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To: AFQ Inspectors
Specialist Group Inspectors (Fire and Explosion)

GAS FIRED SPECIAL ATMOSPHERE FURNACES: ISOLATION AND BURNER SUPERVISION

This 2-part OC provides guidance on safe isolation and burner supervision in special atmosphere furnaces, specifically furnaces lacking flame-failure devices. The Information Document (ID) may be copied and given to interested parties outside the HSE.

INTRODUCTION

- 1 A major explosion occurred in 2002 during maintenance work on an Ipsen Abar T7 sealed-quench special-atmosphere furnace. It is understood that this type of furnace is relatively widespread in the UK.
- 2 HSE's investigation into the explosion revealed:
 - the need for improvements in gas isolation and flame supervision (3 out of 5 valves were found to be leaking and no flame-failure devices were fitted); and
 - a lack of understanding amongst operating companies about the standards required for second-hand furnaces.
- 3 The incident demonstrated the dependence of older equipment on operator experience and procedural controls to prevent explosions. By comparison, modern Standards have improved physical safeguards fitted to furnaces of this type, for example the requirement for fitting flame-failure devices.
- 4 As part of the actions arising out of this incident the company prepared a detailed costing for upgrading the existing furnace to the latest standards of burner safety control and supervision. This exceeded £10,000 per furnace (more than the replacement cost for a second-hand furnace) and would be unsustainable for many heat treatment companies. Given the low incident frequency, but taking account of potentially severe consequences, the view of the Specialist Inspector at the time was that upgrading to the latest standards was not reasonably practicable.
- 5 Subsequently, the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) now require a hierarchy of control measures. For example, under DSEAR Reg. 6, the fitting of physical control measures such as flame-failure devices must take precedence over 'software' solutions like supervision. In addition, the Institution of Gas Engineers and Managers (IGEM) published IGE/UP/12. "Application of burners and controls for gas fired process plant including furnace ovens, boilers, air heaters, etc. ", which gives specific guidance that came fully into force in March 2006.

6 The Information Document (ID) sets out the standards to reduce the risk of explosions for older equipment and for machinery supplied second-hand. This includes specifically the fitting of flame-failure devices to all second-hand equipment and retrospective fitting to existing installations where this is reasonably practicable. Where companies argue that physical improvements are not reasonably practicable they will be asked to provide justification by means of detailed risk assessment.

SAFE ISOLATION AND FLAME SUPERVISION OF SPECIAL ATMOSPHERE FURNACES

INTRODUCTION

1 This information document contains internal guidance made available to the public by the HSE. It may not be applicable in all cases and any queries should be directed to HSE. Following the recommendations is not compulsory 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. Health and safety inspectors seek to secure compliance with the law and may refer to this document as illustrating good practice.

2 All publications referred to are published by HSE unless otherwise stated and can be obtained from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA, tel 01787 881165 or via their website <http://www.hsebooks.co.uk>.

BACKGROUND

3 A major explosion occurred in 2002 during maintenance work on an Ipsen Abar T7 sealed-quench special-atmosphere furnace. It is understood that this type of furnace is relatively widespread in the UK.

4 The HSE investigation revealed:

- a. the need for improvements in gas isolation (3 out of 5 valves were found to be leaking);
- b. the requirement for flame supervision (no flame-failure devices were fitted); and
- c. the dependence on operator experience and procedural controls to prevent explosions when using older equipment.

5 Fire and explosion hazards in these furnaces can arise both from the gases used in the special atmosphere and from the gaseous fuel used to heat the oven. This document covers the dangers arising from the fuel source and reinforces the existing HSE guidance in information document HSE 647/7 "Fire and explosion hazards in special atmosphere furnaces used in heat treatment processes."

6 "Code of practice for the use of gas in high temperature plant" IM/12 last issued in 1989, but now superseded by code IGE/UP/12¹ covers the gas supply to furnace burners and requires flame-failure devices to be fitted to this type of furnace. Many furnaces currently in operation pre-date these standards and were built at a time when there was no absolute requirement for automatic flame safeguards and the associated automatic isolation valves (though they were recommended as best practice). This was justified because the plant would normally be operating at 750 °C or above: a safe margin above the lowest auto ignition temperature of the gases admitted to either the burner or furnace chamber.

7 When the furnace operates below the set temperature threshold of 750 °C, there is a risk of unburned gas accumulating in the furnace, or burner tubes, and any subsequent ignition causing an explosion. The risk is highest at times such as maintenance, and process ignition when the furnace is cold. Consequently, emphasis was placed on strict adherence to safe working practice (at least double isolation), and operator burner supervision. Providing these were followed the process was considered to remain safe.

8 As outlined above, automatic flame safeguards have been required by safety standards for over 15 years. More recently, BS EN 676:1997 "Automatic forced draught burners for gaseous fuels", states at clause 4.3.4.9, "the main flame and the flame of any ignition burner shall be monitored by a flame-failure detector device". A similar requirement is contained within BS EN 746-2: 1997 "Industrial thermo processing equipment – Part 2, Safety requirements for combustion and fuel handling systems". Clause 5.2.6.1 states "The main flame and if applicable, the ignition burner flame shall be supervised by means of a flame safeguard".

SAFE ISOLATION DURING MAINTENANCE AND SHUT DOWN

9 Within the current population of furnaces in operation, there is a variety of equipment that requires widely differing standards of operator involvement and supervision. Companies need to ensure that furnace operators are fully aware of those older furnaces that require careful supervision, when the furnace is below 750 °C.

