

# **industrial health and safety**

## **Oxygen**

Precautions to be taken in the preparation of plant  
and equipment

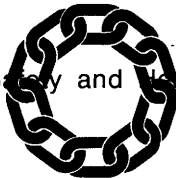


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## Oxygen :

Precautions to be taken in the preparation of plant  
and equipment

Steel Industry Safety and Health Commission



Directorate-General 'Employment and Social Affairs'

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1. Precautions to be taken in the preparation of plant and equipment

The Steel Industry Safety and Health Commission presents herewith a study carried out by its Working Party 'Safety - Oxygen' on the proper preparation by the manufacturer of plant and equipment for the safe and reliable use with pressurized gaseous oxygen.

This study contains a recommended specification which the SISHC believes undertakings in the iron and steel industry will find very valuable when ordering such equipment.

The SISHC urges iron and steel undertakings to make the greatest possible use of the information contained in this study in order to achieve the highest possible standard of safety.

2. Requirements for proper preparation of plant and equipment to be used with oxygen

In the last few years, there have been a number of cases of spontaneous combustion (i.e. combustion occurring without external sources of energy) of all-metal shut-off and control devices and connections also of sections of piping made of non-alloy carbon steel. These fittings conformed to the recommendations of the SISHC (1).

It was not possible to accurately determine the exact causes of combustion from an analysis of the circumstances in which these accidents occurred or from an examination of the damaged components.

In general terms, the known causes of spontaneous combustion in installations and equipment for pressurized gaseous oxygen are as follows:

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(1) See list of documents on pressurized gaseous oxygen published by the Commission of the European Communities as part of the activities of the Steel Industry Safety and Health Commission, and listed in the 'References' section.

- 2.1. Impact and/or penetration of particles, (whether combustible or not, and whether or not previously heated by friction) on and in a non-metallic material (packing of jointing of organic matter).
- 2.2. Heating of organic matter as a result of the rapid rise in pressure (adiabatic compression) which, for example, may occur when a shut-off device is quickly opened on to a short section of piping of reduced volume.
- 2.3. Variations in the temperature of an expanding gas stream.
- 2.4. Rise in temperature of organic or metallic materials as a result of accumulation of energy by vibration.
- 2.5. Lowering of the ignition temperature of non-metallic materials in the presence of catalysts.
- 2.6. Heating by the Joule effect (caused by a circulating electric current) of a dust deposit establishing electrical continuity between metallic components which had been isolated from each other by organic non-conductors.
- 2.7. Accumulation of electrostatic charges within a gas stream. Recent hypotheses suggest that this phenomenon is most likely to occur when very fine sprays and solid particles are present simultaneously.
- 2.8. Limited and very localized heating by the formation of an electrolytic couple between two different metallic materials.
- 2.9. Explosive oxidization, especially oxidization of oils and greases.



- 2.10. Heating of particles, whether combustible or not, as a result of prolonged friction caused by eddies occurring in an all-metal chamber or pocket without gas circulation.

To return to the circumstances in which the incidents mentioned above occurred, a number of causes of spontaneous combustion can mainly be discounted in view of the very high ignition temperature of metallic materials in oxygen - at least 850°C. (As mentioned previously, the damaged fittings and sections of piping were made entirely of metal).

The causes which it seems reasonable to discard are:

- 2.1 - impact and penetration of particles in organic materials
- 2.2 - heating of organic matter by adiabatic compression
- 2.3 - variations in the temperature of a gas stream
- 2.4 - vibration
- 2.5 - catalysis
- 2.6 - Joule effect
- 2.8 - Electrolytic
- 2.9 - oxidation reaction
- 2.10 - prolonged friction of particles caused by eddies.

Given the absence of all organic matter (plastic jointing or packing, lubricant whether approved or not, or incomplete removal of prohibited lubrication during degreasing), the only possible cause of spontaneous combustion is:

- 2.7 - the accumulation of an electrostatic charge within a gas stream, a necessary condition being the coincidence of microdrops and dusts.

The fine sprays which this theory poses could result from the condensation of atmospheric moisture, or from the atomization or condensation of approved lubricants, solid

particles are always present in oxygen installations no matter how high the standard of cleaning.

Most of the causes of spontaneous combustion affecting all-metal fittings occurred when new installations first became operational, or old installations resumed operation after repairs or maintenance work.

In these cases, atmospheric moisture had entered the equipment.

This hypothesis is therefore worth considering; but as it has not yet been confirmed by systematic research carried out in accordance with rigorous scientific method, it cannot be taken as a finally cause.

