

Cylinder Requalification and Markings

U.S. and International Requirements

Introduction

The purpose of this paper is to assist SF₆ gas handlers in understanding the markings on cylinders used for SF₆ and the corresponding regulatory and Standards requirements.

Cylinder Specifications

In the United States, three-cylinder types are used to transport and store SF₆: 3A, 3AA, and 3AL. These three types are used because the materials, service pressure, and wall thickness make them suitable for SF₆. The U.S. Department of Transportation (DOT) governs the requirements for each type of container, and the table below compares some of the salient requirements for each specification:

	3A (49 CFR §178.36)	3AA (49 CFR § 178.37)	3AL (49 CFR § 178.46)
Material	Seamless Steel; shortlist of authorized materials and quantities	Seamless Steel; long list of authorized materials and quantities	Seamless Aluminum; heat treatable aluminum alloys
Water Capacity	≤ 1,000 lbs	≤ 1,000 lbs	≤ 1,000 lbs
Service Pressure	≥ 150 PSIG	≥ 150 PSIG	≥ 150 PSIG
Wall Thickness	A minimum wall thickness of 0.100 inches is required for any cylinder over 5 inches outside diameter.	A minimum wall thickness of 0.100 inches is required for any cylinder with an outside diameter of over 5 inches.	The minimum wall thickness for any cylinder with an outside diameter greater than 5 inches must be 0.125 inches.
Testing	Pressure* Flattening Physical Leakage	Pressure* Flattening Physical Leakage	Pressure** Flattening

*Each cylinder must be tested to 5/3 times service pressure

**The minimum test pressure must be the greater of 1) 450 psig; 2) two (2) times the service pressure for cylinders having service pressure less than 500 psig; or 3) 5/3 times the service pressure for cylinders having a service pressure of 500 psig or greater

Requirements for Cylinder Requalification

Because these containers are often in use for over a decade, the DOT has promulgated requirements governing container requalification in 49 CFR §180.209. Containers manufactured under any one of the three specifications must be requalified every five years. 3A and 3AA containers may be requalified every 10 years if used to store SF₆, the water capacity is less than 125 lbs., and was manufactured after

December 31, 1945^{1,2}. Generally, 3A and 3AA containers must also be requalified using hydrostatic testing at 5/3 service pressure, but this requirement is waived if the container is used to store non-corrosive gas, such as SF₆³. In this case, a visual inspection in conformance with CGA C-6 or C-6.3, as applicable, is sufficient for a period of five more years, after which time hydrostatic testing is required⁴.

Containers manufactured to specification 3AL have similar requalification requirements but with some differences. For example, these containers must be (hydrostatic) pressure tested—there is no option for a visual test⁵. Further, when they contain SF₆, they must be requalified every five years⁶.

Hydrostatic Testing

Hydrostatic testing involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection and pressurizing the vessel to a level higher than the service pressure for 30 seconds or more. After this period, the requalifying entity releases the pressure and records cylinder expansion, followed by an internal visual inspection. A good description of this process can be found in ISO 9809 *Gas cylinders—Refillable seamless steel gas cylinders—Design, construction, and testing*.

There are a variety of firms that provide cylinder requalification services, including (but not limited to):

- a. Western International Cylinder
- b. All Safe Global
- c. Hydrostat Inc.
- d. Central Welding Supply
- e. Airgenics Inc

Markings

The U.S. Department of Transportation regulates cylinder markings to indicate compliance with requalification requirements as follows:

49 CFR § 178.35(f):

- a. The specification marking must appear first, followed immediately by the cylinder service pressure—for example, DOT-3A1800.
- b. A symbol (comprised of letters and representing the cylinder manufacturer) and registered with the U.S. Dept of Transportation must be placed just below, immediately before or following the serial number.
- c. The cylinder serial number must be placed just below or immediately following the DOT specification marking.

¹ 49 CFR §180.209(b).

