual fire hoses/monitors and hydrants. Total water demand would be the flow requirement for the sprinkler system plus flow requirement for the worst-case number of legs in the deluge system (for example, four legs out of the seven) plus an allowance for the manual hoses.

For example, total flow requirement for the above sprinkler, deluge and hose system, might be as high as 10,000 litres of water a minute. If the supply needs to last for 120 minutes, this means that on-site water tanks (or other sources) would need a volume of some 1,200,000 litres. This is 1,200 m^3 of water, or 1,200 tonnes. Often the most expensive parts of any fire suppression system are the tank, pumps and water main required. In brief, fire suppression systems can consume very large volumes of water very quickly.

You should consult with your environmental regulator on this aspect. Using the above example, where will the 10,000 litres of water flow to if the fire system is activated? Containment of contaminated fire water is an issue you should consider carefully and in consultation with your environmental regulator.

5.2. Alternative water supplies

If alternative water supplies, such as from a nearby river, are to be used to supplement tanked or mains supplies, then these need to be capable of being accessed promptly. There is little point in assuming that a near-by lagoon/lake/canal can be used as part of water flow requirements if it would take three hours to arrange pipes and pumps to this lagoon/lake/canal (in these cases fixed pipes and on-site pump capacity may be required). Alternative water supplies also need to be reliable: Relying on a lagoon which is only half full or empty for part of the year may result in water shortage issues. In addition, the alternative water supply may contain grit, gravel, sediments etc and filter systems may be required to reduce the risk of blockages in pipework and hoses and damage to pumps.

Overall, alternative water supply requirements need careful thought - it is far better to do this in advance rather than wait for a fire and then run-out of water after a short period of time, or be unable to access water quickly and effectively.

One source of alternative water supply is the recirculate water. For example, water from a deluge system may flow into a sump on site from which it can be pumped back into the deluge system, or water run-off from hoses may flow into a lagoon where it can be recirculated from. This sounds attractive as a way of reducing water storage requirements, but can have issues:

- Grit, gravel, sediment etc can be an issue as for lagoons, rivers etc
- Recirculating fire water may concentrate hazardous substances and/or biological agents – the water will have passed through burning wastes, and the more times water passes through this cycle the more these may concentrate. This may poses health issues to those fighting the fire
- The eventual run-off water may be more concentrated in its contamination than water only used once, which may pose environmental damage issues
- How will you capture the water? For sites with sumps this may be easier, but otherwise there will need to be a method to channel 'used' fire water to where it can be accessed

If you are considering recirculating fire water you should consult with your fire and rescue services and environmental regulator. There may be compromises you can arrive at. For example, using recirculated water in fixed systems such as deluges but not manual systems such as hoses (that is not for systems where a person may be at the 'point of delivery' and so may be exposed to harm).

5.3. Water mains and supply to fire systems

Large waste management plants will typically have a water main to supply their fire systems, fed from a water tank or other reliable supply. This main may be a ring-main around the whole site, or a single main with branches. In most applications for large sites a ring-main may be better as water can be fed from both ends of the ring, so if a leak or block occurs water supply can be maintained.

For example, at a smaller site equipped with a sprinkler system and manual-use water monitors a single underground main from a water tank may be installed, feeding a manifold at the waste hall. Pipes from this manifold feed the sprinkler system and each monitor. In this type of arrangement you may want to consider having two mains legs from the tank to feed the manifold from both ends. In the event of a leak in one leg, this leg can be valved-off to maintain water supply.

For larger sites with multiple suppression systems an underground ring-main is more likely. From this ring-main 'lead-ins' come-off the main leading to manifolds in the waste hall/s. Pipes from these manifolds feed specific fire systems. Between each lead-in of the ring-main an isolation valve must be fitted. This is in case of a leak or other failure in the main or a lead-in - the affected section can be valved-off and water fed from the other end of the ring-main. Whatever system is used, valves and other parts of the system must be to fire engineering standards - normal water valves and other components are not good or reliable enough.

Water supplies can be pumped or un-pumped. Un-pumped supplies are unlikely to be able to supply the pressures required for sprinkler and deluge systems (6 – 10 bar often being required). Un-pumped supplies may be sufficient to feed hydrants and fire hoses, provided the flow is adequate. For sprinkler, deluge etc systems pumped supplies are very likely to be required.

Pumps must be able to supply adequate water volume and pressure for the systems they feed. In most cases two pumps are better than one, in case of failure. The more volume of water a pump provides the lower the pressure becomes. Fire pumps should have 'performance curves' showing the relationship between volume provided and pressure - maximum supply need must be within this performance curve.

Typically water mains and lead-ins will be underground, with the lead-ins coming to surface to feed manifolds and systems. For above-ground pipes consideration must be given to freezing, and pipes either lagged or fitted with trace heating up to the point at which they become 'dry', if dry systems are installed (no water in the pipe in normal circumstances). Beyond control valves between wet and dry sections pipes typically do not need to be protected. However, drain-down points must be provided so that following tests of systems (or use) water can be drained out of dry sections to prevent freezing and pipe failure.

At a maximum one lead-in from a main should normally only supply up to five applications. One sprinkler system would be one application, one deluge is one application, one hose or hydrant is one application, one water monitor is one application (for multiple water monitors where one monitor is duty and one stand-by these may sometimes be considered in some situations as one application).

However, this is a maximum and good risk engineering should be used - having just one lead-in to a large sprinkler system may leave it open to failure. The number of lead-ins and number of applications on each requires risk assessment to prevent large sections of fire suppression equipment being impaired in the case of a leak or similar failure in the main and/or a lead-in.

Ideally, each application should have its own lead-in, but this is often not practical. One potential solution is to run above-ground pipes between manifolds where lead-ins split to feed systems. In this way a manifold can be supplied from both ends in the case of a leak or other failure.

All pipework, (and all fire system components) including feed pipes to sprinklers, deluges etc, must be to the appropriate standard, including their construction, materials used, joints etc. For example, the standards in NFPA for water pipes to supply fire systems. As above for sprinklers and deluges, all pipework must be hydraulically balanced to ensure adequate water flows. Valves and other pipework items must be to fire engineering standards - general water supply valves etc are not reliable enough for fire systems as a failure in just one valve can have severe consequences should a fire occur.

5.4. Supply to hoses and other manual systems

Manual systems, such as hoses, can be fed either from pumped water supplies, or non-pumped-supplies, such as a water main running around a site with hydrants located on it. The pressures in these different systems will be different. It is not possible to predict what water flow will be required for manual systems. This will depend on many factors, such as how many hoses are used both by site staff and/or by the fire and rescue services if they attend a fire. As a result water demand requirements for such systems are normally simply given as an 'allowance'. This allowance depends on factors such as combustible occupancy and require calculation by a competent person.
Note - where hoses and manual-use monitors are both provided the calculated allowance should be provided for each system: For example, if the allowance is 2,800 litres/minute then this should be 2,800 for hose use and an additional 2,800 for monitor use.

Where required, on-site hydrants should be easy to access, clearly signed and typically spaced around buildings at no more than 75 metre intervals (dependent on site specific assessment). And, any hoses kept on site should be long enough to reach all parts of the site from the nearest hydrant.

