GUIDANCE DOCUMENT

MGD 006 ISSUE 1.0

Percussive Events Guidance

For Installers, Certification Bodies and Manufacturers

This document was funded by the MCS Charitable Foundation.

It is published by The MCS Service Company Ltd.

The MCS Service Company Ltd welcomes comments of a technical or editorial nature and these should be sent to *meetings@mcscertified.com*

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ABOUT MCS

Giving you confidence in home-grown energy

With energy costs constantly rising and climate change affecting us all, low-carbon technology has a bigger and bigger role to play in the future of UK energy.

We're here to ensure it's a positive one.

Working with industry we define, maintain and improve quality – certifying products and installers so people can have confidence in the low-carbon technology they invest in. From solar and wind, to heat pumps, biomass and battery storage, we want to inspire a new generation of home-grown energy, fit for the needs of every UK home and community.

About

The Microgeneration Certification Scheme Service Company Ltd (MCSSCo Ltd) trades as MCS and is wholly owned by the non-profit MCS Charitable Foundation. Since 2007, MCS has become the recognised Standard for UK products and their installation in the small-scale renewables sector.

We create and maintain standards that allow for the certification of products, installers and their installations. Associated with these standards is the certification scheme, run on behalf of MCS by Certification Bodies who hold UKAS accreditation to ISO 17065.

MCS certifies low-carbon products and installations used to produce electricity and heat from renewable sources. It is a mark of quality. Membership of MCS demonstrates adherence to these recognised industry standards; highlighting quality, competency and compliance.

Vision

To see MCS certified products and installations in every UK home and community.

Mission

To give people confidence in low-carbon energy technology by defining, maintaining and improving quality.

Values

1. We are expert – ensuring quality through robust technical knowledge
2. We are inspiring – helping to reshape energy in UK homes and communities
3. We are collaborative – working with industry and government to create positive change
4. We are principled – operating in a way that's clear, open and fair
5. We are determined – supporting the UK's drive towards a clean energy future

FOREWORD

Explosions in biomass fired appliances are well-known and the risk has been identified in relevant design standards and operating guides for many years. However, continued incidents with solid fuel biomass appliances show that users, installers, and Manufacturers do not fully understand the risk of explosions.

Fireside explosions of combustion gases remain one of the most significant hazards when operating a biomass boiler. The fact that these incidents occur at all scales from small sized pellet boilers right up to large steam biomass units shows that there is an awareness gap that needs to be filled.

This guidance document is based on review of information available on fire-side explosions, how they occur, and the risks associated with them. It was found that general guidance concerning the safety of biomass boilers was only available in a small number of design and safety guides (1) (2), and specific guidance on avoiding fireside explosions is limited.

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1 SCOPE

In this work, fire-side explosions in biomass appliances specifically refers to delayed overbed ignition of a flammable atmosphere. Other events such as dust explosions are out of the scope of this document. The range of appliances that are covered by this work is between 4 kW and 4,000 kW and although this range of small and large installations is wider than the scope of MCS Standards, the guidance is still applicable. Smaller installations (usually domestic <45kW) and larger commercial installations will have different design, installation, and maintenance however, the risks of fireside explosions and mitigation is often the same. The guidance is predominantly for use with new appliances or installations. It can also be used by to assess whether existing systems are at risk.

2 OBJECTIVES

The objective of this work is to provide guidance to stakeholders, to reduce the occurrence of explosions. In particular, Manufacturers, MCS Contractors, and Certification Bodies need to be aware of the risks of explosions, how they occur and what can be done to mitigate the risks. The areas where guidance could help are shown in Table 1 for each party.

