Health and Safety Executive

Health and Safety Executive/Local Authorities Enforcement Liaison Committee (HELA)

Local Authority Circular

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To: Directors of Environmental Health/Chief Environmental Health Officers of London, Metropolitan, District and Unitary Authorities and Chief Executives of County Councils.

For the attention of: Environmental Services /Trading Standards /Fire Authorities /Other

This circular gives advice to local authority enforcement officers

Banana (and other fruit) ripening rooms

The attached operational circular (OC 535/2) is equally relevant to both HSE/LA enforcement officers.

Health and Safety Executive	Operational Circular
	OC 535/2

Review Date	22/10/2014	Open Government Status	Fully Open
Version No & Date	2: 22/10/2004	Author Unit/Section	Agriculture & Food Sector

Target Audience:
All FOD Inspectors

Banana (and other fruit) ripening rooms

This OC describes the process of banana (and other fruit) ripening using ethylene gas, and the fire, explosion and other hazards which may arise. It gives information on precautions to be taken, and provides advice to inspectors. It does not deal with hazards and precautions in the use of gas fired equipment for heating the rooms. The OC updates information previously contained in version 1 issued in 1991.

Background

1 Bananas imported green into the UK, and other unripe fruit (e.g. kiwi fruit, mango fruit), are ripened in specially

constructed rooms by exposure to a controlled atmosphere containing ethylene gas at a concentration of typically 100-200ppm (0.01% to 0.02% by volume in air). The ethylene is introduced from pressurised cylinders, or cartridges or a catalytic generator. Ethylene obtained from cylinders is often at a higher level, up to 1000ppm (0.1%) since it is a one shot injection and more ethylene is introduced to compensate for room leakage. If ethylene generators are used, the maximum achievable concentration is in the order of 400ppm (0.04%) in a free space of 100m^3.

2 If the introduction of ethylene is uncontrolled there is a risk that the ethylene may reach or exceed the lower explosive limit (LEL) of 3.1% and be ignited by unprotected electrical apparatus or gas heating systems or other incendive sources, resulting in a fire or explosion. There are also potential acute risks from oxygen depletion and from the accumulation of other gases such as carbon dioxide; these health risks are exacerbated by the enclosed nature of the process.

The process

3 A typical ripening procedure for bananas is as follows:

1) Green bananas in cartons and at a fruit pulp temperature of around 14^oC are loaded into the ripening room (lower temperatures can damage the fruit).

2) The room is closed and heated for 12-16 hours until the pulp temperature reaches 15-17^oC. This temperature is controlled and maintained by a thermostat. During summer conditions, a refrigeration system will cool the room to maintain the set temperature and remove the heat of respiration.

3) Ethylene is supplied into the room at a concentration of around 100-400ppm (0.01 - 0.04%). The room is then kept closed for 24 hours. The ethylene acts as a catalyst initiating the hormonal process of ripening.

4) At the end of this time the room is ventilated to clear the ethylene gas and the carbon dioxide released during the initial ripening phase.

5) The room is then closed again and the atmosphere controlled at 17^oC reducing to 15^oC over three or four days. The fruit pulp may reach a temperature of 32^oC during this process and gases, including carbon dioxide, are evolved in substantial quantities. Most of these gases would normally be vented off by ripening room operators to maintain the carbon dioxide level below 1%, as carbon dioxide levels exceeding 7% inhibit further ripening.

6) The room is finally ventilated and the ripe fruit removed. A common way of ventilating involves opening the doors for at least five, and usually fifteen, minutes before entry is made. Extractor fans may also be used.

N.B. The amount of ethylene gas required for a ripening room is normally calculated on the free air space after the bananas have been loaded (i.e. if bananas take up 35% of the room size, the amount of ethylene required is calculated for the remaining 65% free air space.

