



HSE APPROVED SPECIFICATION

SPECIFICATION DOT- 4E(HSE)

WELDED ALUMINIUM CYLINDERS

Issue 1

February, 1998

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Type, Size and Service Pressure

- .1 The cylinder shall be constructed of not more than 2 seamless drawn shells with not more than one circumferential weld. The circumferential weld shall not be closer to the point of tangency of the cylindrical portion with the shoulder than 20 times the cylinder wall thickness. Cylinders closed in by spinning process and cylinders with longitudinal seams are not authorised. The water capacity shall not be greater than 454 Kg (1000 pounds) nominally.
- .2 The service pressure shall be at least 15.5 bar (225 psi) and not over 34.5 bar (500 psi).

Certificate of Compliance

- .1 The inspection body approved by the HSE shall certify that the manufacture, inspection and testing of the cylinders was carried out in compliance with the requirements of this specification.

Duties of Inspector

- .1 Inspect all material and reject any material not complying with requirements of this specification.
- .2 Verify chemical analysis of each lot of material by analysis or by obtaining certified analysis: provided that a certificate from the manufacturer thereof, giving sufficient data to indicate compliance with requirements, is acceptable when verified by check analysis of samples taken from one aluminium cylinder out of each lot of 200 or less.
- .3 Verify compliance of cylinders with all requirements including markings. Inspect inside before closing in both ends. Verify material properties. Obtain samples of all tests and check material analysis, witness all tests; verify thread by gauge; report volumetric capacity, tare weight (see report form) and wall thickness as approved.
- .4 Furnish complete test reports required by this specification to the maker of the cylinder and, upon request, to the purchaser. The test report must be retained by the inspector for 15 years from the original test date of the cylinder.

Aluminium

(a) Shall be of uniform quality. The following chemical analyses are authorised.

.1 Table 1 - Authorised Materials

Designation	Chemical analysis - limits in %
Iron plus silicon	0.45 maximum
Copper	0.10 maximum
Manganese	0.10 maximum
Magnesium	3.1/3.9
Chromium	0.15/0.35
Zinc	0.20 maximum
Titanium	0.20 maximum
Others, each	0.05 maximum
Others, total	0.15 maximum
Aluminium	Remainder

Analysis shall regularly be made only for the elements specifically mentioned above. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis should be made to determine conformance with the limits specified for other elements.

.2 Identification of material

(a) Required; any suitable method that will identify the alloy and manufacturer's lot number.

.3 Defects

(a) Materials with seams, cracks, laminations or other injurious defects shall not be allowed.

Manufacture

.1 By best processes and methods; dirt and foreign particles to be removed as necessary to afford proper inspection; no defect acceptable that is likely to weaken the finished cylinder appreciably; reasonably smooth and uniform surface finish required; all welding must be by the gas metal arc process.

Welding

- .1 The attachment to the tops and bottoms only of cylinders by welding of neckrings or flanges, footrings, handles, bosses and pads and valve protection rings is authorised: *provided*, that such attachments and the portion of the cylinder to which it is attached are made of weldable aluminium alloys.

Wall thickness

- .1 The minimum wall thickness of the cylinder shall be 3.6 mm (0.140 inch). In any case, the minimum wall thickness shall be such that calculated wall stress at twice service pressure (Test Pressure) shall not exceed the lesser value of the following:
 - .1.1 137N/mm² (20,000 psi)
 - .2.2 One-half of the minimum tensile strength of the material as required in clause 13.0.
 - .3.3 77% of the guaranteed minimum yield stress.
- .2 Calculation must be made by the formula:

$$S = [P(1.3D^2 + 0.4d^2)]/(D^2 - d^2)$$

where:

S = wall stress in N/mm²;

P = minimum test pressure prescribed for water jacket test;

D = outside diameter in mm;

d = inside diameter in mm.

Minimum thickness of heads and bottoms shall not be less than the minimum required thickness of the side wall.

Opening in cylinder

- .1 All openings must be in the heads or bases.
- .2 Each opening in cylinders, except those for safety devices, must be provided with a fitting, boss or pad, securely attached to cylinder by welding by gas metal arc process or by threads. If threads are used, they must comply with the following:
 - .1.1 Threads must be clean-cut, even, without checks and cut to gauge.