Left to right: Fire water tanks and pump house at a recycling plant, on-site fire hydrant at a wood waste site, foam storage tank and systems at a large waste recovery plant

6. Other factors

6.1. Plant control actions

Detectors activate alarms and suppression systems. They can also instruct plant control systems, such as emergency-stopping conveyors to prevent fire spread. The specific plant actions required when detectors activate in the event of a fire is a matter for careful assessment. For complex waste management plants it is critical that it is clearly understood what actions (fire system actions and plant actions) are produced by specific activations of detection systems. For example, for a fire detection in one area of a plant you may want conveyors in that area to stop, but for other parts of the plant to continue operating to remove wastes from adjoining areas to reduce the risk of fire spread.

For large and complex plants a consequences matrix is one way of recording these actions. Typically consequences matrices start by listing the detection systems in each compartment/area of the site/plant. Next to these is noted what alarm the activation of a detector produces, then what fire systems are activated and then what plant control actions occur when a detector is activated. This can provide a clear and concise view of what does what and what activation produces what actions.

Consequences matrices can also be:

- Used during plant and fire system design to think-through detector activations and what suppression and plant actions are required, and in what order
- Extended to include what actions are expected of employees for specific scenarios and detector and alarm activations, which can then be used as a training aid
- Used as a checklist to test actions for existing plants – for example, it may be expected that a detector activation in one area produces specific alarm, fire system and plant actions, but does it really? There are examples of waste management plants conducting checks using a consequences matrix only to discover that their suppression and plant actions do not occur as they expected

6.2. Life safety

In developing and designing a fire system you will need to ensure that an assessment and allowance is made for any situation where you have employees in an area where fire systems may activate, or who may be affected by the actions of automated fire systems. You will need to ensure that the automated responses aimed at containing and dealing with fire, smoke, and fire water run-off cannot inadvertently trap or delay the escape of personnel.

6.3. Electrical systems and fire systems

In developing and designing a fire suppression system you will need to ensure that consideration is given to the potential for water from fire suppression systems or fire water run off to interact with the plant electrical systems. Although the automated fire activation systems may isolate the electrical supplies to the area, where fire has been detected machinery can retain significant quantities of stored energy, especially where an emergency shutdown process has been executed.

Junction boxes and electrical panels within the arc of water monitors (especially cannons) need to be rated to resist the water they may be exposed to. Electrical systems should be at high level, or where unavoidably floor mounted, raised up on plinths to a level where they will remain clear of any fire water run-off. Critical systems may need further protection, both from fire and the actions of fire systems.

6.4. Commissioning, testing and maintenance

Fire detection, alarm and suppression/extinguishing systems are complex equipment, and in common with all complex equipment they need to be commissioned, tested and maintained.

- All newly installed fire detection, alarm and suppression/extinguishing systems must be commissioned to ensure that they function as expected and required. Commissioning testing will also allow the supplier/installer to issue a certificate for the system, which your insurer may want a copy of. Your insurer may also have specific requirements for commissioning, and may want to witness commissioning tests – you should liaise with your insurer on this. For a simple detection and alarm system commissioning may be straightforward (a function test). For more complex systems commissioning may be lengthy and complex

- All fire detection, alarm and suppression systems need regular maintenance, testing and checking. Detail of the timing and content of specific maintenance, checks and tests required should be provided by the supplier/installer. However, your insurer may have specific requirements (see below on insurer requirements) which you should also include in your maintenance, testing and checking regimes. Maintenance, testing and checking should be recorded and these records kept, as for any item of equipment. Systems should also be subject to defect reporting and repair regimes. In serious cases a defect in a fire detection, alarm or suppression/extinguishing system may mean that operations, or part of an operation, may need to stop until a repair can be made. You may wish to identify any such potential critical impairments in advance and plan for them

Tip – for large complex sprinkler, deluge etc systems commissioning may involve live-testing of the system. This may be difficult to arrange or may pose a risk of damage, such as live testing of a wide area deluge which releases thousands of litres of water onto equipment (something you only want to occur if there really is a fire). In these cases a combination of air pressure testing of pipework to ensure no leaks, and volume testing of mains and lead-ins may be better. For example, discharge of water from a lead-in into a tank rather than the actual system it feeds to assess water flow and pressure.

Experience is that in the event of a fire detection, alarm and suppression systems can fail, or not perform as expected, for a variety of reasons. This may be because the system is under-specified or unsuitable for the application and environment it is being used in. However, one of the most common reasons is that the system has not been maintained, tested and checked as it should have been. Or, that a defect in the system had been identified but not addressed.

6.5. Fire compartments and fire walls

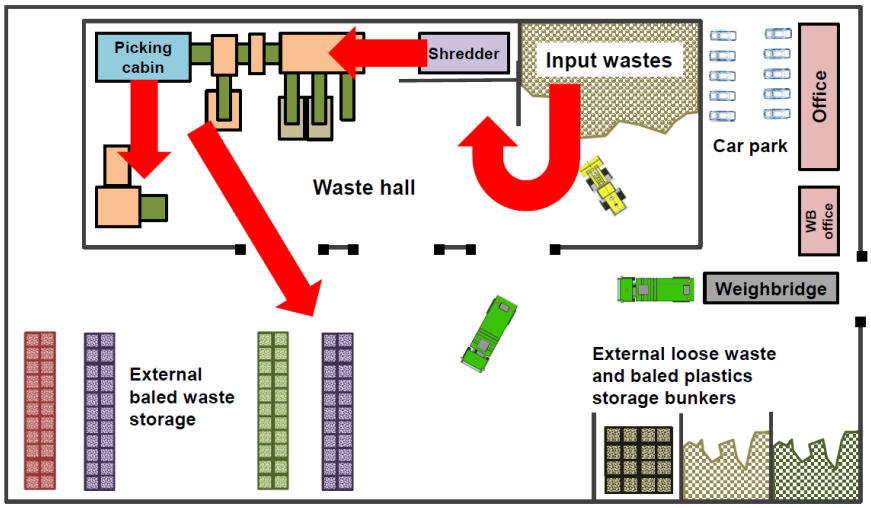
Compartments

The use of fire compartments is common in many types of building. For example, a large office building is likely to be split into 'compartments' separated by fire walls with fire doors. The aim of splitting buildings into such fire compartments include reducing the risk of fire spread, so reducing damage, allowing time for people to evacuate more safely, and allowing fire systems such as sprinklers time to do their job.

