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Gas cylinders — Procedures for change of gas service

Bouteilles à gaz — Mode opératoire pour le changement de service de gaz

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11621 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 4, *Operational requirements for gas cylinders.*

Annex A of this International Standard is for information only.

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Introduction

It is occasionally desirable to change gas cylinders from one gas service to another. Certain of these service changes can be made quite easily, while others require a careful inspection of the interior and exterior of the cylinder to detect the presence of corrosion products or contaminants, which must be removed for safety reasons or to avoid undesirable contamination of the contained gas.

This International Standard has been prepared to assist those engaged in the filling of gas cylinders for changing cylinders from one gas service to another.

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Gas cylinders — Procedures for change of gas service

1 Scope

This International Standard applies to seamless steel, aluminium alloy and welded steel refillable cylinders of all sizes, including large cylinders (water capacity greater than 150 l).

It provides general requirements and procedures to be considered whenever a cylinder is being transferred from one gas service to another for permanent and liquefied gases.

It does not apply to cylinders for dissolved acetylene, radioactive gases or gases listed in group G of table 1.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5145:1990, *Cylinder valve outlets for gases and gas mixtures — Selection and dimensioning.*

ISO 6406:1992, *Periodic inspection and testing of seamless steel gas cylinders.*

ISO 10156:1996, *Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets.*

ISO 10460:1993, *Welded carbon steel gas cylinders — Periodic inspection and testing.*

ISO 10461:1993, *Seamless aluminium-alloy gas cylinders — Periodic inspection and testing.*

ISO 11114-1:—[1], *Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials.*

1) To be published.

3 Abbreviations

NDT = Non-destructive testing.

SCT = Stress corrosion testing.

4 General requirements

Cylinders are manufactured in accordance with international and/or national standards and are intended for use with a variety of gases under specified filling conditions. Although some cylinders are restricted to specific gas services, the majority of cylinders can be transferred from one gas service to another, provided applicable regulations are observed and appropriate procedures are followed and material compatibilities are considered (see ISO 11114-1).

Cylinders which have been in service may have been exposed to conditions that render them unsafe during, or when transferred to, a different gas service. These conditions could result in contamination, corrosion or residual gases that may react. Therefore, it is essential that all procedures detailed in clause 5 and displayed in tables 1, 2 and 3 be carefully followed.

Particular attention shall be directed to assuring that purging or cleaning procedures, where specified, remove all residual gas, contaminants or corrosion products and that cleaning agents are removed and cylinders dried and sealed to prevent entry of dirt or moisture after cleaning.

Persons using this International Standard shall be knowledgeable in the handling of compressed gases and be familiar with the chemical and physical properties of the commodities which they charge into cylinders and of the contaminants which are likely to be found therein.

4.1 Grouping of gases

For the purposes of this International Standard, the gases for which cylinder transfers are most frequently desired have been separated into several groups. This separation has taken into consideration the chemical and physical reactivity of the gases and of the contaminants which are most frequently encountered.

The requirements in this International Standard may not be applicable to gases or mixtures which are not included in the gas groups given in table 3. Recommendations for the cleaning of cylinders which have contained such gases shall be obtained from the manufacturer of the cylinder and/or gas. The values quoted in table 1 for the FTSC code are taken from ISO 5145 or ISO 10156.

4.2 Gases which may affect cylinder condition

Cylinders which have been in certain gas services may be subjected to conditions which could affect the future serviceability of the cylinder or render it unsuitable for use in any other gas service. Cylinders in such services are subject to rigid requalification procedures or may be prohibited from use in other gas services. Examples are:

steel cylinders in carbon monoxide/carbon monoxide mixture service which may be subject to stress corrosion cracking;

steel cylinders which have been in hydrogen service but which were not designed and manufactured for this gas (see ISO 11114-1).

5 Actions for change of service

5.1 General

Because of the potential safety problems (e.g. corrosion, contamination, compatibility), specific actions are required when transferring a cylinder from one gas service to another. The steps (set of actions), denoted by a number, are

listed in table 3. Table 2 shows in tabular form all the steps to be taken for each transfer. It is important that each step be taken. The gas groups are shown by name and letter in table 1. The actions given in table 3 are described in detail in 5.3.1 to 5.3.10 inclusive.