Table 1: Areas identified as requiring guidance

Area	Manufacturers	MCS Contractor	Certification Bodies
Stakeholder role in minimising risk	✓	✓	✓
Risk identification and assessment	✓		
Nature of the risk	✓	✓	✓
Approaches to risk removal, reduction, mitigation	✓	✓	✓
Briefing end users on the risks	✓	✓	
Actions after an explosion being reported	✓	✓	
Evidence required by Certification Bodies	✓		
System / installation design		✓	
Maintenance		✓	
Information needed from Manufacturers			✓
Framework for assessing risk assessments			✓

3 GUIDANCE FOR MCS CONTRACTORS

Incidents of fireside explosions have occurred involving biomass appliances. An MCS Contractor can influence key phases of an appliances lifespan which impact the occurrence of fireside explosions. In the past problems with installation, commissioning and maintenance of biomass appliances has been shown to result in fireside explosions. Getting these three phases completed correctly positively influence the risk of fireside explosions. MIS 3004 (3) is the principal standard covering work undertaken on solid fuel biomass appliances and defines good practice and competencies needed when working on solid fuel biomass systems.

The aim of this guidance document is to advise MCS Contractors who are certificated to MIS 3004 on the risk of explosions in biomass appliances and to provide further information on how they can reduce the risk of explosive incidents in biomass appliances. This guidance is solely aimed at fireside explosions of combustion gasses and is not intended to cover any other risks associated work on biomass appliances.

3.1 APPLIANCE INSTALLATIONS AND DESIGN

The requirements of MIS 3004 ensure that the MCS Contractor "must be competent to review and verify that the design in regard to safety and applicable regulations meets the design requirements set out in this Microgeneration Installation Standard". The MCS Contractor must therefore have a thorough understanding of the appliance and the system to review the installation prior to undertaking work. Considering the appliance Manufacturers requirements and recommendations as well as the relevant risks is an important part of this review. The MCS Contractor must ensure that in installing the appliance, it does not violate the Manufacturer's installation requirements or place it into a system that it is not designed for. Installing biomass appliances which go against the requirements of the Manufacturer's instructions can potentially lead to very serious consequences. Minimum clearances, system requirements and additional safety equipment listed as minimum requirements by the Manufacturer should always be included in the installation to ensure appliance safety.

3.2 COMMISSIONING

Commissioning has an important role in ensuring the safety of biomass systems prior to their operating life. MIS 3004 requires "All personnel engaged in commissioning must have a comprehensive technical knowledge of the appliance interfacing services and structures to complete the specified processes". When completed correctly commissioning will identify any installation errors or defects with the appliance which may have potentially led to dangerous situations. The risk of explosive incidents is greatly reduced if the commissioning is completed thoroughly before the handover to the end user. Commissioning notes on fuel type, control setpoints and any other adjustments made should be recorded and kept with the appliance documents. Appliances with these commissioning notes can be reset back to safe operation if

set points are lost or unauthorised changes have been made. Commissioning directions from the Manufacturer may not cover all risks of fireside explosions and therefore the person undertaking the work must consider further risks of the work they are undertaking ensure that the appliance is never left in a situation where a dangerous situation may occur.

MIS 3004 covers handover to the user after installation is complete. This is an important part of ensuring that the user receives all documentation for the appliance and that they have the information required for safe operation after the MCS Contractor leaves site. The handover in MIS 3004 contains instructions on operation and documentation / registration requirements. The handover should go further than the minimum set out in MIS 3004 and should also always include a face to face end user training for the appliance. This training is vital to the safe operation of biomass appliances and will already be included by most MCS Contractors ensuring end users operate the appliance correctly and safely. During the handover the end user must be fully educated on the mechanisms of how the biomass appliance works, how biomass combustion differs from other technologies and the specific risks of fireside explosions. This should also include detailed information on the maintenance requirements of the appliance and education of the risk associated with poor maintenance as well as how to identify poor performance or malfunctions from the appliance. The appliance should never be left operating before the owner and/or operator handover has been completed. Explosions in biomass appliances have occurred where Contractors have left appliances running after commissioning without being present.

3.3 MAINTENANCE

Commissioning and maintenance records should be kept with the appliance and the maintenance or service engineers should always refer to them before undertaking work to ensure any issues are identified and that any tasks undertaken follow the Manufacturer's instructions and recommended maintenance intervals

Best practice should always be followed when maintaining an appliance and any work undertaken should always be recorded in the appliance maintenance log. The MCS Contractor should create one if none exists. It is an absolute requirement that if any changes other than maintenance are made to an installation, that an appliance logbook is created and maintained on site where it can be referenced. This should contain a record of all changes to the installation. It is unacceptable for service engineers to remove such logbooks or maintenance logs for commercial advantage.

