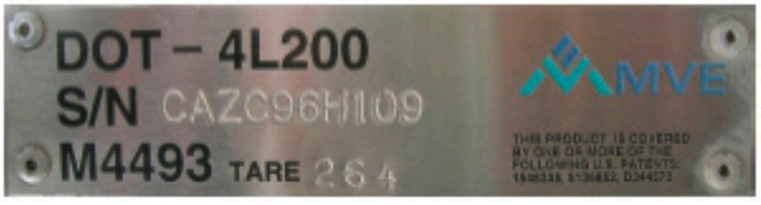
Cryogenic Liquid Cylinders

By Tim Neeser Published: June 15, 2010

Fill plant personnel must understand the basic operations and DOT regulatory requirements when distributing liquid cylinder containers.

The distribution of cryogenic liquid cylinders over the past few decades has not changed much since their design was upgraded for durability and efficient filling practices were adopted back in the 1980s. However, operators must not lose sight of the regulations for the safe distribution of this convenient packaged gas product. They must understand the operation, stamping and filling requirements, as there are likely various models and manufacturers of these cylinders in their fleets.



This article will focus primarily on the regulations governed by the Department of Transportation (DOT) under the Code of Federal Regulations (CFR49) section 178.57, where the DOT – 4L code for transportable liquid cylinders is found. This code is relatively short and efficient, with clear requirements for manufacturing, repairing and servicing cryogenic liquid cylinders for over-the-road distribution.

Safety Devices

One of the most important requirements in the 4L code is the marking and calculation of the safety devices used to protect the inner pressure vessel. Manufacturers use these guidelines to design and select the appropriate safety devices based on calculations derived from the Compressed Gas Association (CGA) code, pamphlet S1.1 (CFR49 section 173.316). These safety devices are marked and sized accordingly to meet the minimum requirements for the capacity, liquid service and maximum operating pressure of the liquid cylinder on which they are installed. Confirming this requirement during the procurement of replacement relief valves and rupture disks from a reputable supplier will help ensure device compliance.

Based on the liquid cylinder stamping data, calculating the pressure settings on both of these safety devices is actually relatively simple. On a DOT – 4L coded cylinder, you can find the service pressure on the cylinder data plate. The service pressure (psig) is noted directly after the DOT marking: DOT – 4L SP. This will be a three-digit numeric value that dictates the design of the inner vessel thickness and the maximum allowable operating pressure calculation from the manufacturer.

Model Suffix	Model Color	Service Pressure (psig)	Maximum Relief Valve (psig)	Maximum Rupture Disk (psig)
LP	Yellow	100	110	200
MP	Blue	200	235	400
HP	Orange	292	350	584
VHP	Red	412	500	824

To calculate the maximum allowable operating pressure or maximum relief valve setting, the following equation is used:
1.25 x Service Pressure – 15 psi (for vacuum)
= Maximum Relief Valve

For example, a liquid cylinder with a service pressure of 200 psig will yield a maximum relief valve setting of 235 psig. Some manufacturers have adopted a model and color coding system to safely communicate this information.

To determine the maximum rupture disk setting, the following equation is used:
2 x Service Pressure = Maximum Rupture Disk

In the example above, the maximum rupture disk of 400 psig is calculated. Incidentally, the maximum rupture disk pressure rating is the hydrostatic test pressure of the inner vessel during its manufacturing process.

Filling Regulations

The second most important requirement in operating DOT – 4L liquid cylinders is following safe filling practices. As we all know, there have been many model cylinders in use over the years that have had unique capacities and operating pressures. The DOT – 4L code references the CFR49 section 173.316 for the liquid cylinder manufacturer to establish proper safe fill levels. Because of the variables from service (gas densities), gross capacity and maximum allowable operating pressures, a 4L cylinder MUST be filled by weight. This process ensures the liquid cylinder has enough gas space after filling to prevent liquid from escaping through the safety relief valve in the event the cylinder remains idle and the liquid grows (expands) as heat enters the inner vessel.

STANDARD FILLING WEIGHT TABLE

RELIEF VALVE Setting (PSIG)	ARGON		NITROGEN		OXYGEN		CO_2		N_2O	
	LBS	SCF	LBS	SCF	LBS	SCF	LBS	SCF	LBS	SCF
DURA-CYL 180 HP (350 psig max. RV) Gross Cap = 196 Liter										
0 to 45	573	5541	327	4514	465	5615	-	-	-	-
46 to 75	560	5416	319	4403	452	5458	-	-	-	-
76 to 105	547	5290	310	4278	444	5362	465	4065	448	3903
106 to 170	526	5087	301	4155	431	5205	452	3951	435	3789
171 to 230	513	4961	297	4099	422	5096	448	3916	426	3711
231 to 295	495	4787	293	4042	413	4987	439	3837	418	3641
**296 to 360	487	4710	280	3865	401	4842	431	3767	409	3563

The only way to safely determine the DOT – 4L filling limits is to use the manufacturer's published values. Do not interpret model numbers for filling volumes as these are only nominal values that have no accurate relevance to the filling weights. Additionally, you should use the actual relief valve setting on the liquid cylinder to determine the proper maximum fill weight as noted on the example table above.

It is important to fill all liquid cylinders by their published fill weights to comply with the DOT – 4L regulations. There is, however, one exception to the filling regulation (CFR49 section 173.320): If you are operating under the 25.3 psig (40 psia) relief valve setting (22 psig is typically used in liquid service), you are not required to fill by weight so the operator can fill the liquid cylinder to "vent full." This is allowed because the liquid will not have a chance to grow as the relief valve is set very low and hence there is minimal risk of liquid dispensing out the safety relief valve.

The fill plant operating standards must have these practices incorporated into their liquid cylinder filling section so they are clearly communicated to the liquid cylinder repair and filling personnel. As liquid cylinders change service and/or operating pressures (frequently done to match the customer's application requirements), and as personnel changes at the fill plant, it is imperative that these two DOT – 4L regulatory requirements are consistently followed to ensure safe handling by all personnel who come in contact with liquid cylinders on a daily basis.

Meet the Author

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