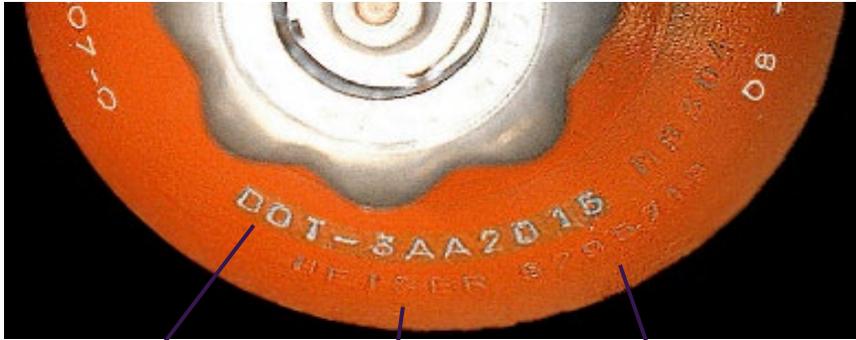
² Other conditions apply

³ 49 CFR §180.209(a), Table 1

⁴ 49 CFR §180.209(g)

⁵ 49 CFR §180.209(a), Table 1

⁶ Ibid.



**Specification
Marking**

**Cylinder
OEM Symbol**

**Serial
Number**

49 CFR § 178.35(f): Cont'd

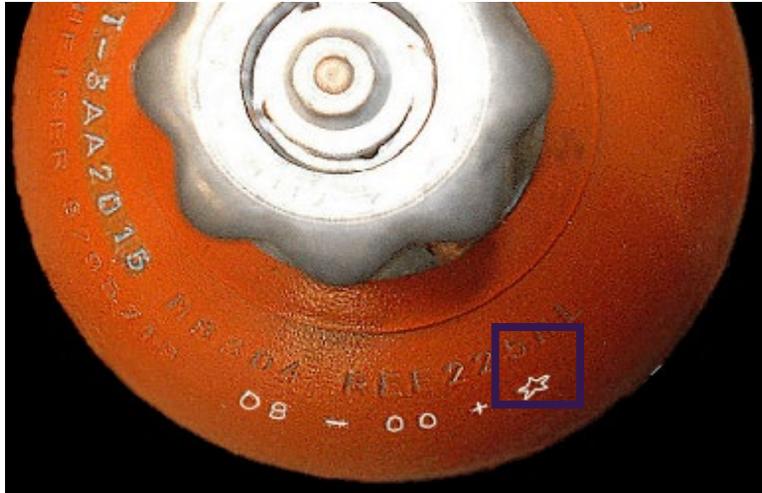
- d. The inspector's official mark and date of the test (such as '5-95' for 'May 1995') must be placed near the serial number.



49 CFR § 178.35(f): Cont'd

- e. The word "spun" or "plug" must be placed near the DOT specification marking when an end closure in the finished cylinder has been welded by the spinning process or affected by plugging.
- f. Markings on each cylinder must be stamped plainly and permanently on the shoulder, top head, or neck.
- g. The size of each marking must be at least 0.25 inches or as space permits.

49 CFR §180.209(b)(vi): when a cylinder is requalified every 10 years, instead of every five, a five-pointed star must be stamped at least one-fourth of an inch high immediately following the test date.



Note: A cylinder may be sent for requalification while still within the prior five- or ten-year qualified period. As a result, some requalifiers do not remove or otherwise cross out the prior requalification date. Rather, they stamp a new requalification date (usually to the right of the prior date). The correct date is the most recent stamped date. All others are no longer applicable.

49 CFR §180.213(d): Each requalified cylinder must be marked with the qualifier identification number set in a square pattern between the month and year of the requalification date.



U.N. Pressure Receptacles

The Code of Federal Regulations allows for the use of U.N. pressure receptacles (i.e., cylinders that comply with ISO specification and marking Standards) as an alternative to U.S DOT requirements discussed above. For example, 49 CFR § 178.71(g) requires that U.N. refillable seamless steel cylinders (commonly used for SF₆ storage) comply with the ISO 9809 series of Standards for design, construction, and testing.