Maintenance on appliances with no record of previous maintenance work should be considered carefully to ensure that no failure or fault is likely which could cause dangerous situations to occur inside the appliance. A failure of the combustion management in the appliance is likely to create a risk of explosive gasses building up in the appliance. Sensors for managing air ratios and flame detection are therefore of high importance for fireside explosions and should be visibly checked for faults. Where no records exist, assessing the maintenance requirements can be difficult, especially if the boiler has been abused, has developed a fault

and/or the original Manufacturer is no longer operational. Due to the small number of biomass boilers, their diversity and the high number of settings compared to most oil or gas burners, service engineers should not tackle repairs beyond their knowledge and if in doubt get another opinion on the work required.

3.4 REPORTING AN INCIDENT

If an incident occurs where an explosion has damaged an appliance it is important to inform Manufacturers of the incident so that they can investigate the incident and make note of the cause of the explosion. There are many incidents that are never reported to Manufacturers and without this information they are not able to ensure that the incident does not occur again. The fist point of contact by a site after an incident is often the MCS Contractor or maintenance engineer and, for minor incidents this is often as far as the information is reported. If the Manufacturer is never informed of the incident or the cause of the explosion, then they are not aware that there may be an issue. Reporting the problem to the Manufacturer will ensure that biomass appliances are continually improved reducing the risk of explosive events occurring. Information on how to contact Manufacturers can be found in the Manufacturer's instructions for the appliance.

4 GUIDANCE FOR CERTIFICATION BODIES

MCS certification for biomass appliances is an ongoing independent, third party assessment and approval of companies producing appliances. The MCS Mark indicates that these products meet the requirements stated in the relevant standards. The end user may interpret this as confirming the all-round safety of these products. The MCS Scheme also provides certification for MCS Contractors ensuring that they adhere to the MCS installation standards. The MCS Mark indicates that these installers meet the requirements of the MCS Standards, and the end user may interpret this as confirming the all-round safety of the MCS Contractors' work.

Incidents of fireside explosions have occurred even when both the product and Contractor were certified in accordance with the relevant MCS Standards. The occurrence of incidents has shown that compliance with relevant standards used in MCS 008 and adherence to MIS 3004 completely remove the risk of fireside explosions from occurring. This guidance sets out what MCS Certification Bodies (CB) should consider when assessing MCS applications for certification of biomass appliances and installers, to ensure that this type of risk has been appropriately addressed.

4.1 PRODUCT CERTIFICATION - MANUFACTURER RISK ASSESSMENTS

The work that produced this guidance looked at how guidance can be used to reduce fireside explosions by targeting identified parties with guidance. Manufacturers guidance has also been produced alongside this guidance which is relevant to Certification Bodies as it details how fireside explosions of combustion gasses can occur and what can be done to prevent them.

The Manufacturers guidance places importance on risk assessments for reducing the risk of fireside explosions which is particularly relevant to CBs when assessing MCS installations. MCS 008 relies on the requirements within published standards and does not set additional requirements specific risk assessments. However, it is reasonable to expect that Manufacturers should be aware of this risk and to have assessed it with regards to the design and control of their products.

The Manufacturers guidance strongly signposts inclusion in their product risk assessment of a full consideration of the risk of fireside explosions, to act on the risk assessment to remove the risks and to document the risk assessment so that it can be evidenced on request. This requirement will often require a Manufacturer to go beyond the requirements of the relevant design standards and it is important that they do so to ensure the risk of explosions is eliminated in the appliance.

ASSESSING MANUFACTURER RISK ASSESSMENTS

Assessing Manufacturer risk assessments can be difficult especially when they fall outside of the requirements of a standard. It is not the role of the CB to fully

approve the risk assessment however to satisfy the needs of the MCS Scheme there needs to be some assessment that the risks of fireside explosions have been considered. To accomplish this, it is suggested that CBs follow the format below for interactions with the Manufacturer. Three simple key questions that will give you an indication that the fireside explosion risk has been considered:

1. Are you aware of this type of risk for biomass appliances?
2. Have you included it in your product risk assessment?
3. If so, what were the findings, and have you acted on them?