- .2.2 Taper threads to be of length not less than as specified for American Standard taper pipe threads.
- .3.3 Straight threads, having at least 4 engaged threads, to have tight fit and calculated shear strength at least 10 times the test pressure of the cylinder; gaskets required, adequate to prevent leakage.
- .3 Closure of fitting, boss or pad must be adequate to prevent leakage.

Safety relief devices and protection for valves, safety devices and other connections if applied

- .1 No person may offer a cylinder charged with a compressed gas for transportation unless the cylinder is equipped with one or more pressure relief devices sized and selected as to type, location and quantity and tested in accordance with CGA Pamphlet S-1.1. The pressure relief device system must be capable of preventing rupture of the normally charged cylinder when subjected to a fire test conducted in accordance with CGA Pamphlet C-14. Cylinders shall not be shipped with leaking safety devices. Safety relief devices shall be tested for leaks before the charged cylinder is shipped from the cylinder filling plant; it is expressly forbidden to repair leaking fuse plug devices, where leak is through the fusible metal or between the fusible metal and the opening in the plug body, (except by removal of the device and replacement of the fusible metal). Exceptions are as follows:

- .1.1 Except as provided in Notes 1 and 2 safety relief devices are not required on cylinders 305 mm (12 inches) or less in length, exclusive of neck, and 114 mm (4.5 inches) or less in outside diameter.

Note 1: Safety relief devices are required on cylinders charged with a liquefied gas for which this part requires a service pressure of 125 bar (1800 psi) or higher.

Note 2: Safety relief devices are required on cylinders charged with non-liquefied gases to a pressure of 125 bar (1800 psi) or higher at 21°C (70°F).

- .2.2 Safety relief devices are not required on cylinders charged with non-liquefied gas under pressure of 20.7 bar (300 psi) or less at 21°C (70°F)
- .3.3 Safety relief devices are prohibited on cylinders charged with DOT Division 2, 3 or Division 6.1 materials in Hazard Zone A.
- .4.4 Safety relief devices are prohibited on cylinders charged with fluorine.
- .5.5 Safety relief devices are not required on cylinders charged with methyl mercaptan; with mono-, di, or trimethylamine, anhydrous; with not over 4.5 kg (10 pounds) of nitrosyl chloride; or with less than 75 kg (165 pounds) of anhydrous ammonia.

.6.6 Safety relief devices, if used, must be in the vapour space of cylinders containing pyrophoric liquids.

.2 Container valve protection

Containers charged with flammable, corrosive or noxious gases, shall have their valves protected by one of the following methods.

.1.1 By equipping the containers with securely attached metal caps of sufficient strength to protect the valves from damage during transit.

.2.2 By boxing or crating the containers so as to give proper protection to the valves.

.3.3 By so constructing the containers that the valve is recessed into the container or otherwise protected so that it will not be subjected to a blow when the container is dropped on a flat surface.

.4.4 By loading the containers compactly in an upright position and securely bracing in cars or motor vehicles, when loaded by the consignor and to be unloaded by the consignee.

.5.5 By equipping with valves strong enough to avoid damage during transit for containers containing non-liquefied gas under pressure not exceeding 20.7 bar (300 psi) at 21°C (70°F).

Hydrostatic test

.1 By water jacket, or other suitable method, operated so as to obtain accurate data. Pressure gauge must permit reading to accuracy of 1%. Expansion gauge must permit reading of total expansion to accuracy either of 1% or 0.1 cubic centimetre.

.2 Pressure of 2 times service pressure must be maintained for 30 seconds and sufficiently longer to insure complete expansion. Any internal pressure applied previous to the official test must not exceed 90% of the test pressure. If, due to failure of the test apparatus, the test pressure cannot be maintained, the test pressure may be repeated at a pressure increased by 10% over the pressure otherwise specified.

.3 Permanent volumetric expansion must not exceed 12% of total volumetric expansion at test pressure.

.4 Cylinders having a calculated wall stress of 124 MPa (18,000 pounds per square inch) or less at test pressure may be tested as follows:

.1.1 At least one cylinder selected at random out of each lot of 200 or less shall be tested in accordance with paragraphs 10.1, 10.2 and 10.3 of this section.

