DISCIPLINE INFORMATION NOTE			
Other Gases			
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To: Process Safety Inspectors HID and FOD.

REVIEW OF OXYGEN INCIDENTS 1996-2002

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INTRODUCTION

1. This note presents the results of a review of oxygen incidents reported to HSE over the period 1996-2002. It also provides details of the main sources of guidance on the storage, handling and use of oxygen.

2. The information for the review was extracted from FIREX, the CTG5 fire and explosion incident database. All the incidents on FIREX have been reported to HSE under RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations).

3. 158 incidents were identified as being directly attributable to the use or handling of oxygen. These included five fatalities, 25 major injuries and 59 minor injuries. The incidents fall into four main categories:

   - hot work;
   - cylinder filling;
   - breathing/respiratory equipment;
   - substitution.

The details are summarised in the table below.

Year	1996	1997	1998	1999	2000	2001	2002		
Activity									
Hot work	19	12	6	11	10	15	10	83	1 fatal 9 major 48 minor
Cylinder filling	4	5	1	2	1	2	3	18	1 fatal 5 major 2 minor
Breathing/ respiratory equipment	5	2	4	2	5	7	10	35	2 fatal 2 major 4 minor
Substitution	1	1	2	2	1	4	4	15	10 major 4 minor
Liquid oxygen	0	2	1	0	0	0	2	5	0 injuries
Miscellaneous	1	3	4	3	0	0	1	12	1 fatal 0 major 3 minor
Total	30	25	18	20	17	28	30	168	5 fatal 26 major 61 minor

MAIN CAUSES OF INCIDENTS

4. The causes of oxygen incidents are often difficult to identify as much of the evidence is destroyed. Most are attributed to:

a. contamination of equipment;

Valves and regulators can easily be contaminated by oil, grease and dust in a working environment. It is often impossible to identify the particular contaminant responsible for an incident.

b. opening cylinder valves too quickly;

The resulting high velocity gas can project any particles through the system causing impacts and frictional heating. In addition, rapidly opening valves into a 'dead end' such as a closed valve or regulator can also generate heat through compression of the oxygen. The heat generated can be sufficient to cause ignition.

c. oxygen enrichment resulting from poor connections or leaking hoses and pipework;

d. the use of materials not compatible with oxygen or the use of oxygen in equipment not designed for oxygen service.

Hot work

5. Hot work incidents are those where oxygen was used in an oxy/fuel process such as welding, cutting, burning etc. Only incidents where there were problems with the oxygen supply or the associated oxygen equipment have been included. Incidents involving flammable gases or where the process acted only as a source of ignition have been excluded. Sixteen of the incidents involved the use of oxygen lances at foundries.

6. The fatality occurred when the operator opened the valve of a new cylinder. The pressure regulator ignited as described in paragraph 4b above and this in turn ignited the operator's clothing.

Cylinder filling incidents

7. Cylinder filling fires are generally attributed to contamination. As cylinder filling remains an essentially manual operation with the operators in close attendance, they can be hit by flames or missiles.

8. The most serious incident in this category involved gas mixing. Gas mixes are required mainly for the calibration of gas monitoring equipment. Many mixtures are made up of nitrogen, oxygen and a small quantity of flammable gas. Although, the final mixture is non-flammable, the order in which the components are added is critical. In this case, it is thought the operator added pure methane first and then oxygen, instead of adding the oxygen to an inert mix of nitrogen and methane. Following this incident, guidance on gas mixing was prepared by the European Industrial Gases Association (39/01 The safe preparation of gas mixtures).

Breathing apparatus/respiratory equipment

9. There were 35 incidents involving breathing apparatus or respiratory equipment. Nine of the incidents involved flash fires/explosions originating at the pressure regulator. The cause was generally attributed to contamination by the user, or ignition by adiabatic compression caused by opening the valve too quickly. Nine incidents were caused when cylinders were dropped, shearing the valve. The most serious incidents reported were attributed to patients smoking while undergoing oxygen treatment.