5.2 Use of tables 1, 2 and 3

EXAMPLE 1

A nitrogen cylinder is to be transferred to hydrogen service. Determine the gas groups from table 1 (nitrogen = A; hydrogen = E). Using table 2, find A in the left-hand column and proceed across the table to column E where you will find the numbers 1, 4, 6. Go to table 3, which shows what actions are required by steps 1, 4 and 6 (for details, see 5.3.1, 5.3.4 and 5.3.6).

EXAMPLE 2

An oxygen cylinder is to be transferred to 50 % oxygen and 50 % nitrous oxide. Determine the gas groups from table 1 (oxygen and nitrous oxide = C). Using table 2, find C in the left-hand column and proceed across the table to column C where you will find the number 1. Go to table 3, which shows what actions are required by step 1 (for details, see 5.3.1).

Table 1 — Gas groups for change of service

Group	Description	Gases
A	Inert [1]	Nitrogen, argon, helium, neon, krypton, xenon and all gases and gas mixtures having FTSC code 01X[2]0 (but excluding gases in group B).
B	Inert/active [3]	Carbon dioxide, carbon dioxide mixtures and oxygen mixtures containing less than 21 % oxygen having FTSC code 01X0 or 11X0.
C	Oxidizing	Oxygen, nitrous oxide, air and mixtures containing at least 21 % oxygen or more than 60 % nitrous oxide having FTSC code 41X0.
D	Flammable	Ethylene, methane, cyclopropane, other hydrocarbons, liquefied petroleum gases, etc., and all gases and gas mixtures having FTSC code 21X0 (but excluding flammable gases of groups E and F).
E	Embrittling	Hydrogen and all non-toxic gases of group 2 of ISO 11114-1 having FTSC code 21X0.
F	SCC [4]	Carbon monoxide and carbon monoxide mixtures.
G	Toxic Corrosive Pyrophoric	Very toxic (X3XX), toxic (X2XX), corrosive (XXXY [5]) and pyrophoric (3XXX) gases (but excluding group F). **CAUTION — Some of these gases are also embrittling (see ISO 11114-1).**

1) Inert in terms of fire potential (see ISO 10156).
2) X equals any digit.
3) Inert in terms of fire potential, but corrosive in presence of moisture.
4) Stress corrosion cracking.
5) $Y \neq 0$

Table 2 — Actions to be taken when transferring cylinders from one gas service to another

From ↓ / To →		A Inert	B Inert/active	C Oxidizing	D Flammable	E Embrittling	F Carbon monoxide	G Toxic, etc.
A	Inert	1	1, 2	1, 3	1	1, 4, 6	1, 5	1, 4, 3
B	Inert/active	1, 7	1	1, 3	1, 7	1, 4, 6, 7	1, 5, 7	1, 3, 4, 6
C	Oxidizing	1, 7	1	1	1, 8, 7	1, 4, 6, 7, 8	1, 5, 7, 8	1, 3, 4, 7, 8
D	Flammable	1, 8	1, 8	1, 8, 3	1, 8*	1, 4, 6, 8*	1, 5, 8*	1, 4, 5, 8
E	Embrittling	1, 8*, 9	1, 8, 9	1, 3, 8, 9	1, 8, 9	1, 6, 8*, 9	1, 5, 8, 9	1, 3, 4, 8, 9
F	Carbon monoxide	1, 8, 10	1, 8, 10	1, 8, 3, 10	1, 8, 10	1, 6, 8, 10	1, 5, 8*, 10	1, 3, 4, 8, 10
G	Toxic, etc.	Not covered by this International Standard. Only to be performed under tightly controlled conditions using special procedures.						

Table 3 — List of actions for change of gas service

Step No.	Action
1	External examination and preparation: Verify contents/identification Cylinder external surface Valve outlet and operation Check working pressure/specification Ownership Test date — retest if required resulting from change of service Reduce pressure (blow down) to atmospheric pressure using appropriate discharge Remove all existing labels, stencils, etc., after cylinder has been emptied Re-mark with service markings: label, paint, stamp, etc. (after gas has been removed from the cylinder) If the valve is removed do an internal visual inspection
2	Check for moisture contamination
3	Internal inspection for liquid and/or hydrocarbons. If suspected, clean for oxygen service
4	Check materials compatibility in accordance with ISO 11114-1
5	Check moisture level for steel cylinders. Use moisture requirements of ISO 11114-1
6	Check for internal surface defects
7	Check for internal corrosion
8	Cylinder content evacuation
8*	Pull vacuum or purge (only if valve is removed)
9	Check previous service against ISO 11114-1. If not compatible, perform appropriate NDT and hydrotest
10	If suspected that cylinder has been exposed to water, perform appropriate NDT and hydrotest

5.3 Details of actions for change of service

The following gives details and/or explanations of the actions listed in table 3.

