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TRANSFILLING & MAINTENANCE OF OXYGEN CYLINDERS

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1. INTRODUCTION: Recharging of small portable oxygen cylinders by the user is a practice both condemned and discouraged by the Compressed Gas Association (CGA) and the National Fire Protection Association (NFPA). Their condemnation is based on the firm conviction of the majority of the Association members that "transfilling" an oxygen cylinder by "unqualified" personnel is basically unsafe and should not be performed. By logic, therefore, it must be deduced that all personnel assigned to transfilling must be qualified. The purpose of this document is to list the best available information and guide lines for the qualification of personnel who are responsible for the filling of fixed or portable aircraft oxygen cylinders.

   It is a matter of record that the commercial airlines, aircraft manufacturers, and aircraft service stations have been involved in, and will continue to follow, the practice of filling the small portable oxygen units and fixed oxygen cylinders in commercial and general aviation. This practice has developed over the last twenty years and, while there have been occasional accidents, the practice will not be stopped. The lost time, paper work, cost, etc., involved in sending cylinders to a commercial gas supplier is economically unsound. As this is the case, it logically follows that a standardized procedure should be established for charging high pressure oxygen cylinders in those aviation facilities which are required by circumstances to perform oxygen cylinder filling.

2. GENERAL HIGH PRESSURE INFORMATION:

2.1 Pressures: Gases under pressure present a potential hazard in the form of stored energy. Accidents are caused when this energy is improperly controlled or admitted to equipment which is not designed for the pressures encountered. In general, the available energy increases as the pressure increases. Compressed oxygen is available in DOT (Department of Transportation) approved cylinders at pressures up to 18.20 M Pa (2640 PSIG).

2.2 Oxygen is an oxidizing gas and, in itself, is not flammable. Oxygen does, and is required to, support combustion. High oxygen concentrations can accelerate the combustion of flammable materials even to the point of explosion. Almost all materials are combustible in the presence of pure oxygen. Spontaneous combustion of oil and other organic materials may occur in the presence of oxygen-rich environments, particularly when heat is also involved.

2.3 The compression of a gas results in the release of energy in the form of heat. Should compression occur quickly in a container or a closed section of piping, the heat generated can cause a sharp rise in localized temperature. If an adiabatic type compression is considered here, then the theoretically possible temperature rise is a function of the .286 power of the absolute pressure ratio.

$$\text{e.g.} \left(\frac{1864.7 \text{ psia}}{14.7 \text{ psia}}\right)^{.286} = \frac{460 + T}{460 + 70} = 4.0$$

$$T = 1657°F$$

This temperature rise, in a pure oxygen system, can be high enough to cause ignition of oil, grease, solvents, and/or such materials as dust, lint, metal chips, or many organic materials.

Oxygen flowing at high velocity through piping systems can propel particles of foreign material with such force that friction or impact can raise the particles' temperature to the ignition point. This is particularly true where a high degree of cleanliness has not been maintained. Ignition of particles can be sufficient to ignite heavier metal sections, thus causing an accident.

The probability of a temperature rise increases with the differential pressure as is present when rapidly filling an almost empty oxygen cylinder from a full high pressure cylinder. The degree of temperature rise is directly proportional to the ratio of supply cylinder pressure to the residual pressure of the cylinder being filled. Spontaneous combustion of materials, combustible in oxygen, is less likely to occur at near atmospheric pressure conditions. It can be promoted, however, by external sources of heat.

2.4 Transfilling System Material: Materials used in the construction of all components of a piping system must be compatible with, and shall not combine chemically with, oxygen under the conditions of pressure and temperature which will be encountered. Many materials which are considered to be non-reactive at low pressures and normal temperatures may react with oxygen at high pressure and high temperature. For example, steel is a satisfactory material for high pressure oxygen cylinders at normal ambient temperatures. Steel is NOT recommended for oxygen piping system components at high pressure where heat may be generated by friction, compression, or external

2.4 (Continued):

sources. For proper materials refer to SAE AIR 822, Oxygen Systems For General Aviation. However, small diameter, clean, heavy-wall copper or stainless steel tubing is considered safe by most authorities for pressures up to 20.68 M Pa (3000 PSIG). Special attention must be given to the selection of valve seats, packings, hose linings, and gaskets, as many of these materials react chemically with high pressure oxygen. High pressure flexible hose, used in filling systems, shall, in addition to the requirements above, be free from objectionable odor.

