CGA P-40—2011

CALCULATION METHOD FOR THE ANALYSIS AND PREVENTION OF OVERPRESSURE DURING REFILLING OF CRYOGENIC TANKS WITH RUPTURE DISK(S)

THIRD EDITION

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NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendix A (Normative) is a requirement.

NOTE—Appendices B, C, D, and E (Informative) are for information only.

THIRD EDITION: 2011
SECOND EDITION: 2007
FIRST EDITION: 2004

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1 Introduction

Cryogenic transports often use pumping systems that discharge product at pressures exceeding the working pressure of the liquid storage tank being filled. In North America, pumping systems for transferring oxygen, nitrogen, or argon are typically capable of delivering pressures greater than 400 psig (2760 kPa).[1] The cryogenic storage tank being refilled usually has a maximum allowable working pressure (MAWP) that is considerably less than the pump discharge pressure. Depending on the inherent tank design safety factors and the size and flow capacity of the tank pressure relief system, the potential to overpressure the tank during operator-attended manual refill operations exists. CGA P-59, *Prevention of Overpressure During Filling of Cryogenic Vessels*, and EIGA Doc 151/08, *Prevention of excessive pressure in cryogenic tanks during filling,* were written in response to overpressure events that occurred in the compressed gas industry [2, 3]. CGA P-59 and EIGA 151/08 discuss the requirements necessary to ensure that cryogenic storage tanks are not overpressurized in manual refill operations [2].

It is the responsibility of each tank owner to complete a technical evaluation of the storage tank fill and relief device piping. This technical evaluation shall be repeated any time a change is made in either the pump flow and pressure capability or the tank fill and relief system flow capacities. The storage tank owner shall ensure that pump operators are properly trained and certified.

2 Scope

This publication provides technical guidance and the complete equation set needed to determine if a particular vessel can or cannot be overpressurized during the refill operation. Acceptable engineering controls for the protection of cryogenic storage tanks and transport tanks with rupture disk(s) as part of the relief system are provided. The application of these engineering controls constitutes a minimum standard.

The calculations in this publication should be used to evaluate each pumping system and cryogenic tank combination in use with oxygen, nitrogen, or argon. It applies to tanks filled either by pump from a cryogenic transport or by a ground-mounted pump. This applies to cryogenic tanks greater than 265 gal (1000 L) water capacity.

3 Nomenclature

Table 1 contains the definitions of the variables used in this standard.

Table 1—Definition of variables

Symbol	Definition	U.S. customary units (abbreviation)	Metric units (abbreviation)
A	Intermediate variable used in calculation of friction factor		
C	Flow coefficient for an orifice		
C_v	Flow coefficient for valves	gallons per minute per psi (gal/min/psi)	
d	Internal line diameter	inches (in)	millimeters (mm)
d_{disc}	Diameter of the rupture disk based on the minimum net flow area as specified by the manufacturer	inches (in)	millimeters (mm)
d_{fill}	Reference internal diameter for the fill line	inches (in)	millimeters (mm)
d_{ori}	Diameter of the fill orifice	inches (in)	millimeters (mm)
d_{rel}	Reference internal diameter for the pressure relief line	inches (in)	millimeters (mm)
f_t	Friction factor (Fanning friction factor used)		

[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* [1].