5.3.1 External examination and preparation (step 1)

This step is required for each cylinder transferred to any other gas service. Each action listed in this subclause shall be taken for each cylinder. Prior to the following actions, the cylinder contents (gas or gas group) shall be verified to determine actions required from table 2. The actions below do not necessarily have to be performed in the order indicated. At all times, safety considerations shall be observed.

— Carry out an external visual inspection of the cylinder and valve to verify suitability for service. For guidance, see ISO 6406, ISO 10460 and ISO 10461. Note that external contamination of the cylinder and especially the valve may indicate internal contamination.

— Check that the cylinder is equipped with a valve having an outlet connection conforming to ISO 5145 or national standards for the new service. If not, see table 2 to determine if step 8 or step 8* is required, before replacing the valve. Also, check that the valve operates satisfactorily.

— Determine that the pressure relief device, if present, is of an approved type for the intended gas and the working/test pressure of the cylinder.

— Check the working pressure/cylinder design specification and applicable regulations to verify that the cylinder is satisfactory and authorized for the new gas service.

— Check the cylinder ownership to verify that the owner has authorized the transfer to another gas service.

— Check the test date and determine whether or not it is within the specified test frequency for the old and new gas service. Retest, if necessary.

— Reduce the pressure (blow down) to atmospheric pressure using appropriate equipment and discharge to be safe and meet environmental requirements.

— Remove all means of identification concerning the former gas content, such as labels, colour coding and other relevant identification. Stamp markings of the former gas content shall be either removed or crossed out.

— Identify for the new gas service; this includes painting, labelling, stencilling and possibly stamp marking of the cylinder.

— If a valve is removed for any reason, the opportunity should be taken to perform an internal visual inspection. The valve may not require replacement for transfers within the same gas group, but a valve may be replaced because of damage or improper operation. An internal inspection shall always observe for defects, corrosion and contamination. Only acceptable cylinders shall be kept in service. Contaminated cylinders may be cleaned (see annex A). Internal inspection of cylinders having contained oxidizing gases can be performed without evacuation provided that a safety lamp is used. However, evacuation/purging shall be carried out prior to probing or working on the interior surface.

5.3.2 Check for moisture contamination (step 2)

When step 2 is required, it is not mandatory that the valve be removed. The point of concern is the presence of moisture in the cylinder. The absence of liquid water and other aqueous substances can be verified either by a visual examination or by a moisture test for dew point. If visual internal inspection is used, a dry surface appearance is acceptable proof of satisfactory condition. If liquid is found, the cylinder shall be dried, and/or washed and dried, prior to transfer. This step is not required for aluminium-alloy and stainless-steel gas cylinders, other than for gas quality reasons.

5.3.3 Internal inspection for liquid and/or hydrocarbons (step 3)

Before any cylinder is transferred into oxygen or oxidizing-gas service, the valve shall be removed and the cylinder given a visual internal inspection for any evidence of a liquid or a hydrocarbon. Liquids may show as pools on the cylinder bottom or as droplets on the wall. Hydrocarbons may show as liquids or by an oily appearance. If either condition is observed or if there are any other doubts when the internal inspection is being made, the cylinder shall be cleaned for oxygen service (see annex A). After this cleaning, the internal inspection shall be repeated to ensure that the observed contamination and the cleaning solution have been removed.

5.3.4 Check for materials compatibility (step 4)

When step 4 is required, determine that all materials which will come in contact with the intended gas, including the cylinder, internal lining (if present), valve components, pressure relief devices, thread compounds and valve lubricants, are compatible with the intended gas under normal conditions of storage, transportation and use (see ISO 11114-1).

5.3.5 Check of moisture level (step 5)

This step is intended to be more demanding than step 2. When step 5 is required, it shall be verified that each cylinder being transferred is sufficiently dry so that liquid water will not form within the cylinder at the pressure/temperature ranges of use. This shall be verified by a moisture test for dew point. The presence of excessive moisture can be rectified by drying the cylinder. For acceptable moisture levels, see ISO 11114-1. This step is not required for aluminium-alloy and stainless-steel cylinders.