- .2.2 All cylinders not tested as provided in paragraph 10.4.1 of this section must be examined under pressure of at least 2 times service pressure and show no defect.
- .3.3 One finished cylinder selected at random out of each lot of 1,000 or less shall be hydrostatically tested to 4 times the service pressure without bursting. Inability to meet this requirement shall result in rejection of the lot.

Flattening test

- .1 After hydrostatic testing, a flattening test is required on one section of a cylinder, taken at random out of each lot of 200 or less as follows:
 - .1.1 If the weld is not at mid-length of the cylinder, the test section must be no less in width than 30 times the cylinder wall thickness. The weld must be in the centre of the section. Weld re-inforcement must be removed by machining or grinding so that the weld is flush with the exterior of the parent metal. There must be no evidence of cracking in the sample when it is flattened between flat plates to no more than 6 times the wall thickness.
 - .2.2 If the weld is at mid-length of the cylinder, the test may be made as specified in paragraph 11.1.1 of this section or must be made between wedge shaped knife edges (60° angle) rounded to a 12mm (½ inch) radius. There must be no evidence of cracking in the sample when it is flattened to no more than 6 times the wall thickness.

Physical test

- .1 To determine yield strength, tensile strength, elongation, and reduction of area of material. Required on 2 specimens cut from one cylinder or part thereof taken at random out of each lot of 200 or less.
- .2 Specimens must be: Gauge length 200 mm (8 inches) with width not over 38 mm (1½ inches) or gauge length 50 mm (2 inches) with width not over 38 mm (1½ inches). The specimen, exclusive of grip ends, must not be flattened. Grip ends may be flattened to within 25.4 mm (1 inch) of each end of the reduced section. When size of cylinder does not permit scouring straight specimens, the specimens may be taken in any location or direction and may be straightened or flattened cold, by pressure only, not by blows: when specimens are so taken and prepared, the inspector's report must show in connection with record of physical test detailed information in regard to such specimens. Heating of specimen for any purpose is not authorised.
- .3 The yield strength in tension shall be the stress corresponding to a permanent strain of 0.2% of the gauge length.
 - .1.1 The yield strength shall be determined by the "offset" method as prescribed in ASTM Standard E8-78.

- .2.2 Cross-head speed of the testing machine shall not exceed 3.2 mm (0.125 inch) per minute during yield strength determination.

Acceptable results for physical tests

- .1 Elongation at least 7%; yield strength not over 80% of tensile strength.

Weld tests

- .1 *Reduced section tensile test.* A specimen shall be cut from the cylinder used for the physical tests specified in clause 13.0. Specimen shall be taken across the seam, edges shall be parallel for a distance of approximately 50 mm (2 inches) on either side of the weld. The specimen must be fractured in tension. The apparent breaking stress calculated on the minimum wall thickness must be at least equal to 2 times the stress calculated under clause 7.2. and in addition must have an actual breaking stress of at least 207 MPa (30,000 pounds per square inch). Should this specimen fail to meet the requirements, specimens may be taken from 2 additional cylinders from the same lot and tested. If either of the latter specimens fail to meet requirements, the entire lot represented shall be rejected.
- .2 *Guided bend test.* A bend test specimen shall be cut from the cylinder used for the physical tests specified in .clause 13.0. Specimen shall be taken across the seam, shall be parallel and rounded with a file, and back-up strip, if used, shall be removed by machining. The specimen must be bent to refusal in the guided bend test jig illustrated in paragraph 6.10 of CGA Pamphlet C-3. The root of the weld (inside surface of the cylinder) shall be located away from the ram of the jig. No specimen shall show a crack or other open defect exceeding 3.1mm (1/8 inch) in any direction upon completion of the test. Should this specimen fail to meet the requirements, specimens may be taken from each of 2 additional cylinders from the same lot and tested. If either of the latter specimens fail to meet requirements, the entire lot represented shall be rejected.

Rejected cylinders

- .1 Repair of welded seams is authorised. Acceptable cylinders must pass all prescribed tests.

Marking

- .1 Marking on each cylinder stamped as follows:
- .1.1 DOT- 4E(HSE) followed by the service pressure (for example, DOT-4E (HSE) 16.6 bar [240 psi] etc).
- .2.2 A serial number.
- .3.3 An Authorised Inspection Body's official mark.
- .4.4 Date of test (for example, 12-98 for December 1998).