When enquiries into these occurrences were carried out, those in charge of the installations could not give a formal assurance that the damaged fittings had in fact been fully degreased in most cases; and this is considered to be very important.

Unfortunately, it has often been noted that fittings about to be pressurized were found to contain prohibited lubricants in spite of the order specifications, the fact that the equipment was marked as being intended for use with oxygen, and the assurance, indeed sometimes the written assurance, by the manufacturer that the specifications had been complied with.

At present, the market for fittings for use with pressurized gaseous oxygen is clearly a small one. It is supplied either by small or mediumsized firms which engage in this activity only, or by large companies (e.g. in the gas, oil, chemical, steam industries, etc.) adapting their standard products to meet the requirements for use with oxygen.

This is not always satisfactory, the small and medium-sized manufacturers are sometimes faced with situations in which, while acting in perfectly good faith, they are forced to improvise, while from the point of view of the large manufacturers, the requirements peculiar to oxygen may inhibit the rational organization of production.

These problems, however, will not create difficulties if the personnel responsible for the assembly of the installations (management, preparation, supervision, installation) were fully qualified and experienced, faults observed would be rectified immediately prior to assembly. Unfortunately this is not always the case.

Furthermore, not all manufacturers have access to or make full use of up-to-date information which would allow them to modify and improve their internal organizations and the equipment which they supply are unable to up date technological progress.

The departments of the iron and steel undertakings and the engineering firms responsible for the design and implementation of oxygen installations (design department, new development, supplies and power departments) must therefore be fully aware of the hazards involved in the situation described above. They must consequently be extremely strict in enforcing specifications peculiar to oxygen installations.

The Steel Industry Safety and Health Commission has therefore drafted a specification for the use of the competent departments of the iron and steel undertakings (design, new construction, power, purchasing, maintenance departments).

The recommendation is intended for issue by iron and steel undertakings to equipment manufacturers and all other parties associated with the supply of oxygen equipment. All such parties must respect its terms whether the order is received directly from iron and steel undertakings or via any other party.

The text should be attached to any order for plant or equipment to be used with pressurized gaseous oxygen. 5911 EN4.

3. Specification for the preparation of plant and equipment for use with pressurized gaseous oxygen <sup>(2)</sup>

Introduction

- 3.1. Oxygen is a gas which under certain conditions is extremely dangerous. The accidents which it has caused have very frequently resulted in fatalities, destruction of expensive equipment, shut-down of plant and possible redundancy of workers.
- 3.2. In view of this situation, the Commission of the European Communities has, as part of the activities of the Steel Industry Safety and Health Commission, published a code of practice under the title 'Oxygen - the design, construction, location and operation of fittings in oxygen installations' <sup>(3)</sup>.

Specifications

- 3.3. All fittings included in this recommendation will conform to the above code.
- 3.4. All fittings supplied must be completely free of lubricants consisting of animal, vegetable or mineral products. All components (whether unit elements or sub-assemblies) must be carefully degreased after completion and /or immediately before final assembly. If one or more items in a batch of components does not attain a satisfactory standard of cleanliness they must be degreased again and the whole batch subjected to a further inspection.

Final assembly of individual components or sub-assemblies will be carried out in clean premises quite separate from all other working areas, on working surfaces which must also be clean. The workers who carry out the assembly must not contaminate the fittings (i.e. their hands and clothes must be clean).

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(2) Maximum 64 bar

(3) Obtainable from the CEC, Directorate-General for Social Affairs, Luxembourg.

Reference should also be made to section 5 of the document published by the Commission of the European Communities under the title 'Oxygen - filters, receivers, measuring apparatus of importance for safety, lubrication, degreasing of piping and fittings', which covers degreasing.<sup>(3)</sup>

- 3.5. As described in section 5.5. of this document, the standard of degreasing should be checked by wiping the walls and internal surfaces of the fitting with light, very porous paper.
- 3.6. Approved paste and liquid lubricants, where necessary, will be applied after degreasing, in very small quantities and in such a way that they do not extrude or prevail outside the fitting. This operation should be carried out in the presence of the receiving agent appointed by the purchaser.
- 3.7. Immediately after lubrication, all orifices in the fittings will be carefully stopped by means of gastight plugs, which remain effective over a period of time and are resistant to degradation and impact in the course of handling. Seals will be attached to these plugs.
- 3.8. The receiving agent will check that the items provided comply with the various specifications stipulated in the order, and that they have been correctly degreased (see sections 4 and 5), lubricated (see section 6) and sealed (see section 7), and may then affix seals to each of the plugs (see section 7) and provide and attach to the items so prepared the label 'oxygen equipment; and provide documentation signifying appropriate receipt of the items to the purchaser.
- 3.9. The personnel responsible for preparing fittings and ensuring compliance with this specification must have received suitable training.