The Manufacturer should be able to provide you with a satisfactory answer to each question which gives confidence that the risk has been considered and mitigated against.

The design standards covered by biomass MCS certification may not require the Manufacturer to undertake a risk assessment for fireside explosions in their product as not all standards have this as a requirement. This is changing slowly and as biomass standards are updated, they are moving to include more risk assessment activities. MCS Certification Bodies can still request evidence from the Manufacturers that a risk assessment has been carried out even if not required in the standards. If not satisfied that the product has been properly risk assessed and is safe, then the certification can be held until evidence is presented that the risks have been correctly assessed.

In cases where a risk assessment has been produced the risk of fireside explosions should be assessed for fullness and correctness. Manufacturers should check that the control and management of combustion and the combustion gasses in the appliance has been specifically risk assessed for fireside explosions by the Manufacturer. The Manufacturer should be able to detail relevant aspects of appliance operating modes in both normal and abnormal operating conditions and the steps they have taken to mitigate the risk of fireside explosions during these operating modes.

Where there are known issues with a type of appliance it is important that when assessing the product that the risk must have been addressed by the Manufacturer. Issues can also be identified by CBs during FPC assessments by examination of the Manufacturer's complaints log. This will help to ensure that the industry is learning from these incidents and improvements are being made by all Manufacturers to remove the risk.

4.2 MCS CONTRACTOR CERTIFICATION – TRAINING AND AWARENESS

MCS Contractor guidance has been produced as part of this work in which three phases of Contractor interaction with an appliance identified (installation, commissioning, and maintenance) where MCS Contractors have the opportunity to reduce the risk of a fireside explosions occurring.

For CBs certifying the training of MCS Contractors for certification in the MCS Scheme the MCS Contractor guidance section is particularly relevant. It highlights areas where MIS 3004 could go further in ensuring that installers take every opportunity to reduce incidents of fireside explosions. For CBs to certify the training they need to ensure that the training centres and installers understand the risks of fireside explosions, how they occur and the steps that will mitigate them. CBs should therefore ask what training installers are given that specifically address fireside explosions and whether the installer would be able to follow the best practice during installation, commissioning, and maintenance. It is important that all three are covered as they all play a part in reducing the risk of fireside explosions.

5 GUIDANCE FOR MANUFACTURERS

Incidents involving appliances that have been tested and certified show that, despite following available guidance and design standards, incidents can still occur. The number of recent instances of fire-side explosions in biomass appliances has shown that more can be done to ensure prevention.

The aim of this section of the guidance is to improve Manufacturer risk analysis of biomass appliances and provide information on approaches to risk reduction and removal. This guidance specifically addresses the risk of explosions and therefore does not offer guidance on the other risks related to biomass appliance design and operation.

5.1 RISK ANALYSIS

Fireside explosion is a serious hazard which should be considered when designing a biomass appliance. The risk of serious damage to the appliance and to people is high and explosions therefore need to be considered very carefully during the design process. It is not possible to design biomass appliances to be inherently safe from explosions as the requirement for a hot fuel bed will always remain, therefore the risk of explosions must be mitigated using all the tools available to the Manufacturer.

The explosive hazards should be addressed by Manufacturers during a risk assessment for all potential hazards in biomass appliances. There are a number of relevant design standards including those mentioned in MCS 008 (Microgeneration Certification Scheme - Product Certification Scheme Requirements - MCS 008 Issue 1.3) for solid fuel biomass appliances which do not detail the risks of explosions and do not require a risk assessment to be undertaken. Consumer protection laws (4) do require Manufacturers to ensure their products are safe and would reasonably require a Manufacturer to assess the risk of explosive hazards. Design standard EN 303-5 (5) has the most detail on the risks of explosions and includes the requirement to undertake a risk assessment for explosions in biomass appliances.