Methods of introducing ethylene gas

4 Ethylene gas may be produced by one of the following three methods:

1) **Ethylene generators** which use a catalytic process to produce pure ethylene gas from a solution containing mainly ethyl alcohol (ethanol) but which may have trace quantities of other ingredients (e.g. methanol). The solution (sometimes known as 'ripening fluid') is poured into a reservoir on the ethylene generator where it is slowly fed to an internal heater which vaporises the ethanol which then passes to the catalytic converter. Each litre of solution produces about 0.33-0.4 m^3 of ethylene gas. For the purposes of risk assessments the higher figure should be used.

2) **Ethylene cartridges** containing approximately 51g of pure ethylene (0.044 m^3 at 20^oC). The ethylene concentration in the room is controlled simply and accurately by using the appropriate number of cartridges. Ethylene is released by piercing the cartridge with the tool supplied.

3) **Ethylene and ethylene/nitrogen cylinders**. Bulk cylinders may be used containing either pure ethylene or a mixture of 5% ethylene in nitrogen (properly used, such a mixture can reduce the explosion risk).

5 Whichever method is used, the dutyholder should ensure that there are adequate means of dispersing the ethylene gases throughout the ripening room on its release.

Hazards

6 The hazards from this process fall into two main categories:

Fire/Explosion

1) Introduction of pure ethylene gas from cartridges may result in localised and short-lived flammable gas/air mixtures.

2) Extensive flammable gas/air mixtures may result from the uncontrolled addition of ethylene from a large cylinder or multiple discharges of cartridges.

3) Formation of flammable gas/air mixtures may result from spillage of ethanol-based solution used in ethylene generators.

4) Incidents to date show that the main acute hazard from this process is the combustion and explosion of excess quantities of pure ethylene resulting from uncontrolled discharges from large capacity cylinders, although other scenarios are possible.

Toxicity and asphyxiation

5) Oxygen deficiency in the room may result from excess addition of ethylene or ethylene-nitrogen mixture from cylinders.

6) The evolution of carbon dioxide during the fruit ripening process may result in a toxic or asphyxiating atmosphere. For example high levels of carbon dioxide may cause loss of consciousness and death from respiratory failure. Other effects such as headache and exhaustion occur at much lower exposure levels.

Risk assessment and safe system of work

7 The nature and circumstances of this type of process give rise to several potential health and safety risks which should be addressed by the appropriate risk assessments. The fire and explosion hazard should be assessed using the requirements of the Dangerous Substances and Explosive Atmosphere (DSEAR) Regulations, 2002 and the associated guidance and ACoPs (see **paragraph 23** for details of the ACoPs). The toxicity and asphyxiation conditions meet the criteria for the ripening room to be treated as a confined space. There is a specific duty under the Confined Spaces (CSR) Regulations 1997 to provide a safe system of work, and the associated health hazards will need be considered in accordance with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Therefore, a risk assessment should be carried out by a competent person to establish the full nature of all risks and to enable suitable precautions to be put in place and safe systems of work to be implemented.

8 These risk assessments should take into account all the relevant factors including: the hazardous area classification of the room (relating to the probability of there being a flammable gas/air mixture); the potential ignition sources; the volume of the room and the volume that is fruit-free; the gas generation technique and the potential gas levels, particularly for carbon dioxide; ventilation systems; the need for entry; monitoring/checking regimes; training; emergency procedures; and other matters as necessary.

9 From the DSEAR risk assessment, the dutyholder should determine whether the room, or parts of it, should be classified as a hazardous area. The dutyholder can then determine the appropriate risk elimination or reduction measures (further information on the application of DSEAR is available in leaflet INDG300).

10 A calibration chart should be conspicuously displayed in each room showing the quantity of ethylene cartridges or ethanol solution required for ripening, given different volumes of fruit etc. This is particularly important where there are rooms of different sizes in the same premises. These calibration charts should be prepared by a suitably competent person.

11 It is impossible to form a flammable concentration with air using 5% ethylene in nitrogen cylinders. However an asphyxiation hazard will still exist and will require risk assessment.