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(3) Obtainable from the CEC, Directorate-General for Social Affairs, Luxembourg

#### 4. Explanatory Notes

The following points should be noted in connection with the above text (the numbers refer to the different sections of the specification).

- 4.1. It appears that for lack of adequate training, the personnel involved in designing, constructing and operating installations for pressurized gaseous oxygen currently tends to under-rate the potential but unfortunately very real hazards of these installations. It should be remembered that pure oxygen is the ideal comburant and that in the installations required for its use, it is regularly brought into contact with combustible materials.
- 4.2. The recommendations of this code practice command the unanimous support of experts and specialists, but unfortunately, as a result of compromises with existing practice and bad habits, they are not yet fully enough implemented, in the case of certain manufacturers and undertakings.
- 4.3. In view of the above observation, it is very much in the interests of iron and steel undertakings to make clear to manufacturers that they intend to buy only plant and equipment which conforms to this code.
- 4.4. Proper degreasing of fittings before assembly is of vital importance to the operational safety of the installation. One cannot over emphasise this aspect.

The Steel Industry Safety and Health Commission therefore considers that the manufacturer of oxygen fittings must be responsible for compliance with the specifications and safety requirements which apply to oxygen equipment and fittings. The way to ensure these objectives are achieved is to ensure that all fittings are received by a qualified person or agent nominated by the purchaser. With certain exceptions, it is recommended that the qualified person or agent is not a member of the manufacturing company or his staff. It should be noted that certain experts allow for no exceptions whatsoever.

Certain undertakings feel that new assemblies should be dismantled for inspection in situ rather than inspected at the manufacturers. The Commission does not share this view, as dismantling implies handling and hence a risk of contamination (by dust-laden air) or faulty reassembly (internal and external leakage, etc.).

4.5. The method of checking the standard of degreasing by means of very porous paper is not entirely satisfactory as it is subjective. (The same is true of the method based on ultra-violet radiation). At present, however, it is the only method which, when employed conscientiously, gives very good results.

4.6. The lubricants approved for use with oxygen<sup>(1)</sup> are as follows:

- in paste or liquid form:

halogenated carbon chains (chlorofluorinated oils and greases, perfluorinated polyethers)

- in aerosol form:

graphites

molybdenum disulphide

- in solid or powder form:

graphites

molybdenum disulphide

The manufacturers, and of course the users, of oxygen plant and equipment will obtain their supplies of lubricants for use in the presence of oxygen from firms with a good reputation for the quality and consistency of their products. The supplier will provide a certificate of conformity with the specification for each consignment.

4.7. The manufacturers are advised to draw up and issue to the purchaser instructions for the preparation of oxygen plant and equipment, setting out the sequence of operations to be carried out before, during and after assembly for degreasing of components, sub-assemblies and assemblies, for lubrication, or for packaging after preparation.

These instructions will also indicate the nature and commercial specifications of the degreasing agents and lubricants used. These may not be changed without the prior approval of the purchaser.

## 5. References

All the documents listed below have been published by the Commission of the European Communities as part of the activities of the Steel Industry Safety and Health Commission.

They may be obtained from the Commission of the European Communities, Directorate-General for Social Affairs, Secretariat of the Steel Industry Safety and Health Commission - Luxembourg (Grand Duchy of Luxembourg).

### Oxygen

- |   |      |
|---|------|
| - Oxygen pipe connections - 1969  | free |
| - Shut-off and control devices - 1970   | free |
| - The design, construction, location and operation of fittings in oxygen installations - 1971   | free |
| - Filters, intermediate storage vessels, measurement equipment of importance for safety, lubrication, degreasing of oxygen lines and equipment - 1973 | free |
| - Flexible pipes - 1974   | free |



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The inadequate maintenance and cleanness of equipment for use with oxygen under pressure is a frequent cause of spontaneous combustion in valves and fittings. Such accidents are always serious and frequently result in loss of life. This study by the Working Party 'Safety-Oxygen' of the Steel Industry Safety and Health Commission provides the most up-to-date information on this hazard and puts forward a draft specification for firms in the steel industry (or others using oxygen gas under pressure) and engineering consultants, the aim being to make manufacturers of the equipment and assembly firms comply with the conditions laid down.

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