

The water jacket method for hydrostatic testing consist of loading a water filled cylinder into a sealed chamber (test jacket) filled with water and connected to a calibrated glass tube (burette) or Galiso's Electronic Expansion Measuring System (the expansion bowl was invented to replace the burette). The burette or Expansion Bowl is first zeroed and the cylinder is then pressurized to its specified test pressure (test pressure requirements are contained in the U.S. Code of Federal Regulations, 49 CFR 180.205). This test pressure is held for a minimum of thirty seconds. As pressure is applied to "inflate" the cylinder, the cylinder expands and forces water out of the test jacket and up into the Expansion Bowl or burette. After the thirty second test time has elapsed, the Expansion Bowl or burette is read to determine the Total Expansion (in cubic centimeter) of the cylinder under test pressure. The test pressure is released and the cylinder "deflates". As the cylinder shrinks to its approximate original size, water is allowed to drain back into the test jacket from the burette or Expansion Bowl. In most cases the cylinder will not return to its original size, having been slightly stretched by the pressurization process. This stretching is called the Permanent Expansion. The difference between the "Total Expansion" and the "Permanent Expansion" is called the "Elastic Expansion". The Percent Permanent Expansion of the cylinder is determined by the following formula: **Percent Permanent Expansion = (Permanent Expansion/Total Expansion) X100**

When the Percent Permanent Expansion exceeds the predetermined limits for the cylinder being tested, (REE Reject Elastic Expansion), the cylinder must be condemned and removed from service. A high percent permanent expansion value is an indication that the cylinder metal has lost it's elasticity, or that there has been excessive thinning of the cylinder wall and that the cylinder is no longer safe for use. All test records must be saved and maintained for the duration of the re-qualification Plus (+) stamped cylinders may be filled to an additional 10 percent beyond the service pressure that is stamped on the cylinder shoulder for certain specified gases. The Water Jacket Method of testing compressed gas cylinders is the only hydrostatic test method that qualifies for filling to 10% over service pressure. Star (*) stamping makes the cylinder eligible for an extended ten year re-test interval. The procedures of requirements for plus stamping and star stamping are found in 49 CFR 180.209 (c) for plus stamping and 173.34 (e) (16) for the star. REE values for common cylinder can be found in compressed Gas Association Pamphlet C-5, "Cylinder Service Life, Seamless High Pressure Cylinders". This pamphlet is available for purchase from Galiso or purchase directly from the Compressed Gas Association.

Direct Expansion Method

During the direct expansion test, the cylinder is completely filled with water and the test connection is then screwed into the cylinder neck. Water is pumped into the cylinder until the desired test pressure is achieved. (Test pressure requirements are contained in the U.S. Code of Federal Regulations 49 CFR 180.205). The Volume of water that is pumped into the cylinder to reach the test pressure is measured to determine the Total Expansion. The Volume of the water that is expelled from the cylinder when pressure is released is measured to determine the Permanent Expansion. Because air has a different compressibility factor than water, air trapped inside the cylinder will cause inaccurate test results so it is very important that the cylinder is completely filled with water to eliminate trapped pockets of air. The weight of the water contained in the cylinder, the test pressure, test volume (s) and temperature are used to determine the compressibility factor for calculation of the expansion values. DOT regulations prevent the Direct Expansion Method from being used to qualify cylinders for filling to 10% over service pressure and therefore forbid the Direct Expansion test method to be used to re qualify plus (+) stamped cylinders. The Direct Expansion test method is discussed in detail and example calculations are given in CGA pamphlet C-1, "Methods for Hydrostatic Testing of Compressed Gas Cylinders". While not generally practiced in this country, the U.S Code of Federal Regulation permit that certain specified cylinders (used exclusively in non-corrosive service) do not require the total and permanent expansion to be calculated. For such cylinders, the Proof Pressure method may be used.