5.3.6 Check for internal surface defects (step 6)

When step 6 is required, it shall be verified that the inside surface is free of surface defects such as laminations, laps, cuts, gouges or cracks. Certain defects can be detected by visual inspection. However, detection of cracks and small defects requires an NDT (non-destructive testing) test such as an angle-beam ultrasonic test or acoustic-emission test. Cylinders exhibiting an unacceptable level of defects shall be removed from service. For rejection criteria, see ISO 6406, ISO 10460 and ISO 10461.

5.3.7 Check for internal corrosion (step 7)

When this step is required, an internal visual inspection shall be performed to determine whether internal corrosion due to the previous gas service has taken place. Additionally, since it is known that existing corrosion may initiate cracking, only cylinders free from harmful internal corrosion (to be checked by appropriate NDT) may be transferred into group E or group F gas service. This step is not required for aluminium-alloy or stainless-steel cylinders.

5.3.8 Cylinder content evacuation (step 8)

When step 8 is required, it is necessary that the oxidizing or flammable gas in the cylinder being transferred be safely evacuated. Adequate removal of a flammable gas to below its lower flammable limit can be achieved by evacuation, by purging or by filling with water and subsequent emptying and drying. The cylinder contents shall be removed before an internal inspection light or other source of ignition is used in a cylinder.

When step 8* is required, the evacuation or purge is required only if the valve is removed during the transfer.

5.3.9 Check of previous services against compatibility using ISO 11114-1 (step 9)

Cylinders may be in gas service today which current technology would not permit, e.g. a cylinder with too high a strength may be in hydrogen service. If the cylinder is not compatible with its existing gas service (see ISO 11114-1), the cylinder shall be withdrawn from the gas service. However, it may be used in another gas service provided it passes appropriate NDT evaluation (e.g. shear-wave ultrasonic or acoustic-emission testing) and hydrotesting.

5.3.10 Suspected exposure to internal liquid water (step 10)

When step 10 is required (transfer from group E), determine whether or not the cylinder was likely to have been exposed to liquid water internally. If this is likely, then carry out an appropriate NDT evaluation (e.g. shear-wave ultrasonic or acoustic-emission testing). Those cylinders passing these tests may be transferred to the new gas service. This step is not required for aluminium-alloy or stainless-steel cylinders.

Annex A
(informative)

Procedures for cleaning gas cylinders

This annex is for information only. Other acceptable methods may be employed. The methods suggested herein for removing the most frequently encountered contaminants have been found to produce satisfactory results. These contaminants should be removed either for reasons of safety or to prevent product contamination when the cylinder is again filled with a different gas.

A.1 General

A.1.1 Identification of contaminant

Gas cylinders may become contaminated, by filling operations or in service, with various materials. The selection of the appropriate method of cleaning should be based, when possible, on an identification of the contaminant. A sample of the contaminant should be tested to determine whether it is combustible, water soluble, organic-solvent soluble, etc. If a sample cannot be obtained, all clues to the nature of the material should be considered such as odour, appearance (i.e. rusty, oily, discoloured spot, etc.), the previous service of the cylinder and the method of filling, e.g. oil-lubricated compressors.

A.1.2 Selection of cleaning procedure

Almost all hydrocarbon-based contaminants can be removed by either aqueous-solution washing (A.2.1) or organic-solvent washing (A.2.2), either in the liquid phase or in the vapour phase. However, some contaminants become very difficult to remove by any method if an organic solvent is used first, since this solvent converts them to insoluble gums. The cleaning solution must, of course, be compatible with the intended gas service, in particular for oxidizing gases, and must be removed without leaving any harmful residue. Its environmental impact should also be considered. The flow chart given in figure A.1 shows various methods used to clean gas cylinders. These methods are discussed in the following subclauses.