However, in many waste management applications fire compartments are difficult to arrange and may be impractical. This is usually the result of a need to move materials (wastes) between sections of the plant/building. Using the illustration recycling plant given in the section above:

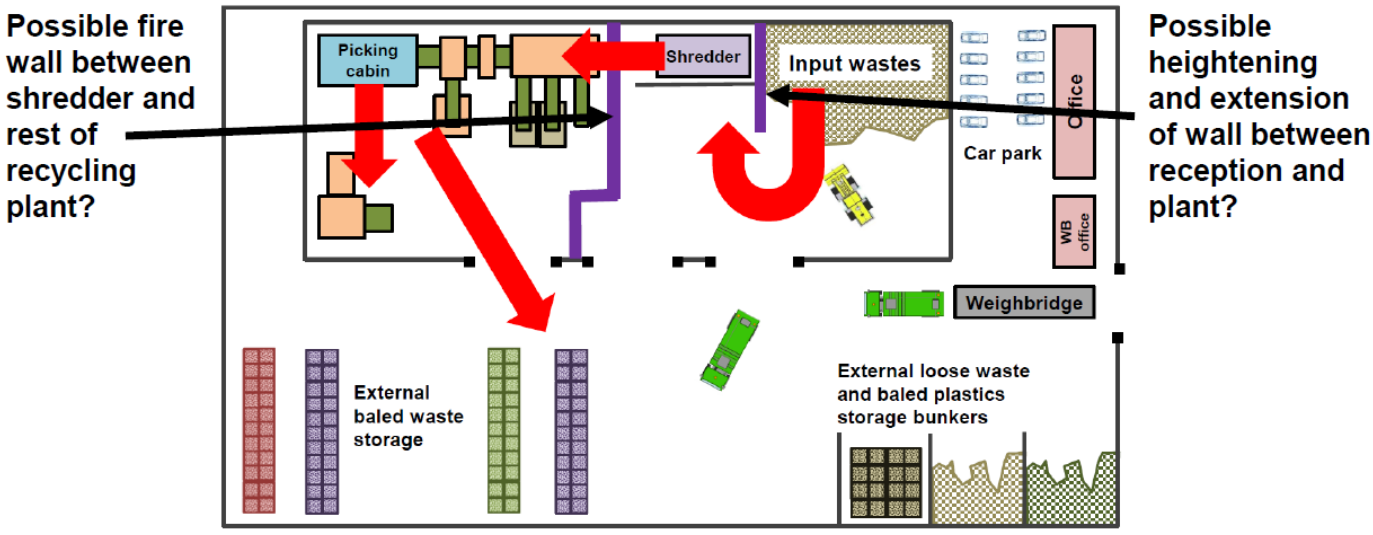
- Wastes need to be moved from the reception area to the input shredder of the processing part of the plant (in this case likely by use of a loading shovel, grab crane or similar)
- Wastes once fed into the shredder at the start of the process then need to travel via the shredder's output conveyor into the rest of the plant for separation into recyclates
- Once separated wastes need to be moved to the baler, or to external storage

This type of practical requirement tends to mitigate against splitting waste management plants into compartments. However, this is not to say that compartments are impossible, or that the idea of splitting a plant to reduce the risk of fire spread should not be attempted. The illustration recycling plant diagram below shows possible required waste movements, as indicated by red arrows.



As noted in the section on design above, two of the main fire risks at the illustration recycling plant are fires in the waste reception area (self-heating, hot and hazardous materials in input wastes etc), which could spread to the recycling plant, and fires in the shredder (gas cylinders, lithium batteries etc), which could also then spread to the rest of the recycling plant.

Using the illustration, it may be possible to install a fire wall between the shredder and the rest of the plant, splitting the building into two compartments. How practical this is will depend on mobile plant movements, structure of the building and other factors (and is likely to be easier at a new build than as an addition to an existing plant). If you are designing a new build plant, then extending the length of the shredder output conveyor will make installation of a fire wall easier – fire/risk engineering should be considered alongside process engineering in new builds. And, of course there will need to be a 'hole in the wall' to allow the output conveyor from the shredder to pass through to the rest of the plant (see below on fire shutters etc).



While this would not split the building into compartments, consideration could also be given to raising the height of and extending the length of the push-wall between waste reception and the shredder to reduce the risk of fire spread (see below on fire walls at bunkers etc).

However, even if you can split your facility into compartments, there will very likely still be a need to move wastes between compartments, typically via conveyors, resulting in imperfect fire walls with 'holes' in them. Fire can spread through such holes by various mechanisms, such as:

- The conveyor itself may have combustible components, such as rubber belt conveyors
- While the conveyor may have been emergency stopped in the event of a fire, residual wastes may still be on the belt which can cause fire spread
- Hot combustion products, such as gasses, can transfer heat via any 'hole in the wall' igniting combustible materials on the other side, or radiative heat itself can breach the wall via the hole
- If the conveyor bed and carriage are steel, then this can heat-up in a fire carrying this heat through the fire wall by conduction

There are various options here:

- Fire shutters – these are typically hatches which slide into place in the event of a fire blocking the hole in the fire wall. These may be difficult to arrange in waste management plants because of the irregular shape of holes required to pass conveyors – they may be impractical to fit and/or ineffective in use because they do not fit exactly in the 'hole'. Fire shutters also require routine cleaning (debris such as wastes can stop them closing) and maintenance. Shutters can be automatic and triggered via the same detector/s as deluge and other systems, or manual (automatic is usually preferred for the obvious reasons)
- Water curtains – these spray a curtain of water across the 'hole'. Note – some insurers do not accept water curtains as they have proven to be ineffective in some cases in stopping high levels of radiative heat passing through – and waste fires can be intense. Check with your insurer before you decide on the use of water curtains
- Deluges – typically arranged longitudinally along conveyors passing through holes. Obviously the longer the conveyor the longer the deluge array can be, and the more likely it is to be effective

If using deluges and/or curtains at holes in fire walls you should consider all of the potential mechanisms for fire spread. For example, deluges should be extended to under the conveyor, and may need to cover conveyor carriages etc with the deluge system to reduce the risk of heat transmission. You may also use combinations, such as a fire shutter backed-up by a deluge.

Note – the examples above assume that a conveyor is the potential issue. There are other mechanical transfer methods such as automated grab cranes, screw elevators and others. As for many other aspects of fire/risk engineering at waste management facilities, specific assessment is required if an effective outcome is to be achieved.

One area where compartments are often seen at waste management plant is with MCC rooms, hydraulic power-packs and similar. These are often in separate compartments (rooms, containers etc) protected by fire walls. For example, it may be practical, depending on your plant's layout, to locate MCC rooms and power-packs in steel containers/separate buildings (such as a brick outhouse) outside of the building: Why place such critical items in higher fire risk areas such as recycling halls unless you have to? If you do have to locate such items in waste halls and similar, protecting them by the use of compartments would likely represent good risk management.

Whatever their location, components such as MCC rooms and power-packs suffer the same 'holes' problem as conveyors, albeit to a lesser extent. They need to be connected to the plant, such as via cabling, hydraulic hoses and pipes etc.

These connections need protecting:

- All holes/breaches in fire walls need sealing, such as with fire resistant foams
- You may want to consider other protection to cables, pipework etc, and where you locate them to make them less prone to damage during a fire
- Hydraulic power-packs should be interlocked to shut-down and depressurise in the event of a fire, via link to your fire detection and alarm systems (non-flammable hydraulic oils may also be possible dependent on the technical specification of the power-pack)

One of the most common faults found during site fire inspections are holes 'drilled' in fire walls to allow cables, pipework etc to pass through the wall without any sealing or other protection being applied. In particular during the installation of plant and during new builds such faults should be high on your agenda during periodic inspections of works.

Fire walls

There are set standards for fire walls, and you should consult with your insurer to ensure you have selected the correct standard. Typically, fire walls are 'rated' by how long they will resist fire spread, such as 30 minutes, 60 minutes, two hours etc. The more critical a component (or life safety aspect) the higher the rating of fire wall required. A 30 minute rated fire wall in an office likely would not be appropriate to protect an MCC room or other critical component.

Fire walls also formally need to be installed by accredited installers, as for other fire related systems. Again, your insurer should be able to advise you, and see the BRE web-site for information. Notwithstanding this, and on a practical note, a 300 mm thick concrete wall is likely to provide a good degree of fire resistance whether it has been installed by an accredited installer or not.