10 As part of the safe working practice for supervision of furnaces during maintenance and shut down, a written safe isolation procedure should be drawn up. This should include completion of a safe isolation checklist or "gas isolation certificate" for the relevant gas supply valves acts as a useful reminder of the correct procedure. It also provides a tool for a supervisory check on completion of the task.

11 During shut down periods, it should be ensured that all manual valves in the gas supplies are safely shut off. This would include pilot gas supplies. HSE guidance on safe isolation⁴, suggests at least double isolation on all gas supplies to the furnace. It is good practice to be able to prove the effectiveness of those isolations by either pressure monitoring or an appropriate gas soundness test. The provision and use of pressure test points is covered in BS EN 676.² The use of gas governors, or supply regulator valves, as one of the isolations is not **appropriate**.

12 All plant, pipe work and isolation valves should be clearly marked and periodically checked for leaks. A suitable programme of maintenance work should be carried out to ensure early detection of leaks or passing valves. Instrumentation should be suitable and capable of clear interpretation.

13 Leakage of purge or treatment gases into the furnace can also create oxygen deficient atmospheres. During maintenance, care should be taken to ensure operatives do not enter an area where there is an oxygen deficiency. The inside of a furnace would be a confined space as defined within the Confined Spaces Regulations 1997, and the Approved Code of Practice "Safe work within confined spaces" would apply. Detailed guidance is contained in HSE booklet L121 "

FLAME SAFEGUARDS – GAS FIRED FURNACE BURNERS

14 In accordance with new standards, new furnaces constructed and supplied after 1998, should be fitted with a flame-failure device that monitors the main and ignition burner flames. In the event of flame failure the gas supply to that burner or bank of burners should be shut off. The isolation valving system should comply with IGE/UP/12 or BS EN 676:1997.

15 Retrofitting flame failure devices may be unnecessary if either the enclosed volume of the combustion chamber and gas passages to the flue is small (less than 0.5 m³) or where the combustion chambers are strong enough to withstand an internal explosion and do not connect with the working chamber. Typically some metallic radiant tubes may come into these

categories. In these cases, a detailed risk assessment should be done to justify the decision not to fit flame protection.

16 For other existing furnace burners not already fitted with flame-failure devices it is considered industry best practice to retrofit them, In particular, if the pilot flame is not readily visible to the operator, flame monitoring should be provided. However, it is recognized that the costs of these modifications are high. Consequently, strict adherence to a safe system of working including manual supervision of the furnace until it reaches 750 °C may, in some circumstances, be an acceptable alternative. Employers should again provide justification if this approach is taken.

17 Where the safety of the plant depends upon manual intervention, it should be continuously manned; otherwise arrangements for safe automatic shutdown in an emergency should be provided. In addition, where it is not reasonably practicable to fit a flame safeguard, a weep by-pass pressure proving system should be installed in accordance with IGE/UP/12 Appendix 11.

18 Safe purging and ignition procedures, including a line drawing of the plant and key to valve labels, should be written down. The information should be displayed in a durable form, near the furnace (eg a plastic laminated card). All furnace operators should be trained and competent in the purging and ignition procedure. Refer to the furnace manufacturers instructions regarding safe working procedures.

19 At no time either during maintenance or furnace start-up should main, or pilot flame burners be left with the gas supply “on” and unignited. A smooth and reliable source of ignition should be available for each burner immediately the gas flow is established. BS EN 676:1997 provides detailed specifications for ignition performance of automatic forced draught burners.

USERS OF EXISTING EQUIPMENT

20 Existing furnaces must already comply with the Provision and Use of Work Equipment Regulations 1998 (PUWER) and the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). DSEAR sets out a hierarchy of control measures (Reg 6) to control risks and places an emphasis on hardware rather than ‘software’ (eg systems of work and supervision). In practical terms this will require the fitting of flame-failure devices to the majority of existing furnaces.

SECOND-HAND EQUIPMENT

21 The legal duties of suppliers and purchasers of new and second-hand equipment are outlined in HSE’s free leaflet ‘Supply of New Machinery’ INDG 270. In essence, any second-hand furnace supplied should meet an acceptable minimum standard of safety and be provided with adequate information about its safe use and maintenance. An acceptable minimum standard would include the fitting of flame-failure devices. But it need not comply with **all** of the latest standards unless it has been refurbished to such an extent that it would be considered a new machine.

REFERENCES

1 IGE/UP/12 “Application of burners and controls to gas fired plant”. Institution of Gas Engineers and Managers 2006. ISBN 0-7177-0073-9.

2 BS EN 676:1997 “Automatic forced draught burners for gaseous fuels”

- 3 BS EN 746-2: 1997 "Industrial thermo processing equipment – Part 2, Safety requirements for combustion and fuel handling systems"
- 4 HSC Oil Industry Advisory Committee guidance booklet "Safe isolation of plant and equipment" HSE books 1997. ISBN 0-7176-0411 X.
- 5 "Safe work in confined spaces - Confined spaces regulations 1997. Approved code of practice regulations, and guidance." HSE booklet L121. ISBN 0-7176-1405.
- 6 "Safe use of work equipment – Provision and use of work equipment regulations. Approved code of practice and guidance." HSE booklet L22. ISBN 0-7176-1626-6.
- 7 HSE Operational Circular OC 200/27 "Provision and use of work equipment regulations 1998."