2.5 Rules:

2.5.1 Only components designed, built, and cleaned for oxygen service should be used.

2.5.2 Only materials suited for the anticipated temperature condition should be selected for the system.

2.5.3 All components should be suitable for the pressure to which they may be subjected.

3. STORAGE:

3.1 Cylinders should not be subjected to extremes of heat and cold.

3.2 Cylinders should be protected from corrosive atmospheres.

3.3 Cylinders should be handled carefully so as to avoid dropping and to avoid physical abuse to the attachments.

3.4 Cylinders or equipment for handling oxygen should be stored in a clean area, free of grease, oil and other contaminants.

3.5 The valve outlet port on cylinder valves must be capped to prevent the entrance of contaminants.

3.6 Supply cylinders should be secured in place by appropriate constraints (in addition to the manifold plumbing).

3.7 During storage or transfer the cylinder valve must be capped or covered for protection from damage and contamination.

4. CONTAINERS: Compressed gases are commercially available in cylinders manufactured to DOT specifications. Such containers are filled, maintained, and shipped in accordance with appropriate DOT regulations. DOT cylinders are marked to indicate the specification number and the "service pressure" for which the cylinders are designed. This marking is normally located immediately below the neck ring, and consists of a combination of numbers and letters. For example, the designation DOT3A1800 indicates that the cylinder

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was fabricated and tested in accordance with DOT Specification 3A for a service pressure of 1800 psig. Additional marks, normally located beneath the above marking, include an identifying mark of the cylinder manufacturer and a serial number. In addition, the date of original manufacture and a symbol identifying the manufacturer are also located on the shoulder of the cylinder. For example, 9D65 indicates the cylinder was manufactured in September, 1965, by the Doe Company. DOT cylinders must be checked for a valid test date prior to each recharge. A DOT 3A or 3AA cylinder must be retested, prior to recharge, if its last test date is older than 5 years (or older than 10 years if the cylinder bears a metal-stamped star adjacent to its identity). A DOT 3HT cylinder must be retested, prior to recharge, if its last test date is older than 3 years. DOT 3HT cylinders must be removed from service after 24 years from the date of manufacture. DOT 3AA cylinders may remain in the special decennial retest program (indicated by a metal-stamped star) only for 35 years since the date of cylinder manufacture.

5. CONTAINER VALVES AND REGULATORS: Oxygen valves in DOT specification cylinders are normally supplied with Compressed Gas Association standard outlets. Only oxygen regulators or other fittings having corresponding thread forms shall be attached to the valve. Proper connecting fittings can be obtained from a gas supplier. Such valves normally are equipped with a safety relief device in accordance with DOT regulations. This device is normally located on the valve and has the appearance of a hexagonal nut with several small holes in it. This device is exposed to the internal cylinder pressure at all times. Under no circumstances should any attempt be made to loosen or tighten this nut while the cylinder is pressurized. Valves in special applications, such as in aircraft or military equipment, are frequently supplied with outlets which do not conform to the Compressed Gas Association standard. Only fittings which correspond to these outlets should be used. Such fittings can be obtained from the supplier of the equipment in which the special valve is used. Regulators are devices used for the control of pressure and flow rate when withdrawing gas from storage containers. They are designed and fabricated for use with specific gases and at specific maximum pressures. Only regulators for the gas and pressure to be controlled should be used. A regulator should never be changed from one gas service to another.