To be effective a fire wall needs to be able to resist fire and not have any breaches in it which could result in fire spread. In addition to the issue of 'holes' in fire walls as noted above:

- Railway sleepers cannot be considered as fire walls – they are made of wood, which in itself is combustible, and have frequently been treated with flammable preservatives
- A bunker constructed of blocks may provide an adequate fire wall. But, concrete 'A' fames may not as there are likely to be gaps at the corners of the bunker where the 'A' frames do not meet exactly. Conversely, 'A' frames arranges in a linear wall to separate waste stacks, or waste stacks from a building wall, may be adequate because there are no corners to contend with
- Steel walls may resist fire, but they will heat-up during a fire and may transfer heat. As such their use may be limited. For example, steel walls between a series of waste bunkers may not be effective as a block to fire spread. However, if the bunker is stand-alone then while heat may radiate from the external face of the steel wall this may be acceptable (this type of application requires specific assessment)

As per the examples given above, one of the most common use of fire walls in waste management is in waste storage bunkers (and reception areas etc), both internal and external. In addition to the points noted above on fire walls, in general:

- Bunkers in waste halls and similar (internal use) do not result in fire compartments – they are open-topped and cannot be considered as compartment walls
- Fire walls in bunkers and similar are of little use if wastes are piled above their height, or if wastes spread-out beyond the wall ends. In general at least 1 metre 'freeboard' should be left between waste height and wall top to account for flame height in a fire. You will need to control waste height and spread in bunkers and similar as part of your site rules and their enforcement
- Construction of bunker walls should be appropriate to their use as fire walls (see above), and maintained to ensure damage such as by mobile plant does not degrade effectiveness

One use of fire walls is to reduce the need for separation distances between waste storage stacks. For example, in the illustration plant used above plastic bales have been stored in a bunker. Provided that the walls of this bunker are appropriate and waste height and spread is being controlled this can be a good method to reduce the need to separate waste stacks by distance, so maximising site area. However, this type of use needs consideration – see main body of this guidance under storage.

6.6. Smoke vents

Smoke vents are openings located in the roof and/or upper walls of buildings. Their aim is to vent smoke and hot combustion products during a fire, so removing heat and energy from the fire and allowing better vision of a fire when fighting it. Vents may be:

- Fixed open – in such cases vents are normally located in the upper walls of buildings rather than the roof to prevent obvious problems such as rain ingress
- Automatic – vents which open in the event of a fire automatically, such as hydraulic or electric opening linked to the building's fire detection and alarm systems
- Manual – vents which are opened manually, such as by pressing buttons in a control room (usually with a back-up manual activation point in a safe locations, as for deluges etc)

Smoke vents can be the topic of debate, and some insurers and fire and rescue services may have negative views of smoke vents (this is one areas where you should consult with your insurer and local fire and rescue services before you install). They can also have other problems:

- By venting smoke and heat vents may prevent heat from reaching sprinkler bulb heads, so preventing them from activating or delaying activation, and may also prevent smoke from reaching detection systems such as aspirating systems so preventing or delaying their activation
- Vents may promote air-flow (chimneys) so encouraging a fire rather than helping

This is not to say that vents should not be installed – in some situations they have been proven to be beneficial. However, you should seek competent advice, and consult with your insurer and fire and rescue services before fitting them.

6.7. Insurer requirements

Many insurers have specific requirements for fire alarm, detection and suppression/extinguishing systems. If you fail to meet these specifications and requirements your insurance may be invalidated. The basic rule here is: **TALK TO YOUR INSURER FIRST**.

- Certification/standards for fire detection, alarm and suppression/extinguishing equipment: Many insurers require specific certifications for fire systems, such as LPCB (Loss Prevention Certification Board) or FM (Factory Mutual). If you install a system which is not certificated to your insurer's requirements they may not accept it, and you may need to start again

- Certification standards for installation and design of fire detection, alarm and suppression/extinguishing systems: As for the equipment itself, your insurer may insist that systems are designed and installed to specific standards. These may be design standards such as NFPA and FM standards, or they may be standards for installation, such as installers being certificated to LPCB standards. Again if the designers of any system do not design it to your insurer's required standards and/or if installation is not by a certificated/approved installer then your insurer may not accept the system
- Standards for commissioning of systems: As above, your insurer may have specific requirements for the commissioning of fire systems
- Standards and conditions for maintenance, testing and checking of fire systems: These are often included in property insurance policies as conditions. For example, that sprinkler systems, fire pumps etc should be tested and checked to given timescales and standards. In the event of a fire you may be asked to prove that you complied with these conditions and requirements – if you cannot your insurance may be invalidated
- Impairment of fire detection, alarm and suppression systems: It is common for property insurance policies to include a condition that you must inform your insurer if any part of your fire system is impaired, such as faulty, damaged, not operational etc. You should inform your insurer if any part of your fire system/s is not working for whatever reason. Your insurer may require you to take specific action, for example if a detection system is faulty that you commence a dedicated fire-watch (you may want to anticipate such actions in advance – this would be good risk management in any case). If your system is impaired and you have not informed your insurer, in the event of a fire your insurance may be invalidated

You should read your property insurance policy (and any schedules and variations) carefully to ensure you are aware of conditions and requirements for testing, maintenance, impairments, certifications etc. If you are in any doubt you should contact your insurer for advice.

Tip – extract any fire system requirements and conditions from your insurance policy. Then list these, and incorporate them into your operating procedures, testing, checks and maintenance regimes. Then ask yourself: 'in the event of a fire could I prove I complied with these conditions, such as by producing records?' If you cannot, you may have a problem making a claim.

Tip – many insurers require installers and maintainers to be accredited to the 'BRE red book'. Search the internet for 'BRE red book' to access the BRE web site, which includes lists of approved installers etc. But, check with your insurer first as they may have different requirements.

Summary

Fire system engineering is a complex and technical area. For example, the NFPA document NFPA13 on sprinkler system design is more than 440 pages long. For all but the most simple fire detection, alarm and suppression/extinguishing systems competent external advice will very likely be required. Most waste management companies simply do not have the competency in-house to design sprinkler, deluge etc systems. However, be careful when selecting external advice - a local fire engineering company may not be aware of the issues associated with waste management plants and may recommend and install a 'standard' system which may not be effective at a waste management site in the case of a fire. Ultimately, you should ensure that your specific needs are assessed and that your fire detection, suppression, fighting and alarm systems are adequate to and effective for the specific risks, situation and environment of your site.

Appendix 3: Producing an accident/emergency plan

1.1 Accident/emergency plans are about how you plan for a disaster, such as a fire, and are aimed at reducing its potential effects. Potential effects could be to human health and safety, your buildings and/or plant, the environment, neighbouring premises and populations etc. All waste sites should have accident/emergency plans (often aimed at various potential disasters). Some organisations may want to go further than accident/emergency planning into disaster recovery and business continuity planning, but these topics are outside of the scope of this document. Accident/emergency plans are nearly always a requirement of environmental permits/waste management licences. Some environmental regulators have also produced guidance on emergency plans and response, and you should be familiar with any such relevant to your site.

1.2 Although you are responsible for producing the accident/emergency plan for your site, liaison with your local Fire and Rescue Service (FRS) and environmental regulator is recommended, as it will assist the FRS and environmental regulator with managing the risk in their area enabling them to respond more effectively should a fire occur.