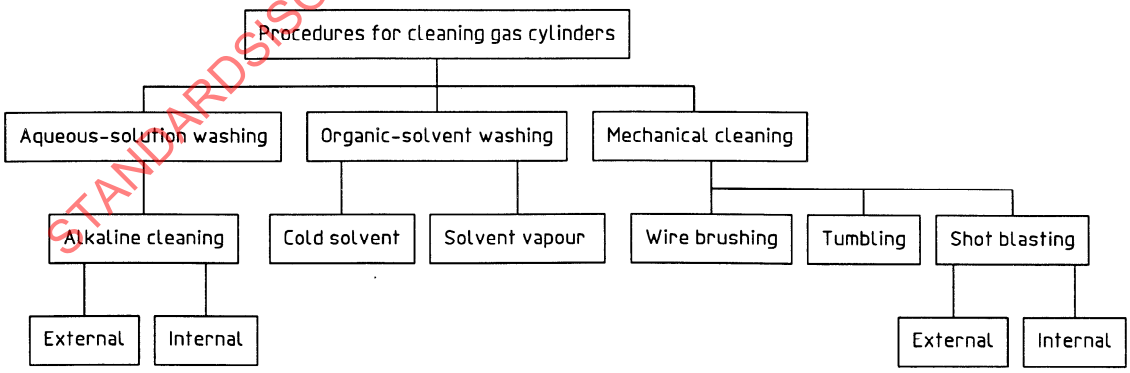

Figure A.1 — Methods used to clean gas cylinders

CAUTION — Aluminium-alloy cylinders are normally manufactured using heat treatment to obtain the final mechanical properties of the cylinder. Thereafter, the temperature for any operations has to be limited. In no case may the temperature used exceed that recommended by the manufacturer. For cylinders manufactured from heat-treated alloys with tempering, the maximum temperature is 150 °C.

A.2 Solvent cleaning

A.2.1 Aqueous-solution washing

There are a number of aqueous solutions which may be used for removing organic materials from cylinder interiors. Almost all of them are based upon an alkaline solution of sodium metasilicate, although some use a straight potassium or sodium hydroxide solution at approximately 8° Baume concentration. An alkaline detergent does not dissolve oil, grease or similar contamination. Cleaning solutions have high wetting properties which enable them to emulsify oil films and coat all objects with a film of detergent so that the oil floats free in the solution. Some means of removing surface films should be provided, as the cleaning action brings much of the foreign material to the surface of the liquid. The preparation and use of one such solution is described below.

A.2.1.1 Alkaline-solution cleaning

CAUTION — Alkaline solutions are caustic, particularly when hot, as they are generally used. They can therefore cause severe burns to the skin and eyes. Personnel working with these materials should wear suitable protective clothing, including goggles or face mask, rubber gloves, rubber apron and alkali-resistant footwear. An eyewash and safety shower should be available nearby.

If the cleaning solution comes in contact with the skin, as evidenced by a burning sensation, rinse the area immediately with water, preferably warm. Vinegar applied to the area will aid in neutralizing the effect of the alkali.

If the cleaning solution comes in contact with the eyes, immediately flush with copious quantities of fresh water and see a physician.

Do not use caustic paint stripper to clean aluminium cylinders. Some detergents, alkaline solutions and organic solvents may react destructively with aluminium and other non-ferrous materials. The use of such solvents for the external or internal cleaning of such non-ferrous materials could render them unsafe for further use. Check with the cylinder manufacturer for recommended cleaning compounds.

A.2.1.1.1 Preparation of cleaning solution

To prepare a maximum-concentration cleaning solution, for every 20 l of clean water add 1 kg of sodium metasilicate and 30 g of sodium dichromate. This produces about a 5 % concentration. Use clean, hot water. Water from the plant boiler should not be used as it may be contaminated.

The strength of the cleaning solution should not be greater than that required for effective cleaning. For example, if the contamination is a light oil, a solution of 150 g to 200 g of sodium metasilicate in 20 l of water will generally be sufficient.

Sodium metasilicate forms insoluble precipitates with the mineral salts in water. If the water used is exceptionally hard, these precipitates should be removed from the cleaning solution by filtration to avoid clogging the equipment. The alkaline solution used for cleaning should be freshly prepared and shall not have been previously used.

A.2.1.1.2 Cleaning procedures

A.2.1.1.2.1 External cleaning

Cylinders coated with dirt, oil or grease, but showing no evidence of such contamination on or in the vicinity of the valve outlet, may be cleaned externally only. The above solution, applied with a brush or rag, will effectively remove most contaminants. Care should be observed that none of the solution or dirt gets on or into the valve outlet. After all contamination has been removed, rinse the cylinder thoroughly with clean, warm water.