6. RESUME: The material which has been presented herein is for information purposes, and is presented to call attention to some of the most important points to be considered when handling oxygen. No attempt has been made to specify the equipment to be used, as this is the joint responsibility of the consumer and the suppliers of gas and equipment. Additional valuable information is available in pamphlet form from the Compressed Gas Association, 500 Fifth Avenue, New York, New York 10036.

The suggested filling or "transfilling" procedure which follows sets forth the most important points to be observed in transferring oxygen from one container to another. It is believed that careful attention and adherence to this procedure will greatly reduce the frequency of occasional accidents associated with the transfer of oxygen.

7. SOURCE OF SUPPLY:

7.1 The source of supply will normally consist of one or more cylinders containing oxygen gas under high pressure. They may be individual cylinders to be connected to the supply manifold as required, or they may be permanently mounted in a portable bank or cart.

7.1.1 Only cylinders which are marked for the same pressure service should be attached to the supply manifold at the same time.

7.1.2 Only cylinders which have their contents clearly identified as "Aviators Breathing Oxygen" (either MIL-O-27210 or SAE AS 1065) should be used.

7.1.3 Supply cylinders should be equipped with valves having outlet connections conforming to Compressed Gas Association No. 540. (See Appendix I for other CGA Publications.)

7.2 Manifolds, gages and piping used to interconnect supply cylinders being filled should have been manufactured and cleaned for oxygen service at the pressure to be contained. Such manifolds normally terminate at a control valve and pressure controlling device which can be connected to the filling hose and the container to be filled. Pressure gages (with both metric and English pressure markings) should be provided which will make possible the reading of pressure on both sides of the control valve or device. These gages should be certified as acceptable for oxygen service and should be checked each 6 months for condition and accuracy.

7.3 A typical manifold source of supply is illustrated in Fig. 1.

8. CONTAINERS TO BE FILLED: Cylinders offered for filling should be carefully examined to determine:

8.1 That they are identified for oxygen service by tag, label, decal, color code, etc.

8.2 That the valves are free of dirt, oil, grease, etc. and in fact are "oxygen clean."

NOTE: Cylinders which are un-identified or which have contained gases other than oxygen, or which show evidence of dirt, grease, etc., in or about the valves should not be filled. Contaminated cylinders and valves should be disassembled, cleaned, and reassembled in a manner suitable for oxygen use by a DOT authorized facility.

8.3 That they are free of defects such as dents, arc burns, excessive corrosion, or evidence of fire damage. Any evidence of damage requires a retest by a DOT authorized test facility.

8.4 That they have been retested within the appropriate time (see Section 4).

NOTE: Cylinders which show evidence of damage or have not been properly retested shall not be filled.

8.5 The proper pressure to which the container may be safely filled (see Section 4).

NOTE: Containers which are not marked to indicate a safe working pressure shall not be filled.

8.6 The presence of residual gas.

NOTE 1: If residual gas is present, it is desirable, when possible, to determine that it is oxygen before any attempt is made to evacuate the container. It is desirable to have some residual gas in the cylinder as this prevents the entrance of moisture and eliminates the need to apply a vacuum prior to refilling.

NOTE 2: All cylinders should be evacuated, purged and dried prior to refilling unless the residual gas is known to be Aviators' Breathing oxygen.

9. GENERAL PRECAUTIONS ON USE OF SUPPLY MANIFOLD:

9.1 Only cylinders found to be acceptable for oxygen service in accordance with Section 8 should be connected to the supply manifold for filling.

9.2 Filling hoses, lines, adapters, etc., must be suitable for oxygen service and suitable for the pressure to be contained. Such devices should be marked "For High Pressure Oxygen Service."

NOTE: When not in use, all such filling devices should be stored in a clean area, or otherwise protected against contamination by dirt, oil, grease, etc. All open ends shall always be capped or plugged.

9.3 Threaded ends or other attachment means shall match the fitting on the cylinder to be filled (see Section 5).

NOTE: Under no conditions should excessive force be used in attempting to make a connection.

9.4 The cylinders being filled should be properly supported in a manner that will not induce any stress on the filling hose, fittings, or supply system.