1.3 Your insurer is also likely to be interested in your plan, in particular property damage, disaster recovery and business continuity aspects. Consider discussing your emergency plan with your insurer, who may have relevant advice to give.

1.4 The effectiveness of your plan will depend on how well you train your staff. All staff and contractors working on-site must be aware of your plan and what they must do during a fire. You should have regular exercises (drills) to test how well your plan works and that staff understand what to do. There is little point in having a good quality emergency plan if no one has read and understood it.

1.5 Your plan should be available electronically and in hard copy**.** Give careful thought to where your plan is located. Employees need to have access, but the FRS also need to have access during an emergency. Many sites place copies of their plan in an ‘emergency services information box’ (also called a premises information box) located at the site entrance or similar so that the FRS can access the plan out of hours in an emergency. In the end, it is no use having a good plan in place if it is in the burning building and cannot be accessed.

Tip – an increasing number of Fire and Rescue Services (FRS) vehicles have on-board computers. If you lodge an electronic copy of your emergency plan with your local FRS then they will be able to access your plan on the way to your site. Contact your local FRS and ask about this. In brief, a high-tech support to your premises/emergency services information box located at your site entrance.

2. Content of your plan

2.1 The content of accident/emergency plans may differ, but should at the least include:

- Communication arrangements, such as named emergency contacts, key holders, incident controllers etc with their telephone numbers and likely response time (for out of hours)
- Communications arrangements with neighbours/nearby premises which may be affected
- Hazardous and combustible materials on site, including wastes. To include locations, likely amounts, hazardous properties and other details (locations should also be marked on your site map as below)
- Specific hazards, such as gas cylinders, fuel stores etc – again mark on your site map;
- Normal number of people working on site and usual hours of work
- Fire-fighting equipment on site and where this is located, such as location of hydrants, fire extinguishers, hoses, drench systems the Fire and Rescue Services (FRS) can plug-into etc
- Location/s and detail of any fixed fire systems on site, such as sprinklers and water deluges, including locations of any external activation points for such systems
- Any other equipment on site which may be of use during a fire, such as heavy mobile plant which could be used to assist the FRS
- Any specific environmental issues, such as drainage issues for firewater, protected habitats neighbouring the site etc
- The procedures, such as evacuation, fire fighting and summoning the FRS, which employees and others on site must follow in the event of a fire. This must include the period before the FRS arrives. Outside of the normal procedures, such as how to call the FRS, these procedures should also include

    - Incident controller identification – who will be your main point of contact with the FRS and how are they identified?
    - Procedures to ensure access is clear for FRS vehicles
    - Use of pollution control equipment to block drains and/or divert firewater to a containment area and/or operate any pollution control facilities, such as drain closure valves/or penstocks
    - Processes outside of the normal, such as using soils to cover fires, removing un-burnt materials with mobile plant, re-circulating firewater to reduce run-off etc
    - Processes relating to isolation of utilities connections such as gas and electricity

2.2 If you expect your employees to fight a fire until the FRS arrives then they must be trained to do so and any fire-fighting by site employees must not be to the risk of their health and safety.

2.3 As part of your accident/emergency plan you should have a map of your site showing at least:

- Layout of buildings (externally and internally, including fire exits and other access points)
- The above should include locations of storage bunkers, fire walls and other similar features
- Location of all stored wastes (externally and internally stored), what these wastes are, how much is in each storage area typically etc, and noting any specific wastes which may pose specific hazards such as plastics and rubber wastes
- Location of your quarantine area, as applicable
- Any locations where hazardous materials are stored on site (location of gas cylinders, process areas, chemicals, stacks of combustible materials, oil and fuel tanks etc)
- Main access routes for fire engines and others and any alternative accesses
- Access points around the site perimeter to assist fire fighting
- Location of hydrants (on and off site) and water supplies, including lagoons, water tanks etc
- Location of fire extinguishers, hoses and other fire-fighting equipment on site
- Any watercourse, borehole, or well located within or near the site
- Areas of natural and unmade ground
- Location and layout of fixed plant (such as recycling plant and equipment), and where mobile plant is usually parked out of normal work hours
- Location of protective clothing and pollution control equipment and materials
- Drainage systems, including foul and surface water drains, and their direction of flow and outfall points
- Location of drain covers and any pollution control features such as drain closure valves/penstocks and firewater containment systems
- Location of utilities isolation points, such as for gas, electricity and water
- Location of any nearby sensitive receptors, such as schools, hospitals, residential, care and nursing homes etc, plus any protected habitats, water boreholes, wells and springs etc used for drinking water etc
- Location of any specifically hazardous off-site facilities, such as a gas storage yard next to your site, or another waste management site which a fire could spread to
- Location of any infrastructure which may be affected by a fire such a major roads, rail lines, overhead power lines etc (note for this and the above off-site items a separate map of a different scale may be useful)

2.4 Your plan should also detail disaster recovery measures as appropriate including:

- The removal of burnt material using appropriate and lawful disposal
- The safe re-commission of plant
- Salvage operations

2.5 Following any fire your accident/emergency plan (and overall fire management measures) should be reviewed and improved as required.

2.6 It is not the intent of this guidance to be the comprehensive guide to accident/emergency planning and you should seek competent advice as to the detail content of your plan. Guidance is also available from various sources, such as the Environment Agency (and other environmental regulators), your local FRS and the Health and Safety Executive.

Tip – involve your local FRS in the production of your plan, or at least lodge a copy with them. Inviting your local FRS to your site so that they can familiarise themselves with site access, location of fire-fighting equipment, water sources etc and include this in their own plan for the site can also be of benefit – if your local FRS is familiar with your site this could save vital minutes should you have a fire.

Appendix 4: Checklists

The checklists below are not comprehensive, but they will allow you to make an outline assessment of your fire management. If you have any specific issues relating to your site, you should consider these in addition to the below. The below may be adequate for a small site, but for larger and more complex sites greater depth is very likely to be required, although the below can be used as baseline to start from. If you answer yes to a question then you may want to add detail in the 'comments and actions' column. If you answer no to any question you should at least note in the 'comments and actions' column why you have answered no, and preferably add actions to remedy the situation.

Note – alongside each individual table heading a reference to the relevant part of this guidance is given. You should complete the checklist with reference to these relevant sections to ensure you capture and consider all the detail required.

Issue/consideration	Yes / No	Your comments and actions
Basics: Advice and consultation (sections 1.3, 1.4 and 1.6)		
Do you have access to competent advice on fire management, fire risk assessment and plans, and if so who?		
Have you searched to ensure you are aware of and have seen relevant guidance on fire management for your site?		
Are any standards set in your environmental permit / license / exemption relating to fire management?		
Have you consulted with your local Fire and Rescue Services (FRS) on your site fire management and plans?		
Have you consulted with your environmental regulator on your site fire management and plan/s?		
Have you consulted with your property and business interruption insurer on your site fire management, plan/s?		
Has the advice of your environmental regulators, FRS, insurer been included in your fire management plan/s?		