Substitution

10. Substitution incidents are incidents where compressed air or nitrogen has been substituted with oxygen, either accidentally or deliberately. This usually occurs where equipment is being pressurised for some reason. The oxygen reacts explosively with any oil or grease present and the equipment may be blown apart. Two of the incidents in this category were attributed to the use of non-oxygen compatible components in oxygen systems.

Liquid Oxygen

11. The use of liquid oxygen is steadily increasing with LOX storage tanks installed at many hospitals. The tanks are filled and maintained by the supplying industrial gas company. The number of reported incidents

involving LOX remains low. However, there are reports of a liquid oxygen tank exploding while being filled at a Japanese hospital in January 2004. The cause has not been published as yet.

Miscellaneous

12. The miscellaneous incidents are those which do not fit into any particular category or where there is insufficient detail. The most serious incident in this category occurred at a sewage treatment works. Contractors were replacing a valve in an underground chamber and confined space precautions had been taken. Elsewhere on the site, oxygen was injected into pipework as part of the water treatment process. The oxygen gas leaked into the underground chamber where the men were working. This was not detected as the risk was thought to be from depleted oxygen levels rather than oxygen enrichment. Sparks from the operator's angle grinder ignited his oxygen-enriched clothing.

GUIDANCE

HSE Guidance

- HSE 8(rev 2). Take Care with Oxygen - Fire and explosions hazards in the use of oxygen (leaflet)
- INDG297. Safety in gas welding, cutting and similar processes
- HS(G)139. The Safe Use of Compressed Gases in Welding, Flame Cutting and Allied Processes

British Compressed Gases Association

- Code of Practice CP 19. Bulk Liquid Oxygen Storage at Users' Premises. Rev 3: 2002
- Code of Practice CP 20. Bulk Liquid Oxygen Storage at Production Sites Rev 2: 2002
- Code of Practice CP 7. The safe use of oxy-fuel gas equipment (individual portable or mobile cylinder supply) Rev 2: 1996
- Guidance Note GN5. The Safe Application of Oxygen Enriched Atmospheres when Packaging Food: 1998

European Industrial Gases Association, IGC documents

- 04/00. Fire hazards of oxygen and oxygen enriched atmospheres
- 33/97. Cleaning Equipment for oxygen service
- 104/03. Safety principles for pressure regulators for medical oxygen cylinders
- 98/03. Safe supply of transportable medical liquid oxygen systems by healthcare service providers

- 89/02. Safe use of medical oxygen systems for supply to patients with respiratory disease

- 39/01. The Safe preparation of gas mixtures

Most of the above documents can be viewed on the EIGA website

British Standards

- BS 4N 100-1:1999. Aircraft oxygen systems and equipment. Design and installation

- BS 4N 100-2:1999. Aircraft oxygen systems and equipment. Tests for the compatibility of materials in the presence of oxygen

- BS 4N 100-3:1999. Aircraft oxygen systems and equipment. Testing of equipment and systems

- BS 4N 100-4:1999. Aircraft oxygen systems and equipment. Guide to the physiological factors

- BS 4N 100-5:1999. Aircraft oxygen systems and equipment. Guide to fire and explosion hazards associated with oxygen

- BS 4N 100-6:1999. Aircraft oxygen systems and equipment. Guidance and recommendations on the selection of materials for use with oxygen

- BS 5N 100-7:2002. Aircraft oxygen systems and equipment. Guide to cleaning labelling and packaging

- BS ISO 15001:2003. Anaesthetic and respiratory equipment. Compatibility with Oxygen

Other guidance

- NFPA 53. Guide on fire hazards in oxygen enriched atmospheres

- ASTM G63. Standard guide for evaluating non-metallic materials for oxygen service

- ASTM G88. Standard guide for designing systems for oxygen service

- ASTM G94. Standard guide for evaluating metals for oxygen service