10. RECOMMENDED AIRCRAFT HIGH PRESSURE OXYGEN CYLINDER RECHARGING PROCEDURES:

10.1 Wash hands with soap and water. Assure clothing is free of oil, grease and dirt. Oily or greasy tools, rags or equipment are not permitted in refilling area.

10.2 Assure cylinder to be recharged has valid hydrostatic test date. Refer to Section 4.

NOTE: DOT 3AA oxygen cylinders bearing a metal-stamped star must be tapped with a hammer per "Hammer Test" of CGA Pamphlet C-6 before each recharge operation. The "Hammer Test" should only be performed when the cylinder pressure is below its rated working pressure.

10.3 Assure cylinder to be charged contains some pressure to prevent entrance of moisture/contaminants. This may be done by cracking valve open slightly and listening or feeling for flow. If cylinder is empty, it must be purged per MIL-STD-1359A and visually checked for interior condition.

10.4 Perform sniff check to detect abnormal odors: portable cylinders - use appropriate mask; fixed cylinders - open valve slowly. If abnormal odors are detected do not fill but tag cylinder appropriately for special corrective handling.

10.5 Place aircraft cylinder to be charged into the safety housing so that it can be seen through fill shield viewing window. See Figure 1. Couple aircraft cylinder to outlet hose of recharger. (Before coupling, assure both male and female connections are clean and dry.)

10.6 Assure valves on recharger are set as follows before starting recharge procedure:

a. Handles closed on all line valves located immediately downstream of their respective commercial supply cylinders.

b. Handles open on all commercial supply cylinder valves. (These valves are to stay open at all times except when changing supply cylinders.)

c. Handle closed on line valve located in recharge line immediately upstream of aircraft cylinder to be recharged.

d. Handles closed on fill hose bleed valves.

10.7 Begin recharge procedure as follows:

a. Note pressure gage reading on aircraft oxygen cylinder to be recharged.

b. Note pressure gage readings for all commercial supply cylinders. Slowly open line valve for the particular supply cylinder having both a gage pressure higher than the aircraft cylinder and a pressure lower than the other supply cylinders.

10.7 (Continued):

c. Fully open valve on aircraft oxygen cylinder. This valve should remain full open until cylinder is fully charged. (Metering of flow rate will be accomplished by manipulating recharge line valve.)

NOTE: Some valves allow filling through a check-valved fill port without opening the valve operating handle.

d. Slowly open the recharge line valve immediately upstream of the aircraft cylinder. Slowly adjust the valve position so that pressure increases at a rate not to exceed 200 PSIG per minute. Continue oxygen flow into aircraft cylinder until its pressure gage reading equals (within ± 50 psi) that of the gage on the supply cylinder being used or its gage reads approximately 10% above its prescribed working pressure.

e. Close line valve adjacent to supply cylinder being used.

f. Repeat steps 7.b and 7.e using supply cylinders with progressively higher pressures until the aircraft cylinder is charged to approximately 10% above its prescribed working pressure.

NOTE 1: To compensate for loss of aircraft cylinder pressure as the oxygen cools to room temperature after recharging, the cylinder should be charged initially to approximately 10% over prescribed pressure. Experience will determine what initial pressure should be used to compensate for the subsequent pressure loss upon cooling. A small top-off will create little heat. A complete recharge will create substantial heating.

NOTE 2: The final stabilized cylinder pressure should be adjusted for ambient temperature per Table I.

10.8 Conclude recharge procedure as follows:

a. Close line valve for supply cylinder last opened. Assure that all line valves for supply cylinders are closed. (Do not close valves on supply cylinders.)

b. Close recharge line valve immediately upstream of aircraft cylinder.

c. Wait approximately three minutes for cylinder to cool.

d. Close valve on aircraft cylinder, if so equipped.

e. Bleed pressure trapped in fill hose line by opening bleed valve. After trapped pressure is bled, close bleed valve and remove hose coupling nut from aircraft cylinder valve.