Basics: Assessments and plans (section 1.5)		
Do you have in place a fire risk assessment for your site, including identification of ignition sources and fuels?		
Does your assessment, and the plan/s based on this, include protection of human life issues (life-safety)?		
Does your assessment, and the plan/s based on this, include protection of the environment?		
Does your assessment, and the plan/s based on this, include protection of your assets, property and plant?		
From this fire risk assessment have you produced and put in place a written plan/s to control fire risk?		
Does your plan/s include physical aspects such as fire-fighting equipment and procedural such as instructions to employees?		
Does your plan/s take account of the likely fire-fighting strategy your local FRS may take should a fire occur on your site?		
Have you reviewed your plan/s to take account of your consideration and actions from this checklist?		
Have you included non-waste facilities such as site welfare facilities and offices in your plan/s?		
Have you included fuels and ignition sources outside the scope of this guidance (derv tanks, gas cylinder stores etc) in your plan/s?		
Whole site considerations: Location and neighbouring premises (section 2.2)		
Are there sensitive receptors (infrastructure, schools, hospitals, care homes, water sources etc) which could be affected by a fire?		
If yes, have you considered these in your plan/s? Does your plan/s include off-site and well as on-site risks?		
Could a fire at your site have a catastrophic effect on a neighbouring site, such as a gas storage yard etc?		

Could a fire at a neighbouring site (such as petrol stations, gas storage facilities etc) have a catastrophic effect on your site?		
If yes, have you liaised with your neighbour/s to ensure your and their plans account for this, including communication issues?		
Do you know what the likely response time for your local Fire and Rescue Services will be to attend a fire at your site?		
If your local FRS would be unable to attend your site quickly, have you accounted for this in your plans?		
Whole site considerations – general ignition sources and precautions (sections 2.3, 2.4 and 2.7)		
Have you identified all potential ignition sources/causes of fire at your site and included these in your plan/s?		
Have you included general ignition sources such as lighting, heating etc in your plan/s?		
Have you banned smoking on site and/or provided smoking areas away from combustible materials – and do you enforce this?		
Do you conduct appropriate routine testing of electrical equipment, both fixed systems and portable (PAT testing) equipment?		
Do you have adequate security arrangements (including out of hours) to reduce the risk of arson/vandalism?		
Have you considered a formal site close-down procedure to detect smoulders which may result in a fire after work has ceased?		
Do you have a housekeeping regime in place aimed at minimising litter, dusts, loose paper/fibres etc?		
Do you have appropriate storage facilities for hazardous materials such as paints, solvents, derv etc?		
Are the means of escape from buildings and from your site in adequate – do you have adequate fire escape provision?		
Have your employees been inducted on the fire precautions at your site, including emergency actions and escape?		

Have your employees been trained in the use of fire suppression equipment such as hoses and extinguishers?		
Do you include fire precautions in your site rules used with contractors, visitors, third party lorry drivers etc?		
Whole site considerations – heavy mobile plant (section 2.5)		
Do you instruct plant operators to clear combustible materials from around exhausts etc at the end of each shift?		
Is your mobile plant at least equipped with hand-held fire extinguishers?		
Is you mobile plant equipped with automatic and built-in fire extinguishing systems?		
Do you maintain your heavy mobile plant to prevent electrical faults and similar potential causes of fires?		
Do you park mobile plant away from waste storage, reception and other waste areas after use?		
Have you considered the role mobile plant can play fighting fires, such as moving wastes away to prevent fire spread?		
If yes, have you trained your employees in the use of heavy mobile plant to fight fires?		
Whole site considerations – hot works (welding, grinding, cutting etc) (section 2.6)		
Do you have appropriate controls in place to minimise the fire risks of hot work (including permit to work systems)?		
Do these include the provision of extinguishers and/or hoses at the scene of any hot work?		
Do these include an instruction that all hot works are a two-person task (one watching and one doing)?		
Do you conduct a fire watch at least 1 hour (or longer as appropriate) after hot works?		

Whole site considerations – water supplies (section 2.8)		
Have you assessed the water supply to your site relative to your potential fire risk – and is it adequate?		
Do you know where the nearest public fire hydrant to your site is – and is this in your emergency plan?		
If the nearest public hydrant is >100 metres away have you considered an on-site hydrant?		
Have you considered potential alternative water supplies such as lakes, lagoons, rivers etc in your plans?		
Have you considered the installation of on-site water tanks and mains to feed fire systems?		
If you have sprinkler, deluge etc systems in place have you gained advice to ensure your water supply is adequate to feed them?		
Have you discussed water supplies with your local FRS, and your environmental regulator?		
Whole site considerations – fire water and fire waste (section 2.9)		
Do you have a drainage plan for your site which identifies all places contaminated fire water may run to?		
Have you included the potential environmental effects of contaminated fire water run-off in your plans?		
Do you need to put in place containment systems to prevent contaminated fire water escape?		
Have you considered ways to reduce the amount of fire water which may be produced in the event of a fire?		
Have you considered in your plans how you would dispose of fire water and/or burnt materials which may remain after a fire?		
Have you consulted with your local FRS and environmental regulator on contaminated fore water issues?		

Whole site considerations – non-waste facilities (section 2.11)		
Have you included non-waste facilities (offices, welfare facilities, weighbridge cabins etc) in your plans?		
Are external waste storage stacks the distances given in appendix 1 (or otherwise protected) from offices, welfare facilities etc?		
Whole site considerations – fire appliance access (section 2.12)		
Have you assessed your site to ensure that FRS vehicles can access it easily (all access points)?		
Have you assessed your site to ensure that FRS vehicles can move around your site easily?		
Do these assessments include access widths, weight and heights of FRS fire tenders and vehicles?		
Are there any obvious issues with access to and around your site, such as overhead power lines, bridges etc?		
Whole site considerations – communications, training and drills (section 2.13)		
Are all of your employees trained in your fire plan/s and do they know what to do in the event of a fire?		
Do you test your emergency response (evacuation etc) frequently (fire drills etc)?		
Do you use toolbox talks and other communications tools to ensure your employees are aware and reminded on fire risks?		
Waste reception – hot/hazardous/flammable loads (section 3.1)		
Have you included specific issues relating to waste reception and reception areas in your plans?		
Does this include the potential for hot loads and/or hazardous materials in loads which may cause a fire?		
Have you put in place controls such as fire watch at the end of the day, not accepting high risk loads at the end of the day etc?		

Have you instructed and trained your employees to be on the look-out for hot loads and hazardous items?		
Waste reception – management (sections 3.2 and 3,3)		
Have you considered the potential for a fire to spread from your reception into other parts of your site/buildings?		
Have you considered the protection of any plant (such as shredders) located direct in your reception area/s?		
Have you considered abnormal situations in your plan/s and any additional precautions you will take in such situations?		
Have you determined the maximum safe amount of waste you can have in your reception area/s at any one time?		
Do you have a management system to ensure these maximum safe amounts are not exceeded?		
Did your consideration of maximum safe amounts in reception include any environmental permit/licence limits?		
Waste treatment/processing – general considerations and detection (section 4.1)		
Does your assessment include general plant/equipment fire risks such as direct heat and electrical and mechanical faults?		
Do you have an adequate maintenance programme in place to reduce the ignition risk posed by electrical and mechanical faults?		
Do you have housekeeping regime in place to remove dust and loose materials from motors and other potential ignition sources?		
Waste treatment/processing – specific items of equipment considerations (sections 4.2 – 4.8)		
Have you considered fitting fire suppression to shredders, bag openers etc which may pose a friction/spark risk of ignition?		
Screens and trommels can provide air to a smoulder resulting in a fire – have you considered fire suppression at screens/trommels?		