12 The introduction of ethylene into a room should be undertaken only by a competent person who understands the hazards involved. Dutyholders should ensure that ethylene concentrations do not exceed 25% of the LEL. The rooms used should have sufficient free volume for this. Manufacturers of ethylene generation equipment also provide recommendations as to the free volume space of rooms.

13 If a generator containing ethanol based solution requires to be moved, it should be switched off, the mains cord removed from the socket outlet, and the manufacturer's instructions closely followed. Only the manufacturer's recommended solution should be used in a generator.

14 Indirect heating systems should be used in ripening rooms, so as not to introduce an ignition source.

15 The main hazards arise from flammable or asphyxiating atmospheres being created by admitting excess ethylene gas into the room. **Therefore, the use of cylinders of pure ethylene should be vigorously discouraged.** Ethylene generators or ethylene cartridges are the preferred options. If cylinders of pure ethylene are in use, they should be located outside in a safe well-ventilated position and be fitted with a pressure regulator and flow-meter, and be automatically timed so that the concentration of ethylene in the room does not exceed 25% LEL.

16 The principal duty under the CSR is to prevent people working in confined spaces so far as is reasonably practicable. Therefore the dutyholder should review the process and activities involved to try to eliminate the need for entry. Where entry is required it should be undertaken using a safe system of work. The room should be sufficiently ventilated and there should be pre-entry gas checks, particularly for oxygen and carbon dioxide levels.

17 All exposures to carbon dioxide should be controlled in accordance with the COSHH Regulations 2002 and should not exceed 0.5% or 1.5% time weighted over an 8-hour or 15-minute period respectively.

18 Ventilation is a key factor both for controlling the process conditions and for ensuring a safe environment. The ripening room should be thoroughly ventilated between loads. As natural ventilation (i.e. open doors or vents) is unpredictable and unreliable, it can only be used with a safe system of work which will involve the provision of permanent or portable oxygen meters to check the atmosphere before entry. A permit-to-work system may also be necessary. Mechanical ventilation is to be expected. Ventilation should be used to eliminate acute risks and adequately control other non-acute health risks e.g. exposure to excess levels of carbon dioxide. Personal monitoring should be carried out as required to ensure that exposure is adequately controlled.

Prevention of ignition sources

19 No naked lights (e.g gas fired heating systems) or other ignition sources should be allowed in the room after introduction of ethylene, until thorough ventilation has taken place, and it has been verified that the ethylene concentration is below 25% of the LEL.

20 If the room, or parts of it, have been designated as hazardous areas, any electrical equipment in those areas should be suitably constructed, installed and maintained in accordance with the requirements of BS EN 60079 (Electrical apparatus for explosive gas atmospheres).

Storage of ethylene cartridges and ethanol based solution

21 Storage arrangements should ensure that:

1) quantities stored are as small as reasonably practicable;

2) a competent person is responsible;

3) no naked flames, smoking or other ignition sources are permitted near storage areas;

4) full and empty cartridges are stored in a safe, suitably ventilated area preferably in open air;

5) ethanol based solution for ethylene generators is stored in a suitable fire resisting bin or cupboard (quantities of up to 50 litres) which may be indoors. HSE publication HSG51 'The storage of flammable liquids in containers' gives further guidance, including arrangements for larger quantities.

Advice to inspectors

22 No special visits are required by this OC. However, at visits inspectors will want to check that adequate risk assessments have been performed and that a safe system of work is employed.

Further information

23 The following Approved Codes of Practice and Guidance and information leaflet for DSEAR are available from HSE Books at PO Box 1999, Sudbury, Suffolk, CO10 2WA, Tel. 01787 881165, Fax. 01787 313995 or email.

http://books.hse.gov.uk[1]

1) L134 - Design of plant, equipment and workplaces;

2) L135 - Storage of dangerous substances;

3) L136 - Control and mitigation measures;

4) L138 - Dangerous substances and explosive atmospheres;

5) INDG370 - Fire and explosion - how safe is your workplace?

[back to top]

Link URLs in this page

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