"The Manufacturer shall undertake a risk assessment covering all potential hazards of the boiler and the measures how to avoid or control them in a safety concept."

EN 303-5 for biomass appliances requires that potential hazards are to be avoided and controlled by either constructional means or the use of safety devices. The potential explosive hazard is not highlighted in EN 303-5 as being of greater importance than other potential hazards, however as there are specific examples of explosive risks given in the standard whereas other risks are not.

Even with the requirements for a risk assessment as set out in the standard, explosive incidents still occur caused by risks which were not foreseen by the Manufacturer. Without identifying these circumstances during the risk assessment, the risk of explosions was not correctly assessed and therefore the risk was not removed or mitigated against.

The ISO-12100 (6) standard on risk assessment and risk reduction is specified in EN303-5 as the document on which to base biomass appliance risk assessments. ISO-12100 is a general standard on risk assessments for machinery and is not specific to biomass appliances however, it is useful for understanding the steps required to complete a full risk assessment required for the safe design of solid fuel biomass appliances. Below are the key steps for completing a risk assessment on a solid fuel appliance.

1) Determine the limits of the appliance
2) Identify the hazards and the potential of the hazards occurring
3) Estimate the risk for the hazard and hazardous situation

5.2 DETERMINE THE LIMITS

Determining the limits of the appliance is an important first step in the risk assessment. It sets the limitations of the appliance which, if exceeded, increase the risk of explosion incidents. A list of relevant areas to consider limitations for are:

- Fuel specification and reasonably foreseeable misuse (moisture content, fines, etc.)
- Operator/service engineer training and knowledge and required interventions and operations.
- Intended use and reasonably foreseeable misuse.
- Limitations of operating modes (start-up, shutdown, slumber modes etc.)
- In use non-ideal operating regimes (cycling, modulation, etc.)
- Failure modes

It is important to understand the limitations of the boiler not only in its optimal designed use but also in foreseeable real-world misuse of the boiler. This is an important consideration as boiler operations that are not designed or intended to repeatedly occur, or which happen out of sequence have been known cause explosive ignitions.

Delayed ignition of a cold boiler

In most biomass appliance start-up procedures, the biomass material is heated until it reaches its ignition temperature. Flammable gases are produced as the fuel is heated. Normally this is not a problem; the biomass ignites, and the boiler can then be brought up to operating temperature in a controlled manner. However, the following steps have been observed, leading to problems and delayed ignition:

1. Fuel is added to (or is already within) the combustion chamber and the boiler fails to light.
2. Fuel in the boiler remains hot and more fuel is added but the fuel still does not light.
3. The hot centre of the fuel smoulders, giving off CO, H_2 and CH_4.
4. These gases mix with air and fill the combustion chamber above the smouldering fire-bed.

5. Eventually a flame breaks through from the fuel and the gases ignite explosively.

For automatic appliances extra fuel can be loaded onto the bed after each failed ignition and the problem is exacerbated. Anecdotally, these delayed ignitions have been observed when the boiler is being brought back on-line following a service. This is probably due to fuel feed systems being partially empty during the first or second attempts to ignite.

5.3 HAZARD IDENTIFICATION

In biomass appliances, fire-side explosions are the result of the formation and accumulation of flammable gases above the fire bed. Pyrolysis and gasification are the mechanisms which produce explosive gas mixtures. To identify all the instances where explosive ignitions could occur, periods where flammable gases may be formed need to be identified.

Combustion design

Pyrolysis is the thermal degradation of material in the absence of oxygen.

Gasification is the thermal degradation of material in limited oxygen. They both occur in reducing atmospheres where there is not enough oxygen for complete combustion. The high volatile content of biomass produces a mixture of gases from pyrolysis and gasification including carbon monoxide (CO), methane (CH_4) and hydrogen (H_2).

Combustion occurs in oxidising atmospheres where there is enough oxygen for complete combustion of the fuel. As biomass material enters the combustion chamber it is dried and heated releasing moisture and the volatile content of the fuel. Primary air is controlled at a rate which is less than the stoichiometric requirement for complete combustion allowing pyrolysis and gasification to occur. Secondary air is fed above the fuel bed, resulting in an oxidising environment in this region where combustion is completed.