.5.5 Additional markings are permitted.

.2 Sequence of marks

Serial number shall be just below or immediately following the DOT-4E(HSE) marks; inspector's official mark shall be near the serial number. Date of test shall be so placed that dates of subsequent test can easily be added. Symbol in front of or following the serial number, with space between, or symbol and serial number stamped into welded on valve spud directly above the DOT- 4E(HSE) mark located on head of cylinder are also authorised. Other variations in sequence of marks authorised only when necessitated by lack of space.

.3 Location of markings

Markings shall be stamped plainly and permanently in the following locations on the cylinder:

.1.1 On shoulders and top head, neck or valve protection collar which may be permanently attached to the cylinder and forming a permanent part thereof.

.4 Size of marks

Space permitting, at least 6 mm (0.25 inch) high.

Inspector's Report

(a) Required to be clear, legible and may be in the following form:

(Place) _____

(Date) _____

Aluminium gas cylinders

Manufactured for _____ Company

Location at _____

Manufactured by _____ Company

Location at _____

Consigned to _____ Company

Location at _____

Quantity _____

Size _____ mm (inches) outside diameter

by _____ mm (inches) long

Marks stamped into the (location of marking) of the cylinder are:

Specification DOT- 4E (HSE) ----- Pressure

Serial numbers _____ to _____ inclusive

Inspector's mark _____

Identifying symbol (registered) _____

Test date _____

Tare weights (yes or no) _____

Other marks _____

These cylinders were made by process of _____ (Manufacturer's name)

(Signed) _____

The material used was type _____

(Inspector)

Authorised in Table I of Spec NoDOT- 4E (HSE)

By _____

(Place) _____

(Date) _____

RECORD OF CHEMICAL ANALYSIS OF ALUMINIUM FOR CYLINDERS

Numbered to inclusive

Size mm (inch) outside diameter by mm (inch) long

Made by Company

For Company

Test No	Check analysis No	Cylinders represented (Serial Nos)	Chemical analysis							
			Mg	Cr	Cu	Mn	Zn	Fe	Al	Ti Si

Aluminium was manufactured by Company.

The original of the certified mill test reports are in files of the manufacturer.

Note: Any omission of analyses by heats, if authorised, must be accounted for by notation hereon reading "The prescribed certificate of the manufacturer of material has been secured, found satisfactory, and placed on file", or by attaching a copy of the certificate.

Chemical analyses were made by: (Place)

(Date)

RECORD OF PHYSICAL TESTS OF MATERIAL FOR CYLINDERS

Numbered to inclusive

Size mm (inch) outside diameter by mm (inch) long

Made by Company

For Company

Test No	Cylinders represented by test (Serial Nos)	Yield Strength (N/mm ²) [psi]	Tensile strength (N/mm ²) [psi]	Elongation (percent)	Reduction of area (percent)	Flattening test	Burst test Bar
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(Signed)

(Place)

(Date)

RECORD OF HYDROSTATIC TESTS ON CYLINDERS

Numbered to inclusive
 Sizemm (inch) outside diameter by mm (inch) long
 Made by Company
 For Company

Serial Nos of cylinders tested arranged numerically	Actual test pressure (bar) [psi]	Total expansion (cubic centimetres) ¹	Permanent expansion (cubic centimetres) ¹	Percent ratio of permanent expansion to total expansion ¹	Tare weight (kg) ² [pounds]	Volumetric capacity ³ and Burst (bar)
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Note 1: When specifications require test for only one out of each lot of 200 or less cylinders, the check on the others must be indicated by a notation hereon reading, "Each cylinder was subjected to a pressure of ## bar (psi) and showed no defect".

¹ If the tests are made by a method involving the measurement of the amount of liquid forced into the cylinder by the test pressure, then the basic data, on which the calculations are made, such as the pump factors, temperature of liquid, co-efficient of compressibility of liquid etc must also be given.

² Do not include removable cap but state whether with or without valve. These weights must be accurate to a tolerance of 1%.

³ Report approximate maximum and minimum volumetric capacity for the lot.

Signed:

Report retention

The makers of cylinders under this specification must retain the test reports required by this specification for 15 years from the original test date of the cylinder.