Filling Cylinders In Water - Time to Review

by Bill High, President, PSI, Inc.

I recently received a copy of a note written by a Mike R. who says he knows his physics and therefore knows that using a wet tub when filling cylinders is beneficial. When just looking at physics we can all pretty much agree that heat transfer is far greater in water than in air. Coldwater divers concluded that fact long ago without any physics classes. However, claiming one law of physics justifies placing dive cylinders into typical dive store water tubs during fill as is still done at some air stations, simply isn't the right thing to do. Fred Calhoun, writing in the Nov/Dec 1988 issue of NAUI NEWS, addressed the dry fill/wet fill issue accurately and in detail. Fred's article is still distributed by PSI in its publication SCUBA CYLINDER REPRINT FILE. The PSI, Inc. textbook, INSPECTING CYLINDERS also explains how the tub fails to achieve what its promoters desire.

Water tubs often contribute to overfilling. There are a number of laws, industry policies and common sense that relate directly or indirectly to the use of water tubs and must be considered when filling cylinders. For example, it is illegal to overfill cylinders. Chilled water tubs can contribute to overfilled cylinders as can careless operators who think overfilling is alright as the water bath will drop pressure some. The Pressed Steel Tank Co. states "PST can provide no assurance that cylinders which have been subjected to over-pressurization are safe to use". Further, structural damage during overfill is cumulative and irreversible. Hydro tests have been shown to be unreliable in detecting fatigue damage for overfill; therefore, even those overfilled cylinders which have passed hydro test may suffer a leak or rupture.

Many fill station operators (FSO) don't know when, by law, a cylinder is full. Each DOT or ICC authorized cylinder must have a legible service pressure marking. A cylinder is full when an accurate gauge shows the marked service pressure at a temperature of 70 degrees F. Many air station gauges are seldom or never tested to assure accuracy. A cylinder filled slowly (as all cylinders should be) in chilled water will actually be overfilled when allowed to come to a higher ambient temperature. It will be difficult to defend an air station with a policy or reputation for overfilling cylinders. It is worth repeating, water tubs often contribute to overfilling.

Reported Water Tub Benefits

Several perceived benefits to using a water bath during fill are offered by tub proponents.

They include (1) cooling allows more air in the cylinder, (2) cooling allows faster fills, (3) the water will absorb the energy of a ruptured cylinder, (4) the tub itself provides explosion protection, and (5) the water bath provides cylinder cleaning.

Relating to benefit numbers one and two above, cylinders, when filled at the industry recommended fill rate of 300-600 psig/min, do not get hot. They may be warm but usually the temperature of the water is too close to the cylinder increase (about 100 to 110 degrees F.

maximum) that the exchange rate is slow and low. We don't want more air in the cylinder than is allowed by law. We don't want fast fills, beyond the industry standard, if for no other reason, than cylinders will get warm and such practice makes the air station un-defendable.

The whole water tub thing began in the mid 1950's when we knew very little about cylinders and their care. Steel cylinders got warm during what we now know to be fast fills. We didn't know about prudent fill rates, and we often ignored the service pressure limit. Cylinders were filled quickly, removed from the water promptly and very little actual in-water temperature reduction took place. Then along came aluminum cylinders with walls nearly ½ inch thick.

The aluminum cylinders didn't seem to get as warm. That was because although we still filled quickly, the heat generated within the cylinder took much longer to transfer to the outside. The water bath cylinder was removed from the water and sent on its way, long before the fast fill generated heat could be dissipated into the water.

What about the perceived benefit that the water bath will absorb explosive energy? There simply is not enough water between the FSO and the exploding cylinder to have any measurable effect whatsoever unless of course the tub is a nearby swimming pool. But, surely the tub itself will provide protection. Not true when you look at a great many of the water tubs in use today. Plastic garbage cans are used as well as sheet metal buckets of one sort or another. The energy within a full, exploding cylinder is so great, well over one million ft. lbs of potential kinetic energy, that all these containers break up and contribute shrapnel to injury and property damage. Even concrete block barriers usually disintegrate.

Ok, well at least a water bath cleans away harmful salt deposits or other contamination. Once again the facts don't support this view. Most tubs used in dive stores today and fortunately there are fewer each year, do not regularly have the water changed. Fresh water is often added to make up for that which has evaporated or been spilled out onto the dive store floor but no total exchange. Consequently, contaminates left by one cylinder remain there for the next and the contamination level increases over time to where the following cylinders are bathed in contaminated water. Don't forget that water puddle on the floor where customers or employees might slip and be injured. OSHA will not treat the store owner kindly.

Water Gets Inside

The greatest concern for water baths when filling cylinders is water entering into the cylinder. With water, metal and the ample oxygen in compressed air, cylinders can be damaged dramatically in a very short time. A study conducted by the University of Rhode Island revealed that under adverse conditions, a steel cylinder with a small amount of salt water (remember the fill tub may contain contaminated water) could be in danger of exploding within as little as 100 days. In a perfect facility, tub water does not enter the cylinder but, in many tubs, water is allowed to enter the valve aperture as well as the fill whip connector. Those water droplets are pushed into the cylinder.

The reader should note that in the above paragraph I referred to a perfect water tub system. A very few do exist, reinforced concrete and steel tubs serving both to hold water and as a blast shield. Cylinders placed into the water cannot drop below the valve aperture, fill whips can't reach water level. It has a drain that is used often. Of course the fill station should be away from customers. Even this perfect water tub for filling is un-needed, although any true

blast protection is a very wise investment. Nowhere else in the gas industry are cylinders routinely filled in a water tub.

Summary

High-pressure cylinders should not be filled in water tubs because the perceived benefit, when the laws and industry policies are followed, is negligible. There is real potential for overfilling cylinders, injecting water into the cylinder and developing a false sense of security that the bath somehow protects the FSO. Air station personnel deserve real protection. To that end, they need to be educated, have a safe air station and only fill cylinders that have been inspected by trained visual inspectors and hydrostatic re-qualifiers.