Conveyors/other mechanical handling equipment can spread a fire rapidly. Does your plant shut-down in the event of a fire detection?		
Have you considered slip-sensors on conveyors to detect potential friction and heating issues from this?		
For de-dusting systems and cyclones etc have you considered dust explosion issues?		
For de-dusting and cyclones etc have you had a DSEAR assessment completed and as required zoned such areas?		
Where de-dusting and cyclone etc have been assessed as being 'zoned' have you put in place appropriate precautions?		
Have you included specialised items of equipment, such as optical sorting systems, eddy-current devices etc, in your assessment?		
Are your mains/electrical plant rooms enclosed and appropriately constructed?		
Have you provided suitable fire detection and fighting equipment in mains/electrical plant rooms?		
Are control panels either in enclosed rooms or suitably protected from dust ingress?		
Have you included the risks posed by hydraulic systems (including fire spread should hydraulic fluid escape) in your assessment?		
Have you considered fire suppression such as sprinklers or similar at hydraulic power packs?		
For balers, are baler operative working platforms and areas out of the path of any potential 'blast' from gas cylinders etc?		
Have you considered gantry level sprinklers or similar at picking cabins above bunkers which may contain combustible wastes?		
Does your picking cabin/s have manual fire alarm points and extinguishers at the least?		
Is fire escape from your picking cabin/s easy, well-marked, lit and clearly understood by your employees?		

Waste treatment/processing – protection of plant and equipment (sections 4.9 – 4.11)		
Have you considered if a fire in waste reception or storage could spread to your plant? What have you done to protect your plant?		
Have you considered if a fire in your plant could spread to reception or storage areas? If so what have you done?		
Have you considered a formal plant close-down procedure including running the plant to clear excess wastes, at the end of the day?		
Have you considered a fire watch at the end of the day to detect any smoulders which may result in a fire?		
Waste storage (internal and external) - general considerations – capacity (section 5.2)		
Have you determined what your site's overall maximum safe waste storage capacity is?		
Have you split this into safe storage capacities for different wastes types, different storage areas etc?		
Have you included issues such as seasonal variations and marketplace variations in your considerations?		
Have you included consideration of any higher-risk wastes in your storage capacity considerations?		
Have you included any environmental permit/licence standards in your storage capacity considerations?		
Have you a management system in place to ensure that you do not exceed your maximum safe storage capacity/ies?		
Waste storage (internal and external) – use of bunkers and fire walls (section 5.3)		
Are any bunkers/fire walls you use in storage adequate in terms of the fire spread protection they provide?		
Are any bunkers/fire walls you use in storage adequate in terms of their robustness and resistance to damage?		
Do you inspect any bunkers/fire walls routinely to check for damage, cracks, holes etc which may reduce their effectiveness?		

Does your stock rotation include removing wastes from the back of bunkers etc to prevent older wastes building-up?		
Do you have procedures and rules in place to ensure wastes are not stored beyond bunker capacity (height and spill)?		
If you use bales of metals as a fire break, have you considered their effectiveness with higher-risk wastes such as plastics/rubbers?		
Waste storage (internal and external) – self-combustion and storage times (section 5.4)		
Have you considered whether the wastes you store may self-heat and pose a self-combustion risk?		
Have you set maximum storage times for wastes which may pose a self-combustion risk?		
Are the maximum storage times you have decided on in line with the times in this guidance?		
Do you have a management system to ensure wastes are not stored longer than maximum, and if they are what action you take?		
Does this management system include the rotation of stock to ensure that older stock is transported off site before newer stock?		
If you break bales or turn stacks as a control for self-heating, do you have controls in place to prevent ignition during these tasks?		
Have you considered monitoring of temperature in loose wastes stored externally, such as by using a temperature probe?		
Waste storage – external storage areas – general considerations (sections 6.2 and 6.3)		
Do you inspect your external waste stacks routinely to detect potential fire risks and ignition sources?		
Have you considered more frequent inspections during times of higher risk for vandalism etc, such as holiday periods?		
Have you considered fire detection and/or suppression/extinguishing systems at external storage stacks?		

Waste storage – external storage areas – stacks sizes and separation distances (appendix 1)		
Do you have an external storage plan which includes maximum amounts of waste to be stored in any one area?		
Do you have a management system in place to ensure maximum stack sizes and minimum separation distances are complied with?		
Have you read and understood the two options given in appendix 1 of this guidance, and decided which applies to your site?		
If you have decided options 1 given in appendix 1 of this guidance applies, why is this the case?		
If you have decided option 2 given in appendix 1 of this guidance applies, why is this the case?		
If option 1 applies, have you produced a storage plan which complies with separation distances/bunker specifications given in appendix 1?		
If option 2 applies, have you produced a storage plan which gives its own bespoke separation distances/bunker specifications?		
If option 1 applies, have you produced a storage plan which complies with stack dimension information given in appendix 1?		
If option 2 applies, have you produced a storage plan which gives its own bespoke stack dimension information?		
Does your plan (either option 1 or 2) include safe access for fire-fighting purposes?		
Does your external storage plan include all of the factors relating to layout given in appendix 1, section 6.1 of this guidance?		
Waste storage – internal storage areas – general considerations (section 7.1)		
Do you have an internal storage plan which includes maximum amounts of waste to be stored in any one area?		
Do you have a management system in place to ensure maximum storage capacity/ies are complied with?		

As part of this plan, have you considered the advantages and disadvantages of internal storage given in section 7.1?		
If you store higher-risk wastes such as plastics and rubber internally, have you considered risks and controls carefully?		
Have you sought advice (such as from your insurer) on the protection of buildings from fires in internally stored waste stacks?		
Waste storage – internal storage areas – separation distances, stack sizes and bunkers (section 7.2)		
Have you considered the separation distances/fire wall use issues in appendix 1 and applied these to your internal storage?		
Have you considered the stack size information in appendix 1 and applied this to your internal storage		
Fire detection, alarm and suppression/extinguishing systems (appendix 2)		
Have you considered fire detection, alarm and suppression/extinguishing systems at your waste reception?		
Have you considered fire detection, alarm and suppression/extinguishing systems at your waste processing area?		
Have you considered fire detection, alarm and suppression/extinguishing systems at your waste storage area/s?		
Where you fitted such systems, have you considered the design and specification issues in section 1 of appendix 2?		
Is your fire detection system reliable, robust and effective (see section 2 of appendix 2)		
Is your fire alarm system reliable, robust, clear and effective (see section 3 of appendix 2)		
Have you assessed your fire suppression/extinguishing systems against the issues in section 4 of appendix 2?		
Is your water supply adequate for your fire suppression/extinguishing systems, fire hoses etc (see section 5 of appendix 2)		

Have you considered plant control system interactions between your fire detection and plant systems?		
Has your fire suppression/extinguishing systems, site hydrants, hoses etc been commissioned to your insurer's requirements?		
Are your fire suppression/extinguishing systems, site hydrants, hoses etc tested and checked routinely to your insurer's requirements?		
Emergency/accident plan (appendix 5)		
Does your site accident/emergency plan include all of the issues listed in section 2.1 of appendix 3 of this guidance?		
Do the maps/plans accompanying your emergency plan include all of the issues listed in section 2.3 of appendix 3?		
Have you consulted on your accident/emergency plan with your local Fire and Rescue Services?		
Have you consulted on your accident/emergency plan with your environmental regulator?		
Have you consulted on your accident/emergency (and disaster recovery) plan with your insurer?		
Have you trained-out your accident/emergency plan to all of your employees – are they clear what to do in an emergency?		
Is a copy of your emergency plan posted in an obvious (and secure) location at your site entrance?		
Have you provided a copy of your accident/emergency plan to your local Fire and Rescue Services?		
Do you review your accident/emergency plan at least once a year to ensure it is up to date?		