NOTE — Alkaline solvents may remove or damage the paint. Cylinders should be inspected, and if necessary repainted, before being returned to service.

A.2.1.1.2.2 Internal cleaning

Cylinders which show evidence of internal contamination must be cleaned internally.

Procedure 1

a) Remove the valve. Fill the cylinder to slightly over half its capacity with a hot alkaline solution, and then plug the neck opening.

b) Lay the cylinder on the floor, and roll it back and forth for about 15 min. Preferably use a cylinder roller, positioning the cylinder horizontally and allowing the cylinder to rotate for 15 min.

c) Immediately upon completion of the rolling, stand the cylinder up, remove the plug and completely fill the cylinder with clean tap water. Be sure the cylinder is full, as the interior walls must be kept wet until the cylinder is rinsed.

d) When ready to rinse, drain the solution by inverting the cylinder. While the cylinder is inverted or inclined with the neck down, rinse the inside with fresh, clean running tap water, making sure that the rinse water reaches all interior surfaces. Continue rinsing until all traces of the cleaning solution have been removed. This may require a rinsing period of at least 10 min.

e) Dry the cylinder immediately after cleaning and perform a visual inspection to determine that the cylinder is clean and free of defects.

f) Install a plug or the proper valve as soon as practicable after inspection.

Procedure 2

Alternative procedures using alkaline solutions for the internal cleaning of cylinders are equally effective. Among those which have been found to result in satisfactory cleaning are the following:

a) A steam lance is inserted to the bottom of the cylinder which has been filled with an alkaline solution. Clean, oil-free steam is injected into the solution through the lance to keep it boiling for 15 min to 30 min. During the boiling process, enough excess boiling water or steam is injected through the lance so that the solution overflows from the cylinder, carrying away the contaminants which have floated to the surface.

b) The cylinder is positioned with the open neck pointing downward. A mixture of high-pressure steam and a cleaning solution, such as the one described above, is injected into the cylinder through a steam lance. The lance should be moved up and down and sideways so that the cleaning fluid will contact the entire inside surface of the cylinder. Rotating the cylinder may be helpful.

c) The cylinder is positioned with its open neck downward, over a short length of tubing. Heated alkaline cleaning solution is injected, through the tubing, upward into the cylinder so that it impacts the bottom of the cylinder and runs back down the cylinder walls, contacting all the interior surfaces of the cylinder.

d) After cleaning with any aqueous or alkaline solution, the cylinder must be thoroughly rinsed with clean water.

e) Thoroughly dry the cylinder immediately after rinsing, and perform a visual inspection to determine that the cylinder is clean.

f) Install a plug or the proper valve immediately to avoid contamination by atmospheric moisture.

A.2.2 Organic-solvent washing

A.2.2.1 General

In these procedures, an organic solvent is introduced into the cylinder using a method that will assure that all interior surfaces are effectively contacted by the solvent. Experience has indicated that, most of all, cylinders which are oil

or hydrocarbon contaminated can be adequately cleaned by organic solvents to render the cylinder suitable for use in oxygen or any other gas service.

This method of cleaning depends upon the ability of the solvent to dissolve organic materials in a short period of time, to leave only a small amount of non-volatile residue on the walls of the cylinder, and not to react chemically with the cylinder material. There are many commercial solvents on the market that meet these requirements.

CAUTION — Since almost all solvents are harmful if breathed to excess, cylinder cleaning with these solvents should be done only in an area with good, positive ventilation, and only by persons wearing adequate protective equipment.

Carbon tetrachloride should not be used for cleaning cylinders, due to its extreme toxicity.

A.2.2.2 Organic solvents may convert some water-soluble contaminants to insoluble gums. If the internal inspection of a cylinder indicates the possible presence of both water-soluble and water-insoluble materials, the cylinder must be washed first with an alkaline solution in accordance with one of the procedures given in A.2.1.1.2.2 and then, if necessary, washed with an organic solvent in accordance with the procedure described below.