Accumulations of flammable gases will only occur if the air is not supplied at the required rate for complete combustion. In these circumstances, pyrolysis / gasification will dominate. Biomass appliances must therefore always be managed so as not to allow pyrolysis / gasification to occur without combustion or the removal of explosive gases. Identifying periods where pyrolysis / gasification will dominate is therefore the key to removing the risk of explosions in biomass appliances.

The accumulation of flammable gases often occurs when there has been a change of conditions in the fuel bed, for example during non-steady state (start up, shutdown or changes in load).

Appliance operations are any tasks the boiler completes during use. Includes but not limited to start-up, shut-down, emergency operations, run modes, modulating modes, slumber modes, fast ignition modes, and any other operation from the boiler.

Appliance functions these are individual functions that the boiler must complete as part of running its operations. Includes but not limited to flame supervision, O_2 monitoring, primary air control, secondary air control, fuel supply, flue gas removal, temperature monitoring, and any other function required by the boiler.

To ensure that all circumstances leading to explosive atmospheres are identified, analysis of all the appliance operations is required. The individual functions that the boiler needs to undertake while completing these operations also need to be listed. Considering each operation should help Manufacturers identify the different instances which would lead to pyrolysis and gasification dominating reactions in the fuel bed. This will force the risk analysis to consider operation at non-steady states. Poor boiler behaviour should also be considered such as boiler cycling due to low load.

Explosion following rapid cycling

This explosion type occurs when biomass appliances don't supply enough air (oxygen) to burn all the fuel during shut down, leaving smouldering fuel in the combustion chamber. Typically, the shutdown process in biomass boilers is well managed to allow the remaining fuel in the fuel bed to be fully burnt out and cooled down so that further pyrolysis and gasification does not take place.

Situations have occurred where the boiler and refractory material are hot when there has been a demand call. Fuel has been charged to the grate and then the demand has been quickly satisfied. The shutdown operation does not manage the excess fuel in a controlled manner and the boiler is now very hot and filled with biomass that will continue to smoulder producing flammable gases which accumulate in the boiler. If, due to a poor control system or system malfunction, combustion air is introduced too quickly, there is the potential for this gas mixture to explode if there is a local ignition source (e.g. flame breakthrough).

This scenario can also potentially occur if power fails during operation of the boiler. If the natural draught in the flue system is not enough to remove the products of pyrolysis from the smouldering fuel, an explosive atmosphere can develop. During restart, the boiler can then introduce air into the boiler causing an explosion.

It is essential that the risk analysis conducted by the Manufacturer is not limited to the minimum requirements. Any operation that influences the combustion taking place in the fuel bed should be fully risk assessed for explosions.

The way that people interact with the appliance, and the tasks required are important factors to consider. The impact of foreseeable operator interventions such as opening of doors or ports

on the boiler should also be assessed. The actions of the operator do need to be included if it is foreseeable that they may cause hazardous situations.

Therefore, reasonable misuse of the boiler by the operator (such as forced start-up after a failed ignition) should be included. Operations and functions which need to follow in sequence should also be identified and risk assessed for opportunities where controls may allow these to occur in an unexpected sequence. The boiler will need to be assessed for operation outside of ideal operating conditions as transitions to poor operating behaviour can occur quickly even in well designed and maintained systems.

Explosion following output modulation

Explosions in biomass appliances have been attributed to a reduction in the load on the boiler. Modulation is a common control strategy in biomass boilers, when the load on the boiler is reduced, the boiler is then able to limit its output to match the load. If the reduction in appliance output is not controlled correctly, then gasification can occur when the air supplied is insufficient for complete combustion. This happens when the air settings are changed too quickly and do not match the actual quantity of fuel in the bed. Modulation directly following a start up where the bed is fully charged with fuel is one such situation where a control system may struggle to correctly match the air requirements in the fuel bed.

Slumber mode in boilers is a control strategy which allows quick ignition by keeping a small amount of fuel burning. If not managed correctly, fuel is unintentionally kept smouldering inside the boiler forming explosive gases which ignite on restart of the boiler.