49 CFR § 178.71(q) addresses the marking requirements of U.N. pressure receptacles and largely mirrors ISO 13769 *Gas cylinders—Stamp marking*. While there is substantial overlap between US DOT regulations and the ISO Standard, the latter entails a specific marking sequence while the former groups the markings into three rows but leaves it open to the manufacturer to choose the sequence within each row. Note that there are two differences between U.S. Code requirements and ISO 13769. First, the DOT requirements put the manufacturer approval number (#3 below) on the bottom row while the ISO Standard places it at the top. Second, ISO does not require the identity mark or stamp of the independent inspection agency (#4 below). It's also important to note that ISO 13769 does not require *all* of the markings illustrated in the figure below, pending the availability of space on the cylinder. An asterisk (*) designates these below.

(12) 25E	(13) USA	(14) 765432	(15) H	(16)* AA6061 T6	(17)* UT
(9)* 5.8MM	(8) 62,1KG	(10) PW200	(6) PH300BAR		
(1)	(2) ISO 9809	(3) USA/MXXX	(4) IB	(5) 2005/12	

1. The 'U.N.' packaging symbol
2. The ISO Standards, i.e., 9809
3. The mark of the country where the approval is granted and the manufacturer approval number
4. The identity mark or stamp of the independent inspection agency (IIA)
5. The date of the initial inspection, the year (four digits) followed by the month (two digits) separated by a slash, for example, "2006/04"
6. The test pressure in bar, preceded by the letters "P.H." and followed by the letters "BAR"
7. (Not applicable to SF₆)
8. The empty or tare weight
9. The minimum wall thickness of the pressure receptacle in millimeters followed by the letters "MM"
10. The working pressure in bar preceded by the letters "P.W."
11. (Not applicable to SF₆)
12. Identification of the cylinder thread type
13. The country of manufacture
14. The serial number
15. The letter "H" shows compatibility of the steel
16. Identification of aluminum alloy, if applicable
17. Stamp for nondestructive testing, if applicable
18. (Not applicable to SF₆)
19. (Not applicable to SF₆)
20. (Not applicable to SF₆)
21. (Not applicable to SF₆)

Requalification for U.N. Pressure Receptacles

Requalification requirements for U.N. Pressure Receptacles are found in 49 CFR § 180.207. These include conformance to 49 CFR §180.213 (see above) for requalification markings. Pressure receptacles (when used for SF₆) can be requalified every 10 years, in which case the five-pointed star is required as per 49 CFR §180.209(b)(vi). Requalification must utilize a hydraulic pressure test (the hydrostatic test discussed above is one option, though not the only option here).

Seamless steel pressure receptacles, commonly used for SF₆, must be requalified in accordance with ISO 6406 *Gas Cylinders—Seamless Steel Gas Cylinders—Periodic Inspection And Testing*. If the

cylinder has a tensile strength greater than or equal to 950 MPa, it must be requalified by ultrasonic examination in addition to the hydraulic pressure test discussed above. This process entails the use of high-frequency sound energy for the detection/evaluation of flaws and for dimensional measurements. The test equipment (typically a U.E. transducer) creates a high-frequency sound wave that travels through the cylinder. When the wave encounters the material's boundary or a discontinuity (i.e., flaw), the wave is reflected back to a sensor. When the cylinder has passed the ultrasonic test, ISO 13769 provides the option but does not require the cylinder to be marked with "U.T."

Seamless Aluminum receptacles must be requalified in accordance with ISO 10461 *Seamless Aluminum—Alloy Gas Cylinders—Periodic Inspection And Testing*. As of the publication of this guide, that Standard has been withdrawn by ISO and replaced with ISO 18119 *Gas cylinders—Seamless steel and seamless aluminum-alloy gas cylinders and tubes—Periodic inspection and testing*. DOT is working on updating the reference but, until they do so, ISO 10461 is binding in the use of U.N. pressure receptacles in the U.S. The Standard contains a range of tests, including hydraulic and ultrasonic testing. Unlike the requirement for DOT cylinders (3AL), U.N. pressure receptacles made of aluminum may be requalified every ten years.

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