



COMPRESSED GAS ASSOCIATION, INC.

TECHNICAL BULLETIN

TB-26—2010

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FILLING NONLIQUEFIED GASES IN TC/DOT SPECIFICATION CYLINDERS TO A SPECIFIED SETTLED PRESSURE

Introduction

The compressed gas industry follows U.S. Department of Transportation (DOT) and Transport Canada (TC) regulations that specify filling requirements for compressed gases. Industry practice is to fill compressed gas cylinders to achieve a specified settled pressure that does not exceed the authorized service pressure at reference temperature in accordance with DOT regulations found in 49 CFR 173.301a(c) or Canadian regulations found in *Transportation of Dangerous Goods Regulations* and CSA B340, section "Filling pressures" [1, 2, 3]. It is recognized that the filling process is subject to variations that affect the settled pressure.

Scope

This publication describes the variations that can occur during the filling of cylinders with nonliquefied gases. This publication contains recommendations to minimize the effect of these variations on the settled pressure. In addition, it identifies the variability in the specified settled pressure that fillers can reasonably expect.

Factors that cause variations in achieving a specified settled pressure

Variations in settled pressure can be attributed primarily to the following factors:

- Personnel—training, experience, and diligence of cylinder filling personnel;
- Methods—rate of filling, thermodynamic data, temperature measurement techniques, filling procedures, etc.;
- Materials—gas supply, cylinder, and cylinder valve;
- Equipment—filling equipment and measuring devices; and
- Environment—temperature, ventilation, and altitude.

Recommendations

The following recommendations, used in combination as appropriate, will reduce variations in reaching a specified settled pressure.

Personnel

Cylinder filling personnel should be trained in the operations they perform, and the training shall be recorded in accordance with the requirements of the applicable regulatory authority. The training shall include regulatory requirements and recognition of the factors affecting settled pressures including: personnel, methods, material, equipment, and environment associated with the filling operation. The trainee shall be directly supervised.

To minimize the impact of these factors, cylinder filling personnel shall have experience with the methods, material, and equipment used in the filling process as well as the environment where the filling is performed. Supervision shall be provided to ensure continued diligence of personnel performing the filling operation, consistent with their training.

Methods

The four primary elements related to methods that influence the settled pressure are:

- Rate of filling—The rate of filling affects the capability to achieve the specified settled pressure by creating a temperature differential between the gas and the outside surface of the cylinder. The filling process shall take into account that the temperature differential between the gas temperature and the cylinder surface is greater with a faster fill rate;

NOTE—The fill rate is affected by the percent opening of the cylinder valve (see Materials).

- Thermodynamic data—It is essential to use accurate thermodynamic data to develop charts and tables for the filling process. The filling facility may use industry recognized algorithms, charts, or tables such as those found in CGA P-15, *Filling of Industrial and Medical Nonflammable Compressed Gas Cylinders*, or National Bureau of Standards Technical Note 1079, *Tables of Industrial Gas Container Contents and Density for Oxygen, Argon, Nitrogen, Helium, and Hydrogen* [4, 5]. The filling facility may use charts or tables derived from their own calculations provided they can demonstrate validity for such calculations;
- Fill by weight—When filling by weight, the proper mass to be introduced into the cylinder shall correspond to the mass a given container will hold if such container were filled to the authorized service pressure at the reference temperature. Various size cylinders should not be filled simultaneously by this process; and
- Fill by pressure/temperature—When filling by the pressure/temperature method, the pressure and temperature readings shall be accurately measured to achieve the authorized service pressure at the reference temperature. This process shall consider where on the cylinder the temperature is measured.

Materials

Each gas has defined thermodynamic and transport properties that shall be considered in the filling process to achieve the specified settled pressure.

The cylinder material properties affect the heat transfer from the gas to the outer surface of the cylinder. The gas temperature is typically correlated to a temperature measurement on the outer surface of the cylinder. Cylinders with total metallic construction generally have higher heat transfer rates than cylinders of composite material construction. Based on the cylinder material properties, a reliable filling process shall be developed to achieve the specified settled pressure.

The cylinder valve flow coefficient and percent opening of the valve have an influence on the gas temperature during filling and should be taken into consideration to achieve the specified settled pressure.

Equipment

The filling process shall take into account the effects the filling equipment and design have on achieving the specified settled pressure.

Pressure and temperature measuring devices used together during cylinder filling shall have certified accuracies. The range, resolution, and readability of the devices shall be appropriate for the values being measured. Temperature measuring devices shall be able to indicate increments of 2 °F (1 °C) or better. Pressure measuring devices shall have a resolution or be graduated in increments not greater than 25 psi (170 kPa) or 1% of the authorized service pressure of the cylinder.¹

When used for filling, mass measuring devices shall have certified accuracies and range, resolution, and readability appropriate for the mass being measured. Mass measuring devices shall have resolution not greater than 1% of the total mass of the gas, equivalent to the amount required to achieve the authorized service pressure.

¹ kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure or (kPa, differential) for differential pressure. All kPa values are rounded off per CGA P-11, *Metric Practice Guide for the Compressed Gas Industry* [6].