A.2.2.3 Cold-solvent procedure

a) Pour clean solvent into the cylinder until it is slightly over one-half full, then plug the neck opening. Lay the cylinder on its side and rotate for approximately 15 min. The cylinder can be rotated either with a mechanical rotating machine or by rolling it back and forth on the floor.

b) Empty the cylinder and observe the discarded solvent. If the solvent is dirty, repeat the cleaning procedure using fresh solvent. Do not use the original solvent as it could redeposit contaminants. If a solvent-reclaiming procedure is available, some solvents may be reclaimed by boiling and condensing the vapours. Otherwise, the solvent must be discarded or used only for routine cleaning of machinery or another non-critical use.

c) After cleaning, dry the cylinder, purge with oil-free air or nitrogen to remove residual solvent and vapours, and visually inspect the interior to determine that the cylinder is clean and free of defects. Install a plug or the proper valve as soon as practicable after drying.

A.2.2.4 Solvent vapour procedure

This solvent-cleaning procedure uses a tank with immersed heaters to vaporize the solvent. The solvent vapour is discharged upward through an injection tube over which a cylinder is inverted. The hot vapours condense on the internal walls of the cylinder being cleaned, dissolve the oil contamination, and return to the tank by gravity. The solvent in the tank thus becomes contaminated. However, the vapour driven off by the heating is free of contaminants and the cylinder is thus washed at all times with clean condensate.

CAUTION — Because of the large volume of organic-solvent vapours generated, the equipment should be constructed, maintained and operated in a manner which will avoid hazardous concentrations of the vapours in the work area.

NOTE — Cylinders with loose scale, paint or dirt inside or outside should not be placed in a vapour degreaser until the loose particles have been removed. This will prevent fouling of the boiler, contamination of the solvent and overheating the coils.

The details of the procedure are as follows:

a) Rinse the cylinder with water, both internally and externally, to remove water-soluble materials, and then dry.

b) Invert the cylinder using an appropriate hanger and lower it over the injection tube of the vapour cleaner. The injection tube shall almost reach the base of the cylinder. Various lengths of tube should be available for use with various cylinder sizes.

c) Leave the cylinder on the cleaner for 15 min to 45 min after vapour has started to issue from the neck of the cylinder. The time required depends upon the neck tube opening and the quantity of contamination.

d) Remove the cylinder from the injector tube and immediately purge it with at least 3 m^3 of oil-free compressed air or nitrogen. The exhaust from the cylinder should be piped to the outside of the building, if the cleaning is done indoors.

e) Immediately dry the cylinder.

f) Perform a visual inspection to determine that the cylinder is clean and free of defects.

g) Install a plug or proper valve as soon as practicable to avoid the entry of atmospheric moisture.

A.3 Mechanical cleaning

A.3.1 General

If the internal inspection indicates the presence of rust, mill scale or other foreign solids adhering to the walls, such material should be removed before the cylinder is again used or the interior is chemically cleaned. These materials can be removed by mechanical cleaning. A number of mechanical-cleaning procedures are described below.

A.3.2 Wire brushing

The interior of small cylinders or cylinders with large neck openings can be cleaned by inserting a wire brush of proper design through the valve opening and rotating it with an electric drill, lathe, etc., while forcing the brush against the wall of the cylinder and moving it or the cylinder up and down to contact all interior surfaces. The cylinder should be up-ended periodically to dump out any loose material.

NOTE — Cylinders containing flammable gas should be purged.

A.3.3 Tumbling

A quantity of hard abrasive material, such as angular chilled cast iron, short pieces of reinforcing rod, etc., are placed inside the cylinder. The cylinder is then rotated in a horizontal position for a sufficient period of time to loosen the material adhering to the walls. The preferred rotation should not be completely circular since such action would tend to make the abrasive material slide on the inner surface without the impinging action which gives superior cleaning. Rotation combined with a rocking or shaking motion which causes the abrasive materials to strike the inner walls of the cylinder is preferable.

A.3.4 Shot or sand blasting

Shot or sand blasting is a method of removing mill scale or corrosion products from cylinder interiors. Care must be taken not to remove an excessive amount of parent metal from the cylinder walls. This method works best when the cylinder is inverted so that the shot and loose material do not accumulate within the cylinder. The motion of the blast nozzle relative to the cylinder surface should be constant and uniform over the entire surface to be cleaned. The motion should never be stopped during the cleaning operation in order to avoid excessive local loss of cylinder wall.

A.3.5 Following any method of mechanical cleaning, the cylinder should be inverted to remove loose particles, then rinsed well with clean water and dried. Install a plug or the proper valve immediately after drying.