Meeting the minimum requirements does not show that the risk assessment has considered all hazards and will not demonstrate the completeness of the assessment. Recent explosions in boilers that have met these minimum requirements clearly shows that they do not completely remove the risk of explosions occurring.

5.4 ASSESSMENT OF RISK

Once the circumstances in which explosions could potentially occur have been identified, the next step is an assessment of the risk. The risk is a measurement of the likelihood or probability of occurrence of an incident combined with the severity of harm. The severity of harm needs to be at the forefront of thinking when considering the risk of fireside explosions. Although the likelihood of an incident is low, the severity of harm to life is often high. The severity of harm can also require the type of explosion likely to occur to be assessed. There are two types fireside explosions which are known to occur in biomass appliances smoke explosions and flash fire, both cause significant damage to appliances and buildings but the risks to the operator can vary.

Types of biomass explosions

There are two types of explosions that are known to take place in biomass boilers, smoke explosions and flash fires. Both types are similar in that they are extremely dangerous occurrences in biomass operation and have been known to cause serious damage to both boilers and the surrounding area.

Smoke explosions occur when the mixture of flammable gases and oxygen form an explosive mixture inside the appliance. Ignition of the explosive mixture causes an explosion inside the appliance. This can be very destructive to boilers, flues and fuel feed systems as it is often in an unvented explosion which causes very high internal pressures to be generated.

Flash fire occurs when the explosive gases are rapidly mixed with incoming air, often through the opening of a door or access port. The sudden introduction of oxygen dilutes the gases in the boiler and begins combustion causing a rapid expansion of gases. Combustible gases are then forced out of the opening, creating a fireball into the space occupied by the operator with destructive effects.

The explosion does not always occur inside the boiler where the gases are produced, build ups inside flues and in fuel storage have been known to ignite as gases leak from the main combustion chamber to other areas of the boiler.

Consideration should also be given to the extent of any flammable gas cloud. Boilers are often able to withstand significant overpressure, however other parts of the boiler such as flue systems are not designed for any significant overpressure. If a flue has also filled with flammable gas large explosions can and have arisen in the past where flue components such as clean-out doors are propelled at high speed across boiler houses causing injury and secondary damage.

5.5 APPROACH TO RISK REDUCTION AND REMOVAL

With the potential harm to both people and buildings being high it is therefore not acceptable that explosions should occur. Any specific risks identified during the risk analysis that are not tolerable and where mitigation methods can be implemented would be reasonably expected to be implemented unless the probability of occurrence is extremely low. The Manufacturer will therefore need to assess probabilities for each risk identified.

The unacceptability of explosions will often require a risk removal strategy to remove or mitigate the risks that could lead to explosions. All potential causes of explosions identified therefore need to be fully understood by the Manufacturer. Design changes and controls are often the best way to mitigate and remove the risk, but other methods can be used successfully. If all the risks have been identified, then completing the risk removal strategy will ensure that the build-up of explosive gases does not occur in the biomass appliance.

There are three measures that Manufacturers can choose from when mitigating the risk in biomass appliances.

Firstly, design measures which remove a risk entirely or reduce it through changes to the boiler, such as new or improved features or even the removal of design flaws which introduced risk. This includes both the physical appliance design and controls and is the preferred method of risk reduction as it removes or mitigates the risk. Care is needed that measures introduced do not introduce new risk.

Design Strategies

There are two design strategies which can be utilised to remove the risk of flammable gas build-up:

1) Reduce to an absolute minimum the periods where biomass fuel may be able to pyrolyse or gasify in the fuel bed without the corresponding combustion of the gases
2) Ensure that the appliance purges the combustion chamber and flue system to ensure that accumulations do not occur

There are two further strategies which reduce the risk of explosions by reducing the harm caused and the probability that they occur. They may be considered but are not acceptable on their own as they are not capable of reducing risk to acceptable levels.

