Pressure Relief Valve and Propane Cylinder Performance Testing

Improving Cylinder Safety and Reliability

Due largely to its reputation as a safe, clean, efficient, and reliable fuel, over 60 million Americans use more than 11 billion gallons of propane for industrial, transportation, agricultural, commercial, and domestic applications every year. While propane does have a remarkable safety record, certain precautions are necessary to assure safe and successful use. As such, the propane industry proactively implements programs, products, and preventions with safety first in mind.

In 2002, the U.S. Department of Transportation's Research and Special Programs Administration (RSPA) revised the regulations governing cylinder inspections and pressure relief devices. Several changes were made, though RSPA did keep the existing visual inspection requirements for cylinders (outlined in CGA Standard C-6, "Standards for Visual Inspection of Steel Compressed Gas Cylinders"), the reference to CGA Standard S-1.1 for pressure relief devices ("Pressure Relief Device Standards-Part 1-Cylinders for Compressed Gases"), and the existing exemption from the pressure relief device periodic replacement in S-1.1. RSPA did, however, state that they "will examine this issue in a future rulemaking, as necessary."

Project Description

In anticipation of possible regulatory changes, the propane industry proactively sought to gather data on the performance of cylinder inspection methods and pressure relief valve (PRV) performance. Accordingly, the Propane Education & Research Council (PERC) funded a research effort, *Relief Valve and Cylinder Testing* (**Docket 10202**) to gain a clear understanding of propane cylinder and PRV performance issues and concerns. Completed February 2003, the National Propane Gas Association (NPGA) obtained the assistance of Battelle Memorial Institute for developing a technical basis to support the expectation that the service life of propane cylinders and PRVs can safely exceed ten years.

Propane Cylinder Applications

In the United States, propane is typically stored and transported in steel cylinders ranging in volume from one quart to 120 gallons. This project focused on the most common storage cylinder for consumer use, the 20-pound propane capacity cylinder, used in the following applications:

- outdoor cooking grills
- heaters
- torches
- mosquito control equipment
- other consumer appliances

Performance Testing

Equipment used for cylinder testing (left), and PRV testing (right)

Testing Program

Cylinders and PRVs in service for two to 60 years were collected from across the country and tested for performance and integrity. The testing program consists of the following objectives:

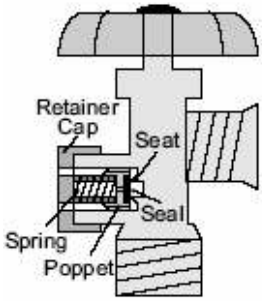
1. Test and evaluate cylinder and PRV performance
2. Examine efficacy of the Visual Inspection Method
3. Examine and publish performance data of PRVs relative to age
4. Consider the probability of matching an unacceptable relief valve (too high relief pressure) with an unacceptable cylinder (too low rupture pressure)
5. Recommend improvements or revisions to the Visual Inspection Method

Cylinder Testing

Nearly 400 cylinders were visually inspected according to CGA Standard C-6, Standards for Visual Inspection of Compressed Gas Cylinders procedures. More than 200 cylinders were subjected to hydrostatic expansion and burst testing using a minimum design burst pressure of 960 psi, which is four times the service pressure of 240 psi and consistent with DOT requirements.

Pressure Relief Valve (PRV) Testing

PRVs are designed to prevent cylinder expansion or rupture in the event of excessive pressure. The spring-loaded valve poppet, with elastomeric seals, relieves pressure resulting from increased temperatures or overfilling; the seals reseat when pressure decreases to an acceptable level. CG-7 type PRVs are used with 20-pound propane cylinders.



Over 230 PRVs were subjected to tests adapted from CGA Standard S-1.1, “Pressure Relief Device Standards-Part 1-Cylinders for Compressed Gases,” including measurements of start-to-discharge, full-open, and reseat pressures and valve full-open flow rates.

Notable Results

Test results were compiled in a comprehensive database which allows direct and detailed comparison of relief valve and cylinder performance and determines failure safety factors with 95 percent confidence. Additional results include:

- Most cylinders were very robust and capable of containing very high pressures
- Surface corrosion does not adversely affect cylinder performance
- Only those cylinders that were subjected to severe corrosion, where the cylinder wall was eroded, failed pressure tests; these cylinders were also rejected by the Visual Inspection Method
- Visual inspection is an effective and conservative performance test; many cylinders that failed the visual inspection, passed the hydrotest
- Cylinders passing visual inspection had a hydrotest safety factor of five or higher
- PRV performance was not shown to be significantly affected by valve age, manufacturer, or original environment

Conclusions

Overall, 20-pound propane cylinders are quite durable, and the Visual Inspection Method effectively identifies damaged or weakened cylinders. Age-based criteria and compulsory replacement of PRVs over ten years old does not reliably improve performance.

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