Appendix 5: Useful links and further reading

The list below is not comprehensive, but does provide an overview of useful documents you may wish to consider. Other guidance is available – you should ask your competent advisor.

Health and Safety Executive, fire and explosion pages:
http://www.hse.gov.uk/fireandexplosion/index.htm

Gov.uk, How to comply with your environmental permit:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298102/LIT_7123_79744e.pdf

Environment Agency – Fire Prevention Plans: Environmental permits:
https://www.gov.uk/government/publications/fire-prevention-plans-environmental-permits

Contact details for your local fire and rescue service: http://www.fireservice.co.uk/information/ukfrs

Advice on fire risk assessment for factories and warehouses:
https://www.gov.uk/government/publications/fire-safety-risk-assessment-factories-and-warehouses

Other guidance on fire risk assessment: https://www.gov.uk/government/collections/fire-safety-law-and-guidance-documents-for-business

WISH (Waste Industry Safety and Health) Forum guidance: www.wishforum.org.uk

Environmental Services Association DSEAR guidance: http://www.esauk.org/esa_reports/index.html

For the full Regulatory Reform (Fire Safety) Order 2005:
http://www.legislation.gov.uk/uksi/2005/1541/contents/made

Spontaneous heating of piled tyre shred and rubber crumb – HSE:
http://www.hse.gov.uk/rubber/spontaneous.htm. FM (Factory Mutual) technical note 8-3 also includes information on tyre storage fire hazards.

SFPE Handbook 3rd Edition - Ch 2 Conduction of heat in solids - National Fire Protection Association – SBN: 0877654514

CIRIA Report C736, 2014 Containment systems for the prevention of pollution:
http://www.ciria.org/Resources/Free_publications/c736.aspx

Environmental Protection Handbook for the Fire and Rescue Service:
http://www.ukfrs.com/pages/research.aspx

Technical insurance standards under the FM Global Data Sheets are available as free downloads at: www.fmglobaldatasheets.com. However, please note that many of these are not waste specific, and the data in them may not be directly applicable. But, they may provide good general information.

Appendix 6: Glossary

Accident/emergency Plan	Part of a written management system that includes an assessment of fire risk on the site and what measures are in place to prevent, detect, suppress, mitigate and contain fire. Note – this is a term used in environmental permits/waste management licences. Other terms, such as emergency plan, fire plan etc, may be used in other regulator aspects. While outside of this guidance, you may also want to consider disaster recovery and business continuity planning
Brands/embers	Small items of material which are on fire, or smouldering which may blow or otherwise travel between stacks and similar and spread fire
Bund	A type of secondary containment. Usually an impermeable construction designed to hold polluting substances that leak, are spilt or run-off from a storage area
Combustible materials	In the context of this document, solid materials that can ignite and burn, such as textiles, wood and paper
Competent advice	Competent advice on fire safety and its technical aspects is critical to good fire control management. Competent advice sources may include: • In-house health and safety specialists – provided that they have sufficient knowledge and experience of fire management and the standards applied • Your local Fire and Rescue Services (FRS). Please note that your local FRS may be best being consulted after you have produced draft management processes, design of site etc • Regulators such as the Environment Agency, Scottish Environment Protection Agency and NRW (the Health and Safety Executive, but only for specific fire issues such as DSEAR). Please note that while such regulators can provide advice this is not their primary role • Insurers – your insurance company may have internal fire management specialists who you can call on at no or lower cost than going to an external consultant • External consultants – suitably competent external consultants. Please ensure that these are experienced and knowledgeable about fire management and standards Note – different stakeholders, such as insurers and regulators, may have different priorities and you may need to consult with more than one type competent advice to gain a full picture
Controlled burn	An operational fire-fighting strategy where the application of fire fighting media such as water or foam is restricted or avoided, to minimise damage to public health and the environment
Exemption	Low risk waste handling operations that don't require a permit or licence. Most exemptions need to be registered with the EA/SEPA

Protected habitat	Examples include: Site of Special Scientific Interest (SSSI), Area of Special Scientific Interest (ASSI), Special Area of Conservation (SAC), Special Protected Area (SPA), National Nature Reserve, Sites of international conservation importance – Ramsar site, Area of Outstanding Natural Beauty (AONB), National Scenic Area
Hazardous substances	Materials that can harm human health and/or damage the environment
Hazardous/Special Waste	Wastes, specified in the European Waste Catalogue, that may be harmful to human health or the environment
Permit/waste management licence	A document issued by your environmental regulator that controls the environmental impact of your business activities. It has conditions which you must follow to prevent your business harming the environment or human health
Firewater run-off	Water that has been used to fight a fire, likely to be contaminated with the products of combustion and un-burnt materials that are washed off the site
Fire Risk Assessment	A structured and systematic examination of the premises/site/buildings etc to identify the hazards from fire. Once identified, a hazard is significant, identify who and/or what is at risk and whether the existing fire precautions are adequate so that the risk associated with the hazard is acceptably low. If the existing fire precautions are not adequate you must take additional action to minimise the risk either by removing or reducing the hazard or by providing adequate control measures
Flammable material	Materials that ignite easily and burn rapidly with a flame. Liquids and articles are usually defined as flammable if they possess a flash point of 60°C or lower
Flashpoint	The lowest temperature at which a liquid produces enough vapour to form an ignitable mixture in air
Foul sewer	Sewers or pipes that collect foul water (sewage and trade effluent) and convey it to a sewage treatment facility. They can be owned privately or by the local sewage treatment provider
Groundwater	Water that is below the surface of the ground in the saturation zone, and in direct contact with the ground or subsoil. The saturation zone is where all the cracks in the rock and all the spaces between the grains of rock and within the soil are filled with water
Penstock/shut-off valve	A sluice or gate valve fitted in a sewer or drain that can be closed automatically or manually to contain spillages or firewater
RDF/SRF	Refuse derived fuel/solid recovered fuel (various types of fuel derived from wastes using various treatment processes)

Secondary containment	A structure such as a bund that surrounds a storage area, designed to contain pollutants in the event of a fire or spillage
Sensitive receptor	Human receptors include hospitals, nursing homes, schools, residential areas, places of work, transport networks. Environmental receptors include source protection zones, surface waters, potable abstractions, groundwater, protected habitats, fisheries
Stack	A pile of solid combustible materials. Any spaces within it will not allow free passage, or exceed one metre in width at their narrowest point
Surface water drain/sewer	Sewer or pipes that collect uncontaminated surface water only, from buildings, roads and yards, which usually discharges directly into rivers, the sea or groundwater
Spontaneous combustion	Combustion which occurs without an external heat or ignition source being applied
Tertiary Containment	A device or structure such as a firewater lagoon, that provides additional containment should secondary containment fail