1) Strengthening of appliances and flue systems to withstand explosions
2) Removal of ignition sources from the boiler to prevent gas mixtures igniting

Secondly, protective measures are used when the risk cannot be removed. In explosions this will be the secondary method of risk reduction where the boiler and boiler operator are protected from harm. This includes locks on boiler doors to prevent them from being opened during operation or covers on sight glasses to prevent them causing damage if an ignition occurs.

Finally, Information for use measures and checks which ensure that risks are not introduced through the installation and operation of the appliance. This information should cover installation and operation of the boiler setting out clearly the requirements to ensure safe use of the appliance. This should cover reasonable misuse of the boiler for example misfuelling or inadequate maintenance. It is recommended that where possible Manufacturers only supply their products to distributed to approved, product specific trained installers. Or in the absence of that, commissioned by the Manufacturer/approved distributor to recognise a safe and compliant installation. This ensures that the end user is protected. Information for use measures and checks should not however be used to mitigate risk where design changes could have been applied. For example, it is not acceptable to exclude or include actions which are reasonably foreseeable such as the operator opening a door or hatch during operation or requiring them to check the fuel bed between ignitions.

The focus of this section has been around ensuring dangerous situations do not occur in biomass appliances. A final note should be that if a failure in the boiler has occurred and there is the potential for a dangerous gas build up the boiler will fail safely and ensure that it cannot operate until the gas build-up has dispersed.

5.6 INFORMATION REQUIRED BY CERTIFICATION BODIES

For MCS Certification Bodies (CBs) to provide certification to an appliance they need to be satisfied that the product is safe during operation. Usually a certification body will only assess a risk assessment if the appropriate standard requires it. As a part of this work on explosions in biomass boilers, a separate guidance document for CBs will be produced to highlight the issue of explosions in biomass boilers and the role of appliance risk assessments in mitigating this risk. An update of the MCS Scheme guidance will be that they need to check that Manufacturers have assessed their designs for this type of risk, what they found and what they did about it and that the Scheme would not expect certification to be awarded if the issue has been ignored. Therefore, regardless of the requirements of an appropriate standard, CBs may request evidence of a risk assessment if appropriate so that they can be satisfied that the risk of explosions had been assessed and will be safe during operation.

Where standards require a risk assessment (current EN 303-5 standard), a CB is required to check the risk assessment carried out by the Manufacturer to assess that the Manufacturer has addressed the risks during operation of their appliance.

Completeness, correctness, and plausibility of the risk analysis by the Manufacturer is verified by the third party

The EN 303-5 standard assists CBs by giving examples of a number of common tasks appliances undertake and common failures in biomass boilers to help the verifier assess whether obvious risks have been addressed by the Manufacturer. These examples cover many of the risks of explosions in biomass appliances, however they do not include all foreseeable conditions or operations of the appliance and the Manufacturer will need to show that they have considered all risks even those that are not covered in the standard. It is up to the Manufacturer to provide the evidence to satisfy CBs that all risks have been identified and addressed.

Recent developments in standards for heating appliances for both solid fuel and gas have shown that revisions of standards have moved to include a requirement for a risk assessment because it is known to improve the safety of products.

5.7 WHAT TO DO WHEN AN ACCIDENT IS REPORTED

There is no obligation to report explosions to an overseeing authority in the UK, unless the incident is 'serious' (see below).

Any unintentional explosion or fire in any plant or premises which results in the stoppage of that plant, or the suspension of normal work in those premises, for more than 24 hours. This definition covers serious fires and explosions at work premises.

If particularly dangerous or destructive incidents have occurred, then the HSE may be involved in an investigation. However, it is thought that numerous incidents each year are not reported. The Manufacturer is only likely to be informed of these incidents when a complaint is made about their product.

As these events can be serious occurrences it is important that all information about the event is recorded and that there is a procedure in place that the Manufacturer follows so that lessons can be learnt, and improvements implemented to ensure that similar incidents do not occur.

Manufacturers should make it known to their distributors and installers that when incidents do occur the facts are reported back to them. Information should also be provided in operating guides on how incidents can be reported to Manufacturers. As incidents occur where Manufacturers are not informed it is important that Manufacturers record information on incidents where information is available and use this information to inform future design work.

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