Tank Burst Disk Modification

Background

US regulations require that all scuba tanks which are to be transported on public roads be fitted with overpressure prevention devices commonly known as "burst disks". These are thin copper disks which are normally held by a hollow plug tapped into the stem of the valve, up against an orifice connecting to the inside of the tank. In the event of extreme overpressure, for example caused by a fire or a compressor whose own overpressure valve has failed, the burst disk is intended to rupture and release the tank contents harmlessly through the hollow plug before the tank itself explodes. The thickness of the disk determines its rupture pressure. US compliant valves are often sold or used outside the US, even if local regulations do not require the use of burst disks.

Although it is fairly common to see burst disk failures when tanks are left in the sun all day (for example at beach dive shops), failure underwater is rare and perhaps has never happened, presumably because tank pressures generally reduce due to cooling when entering the water and then further reduce during the dive. However the consequences of a failure underwater could easily be fatal: the almost immediate loss of air from the tank (and probably from any tank manifolded to it), the commotion and loss of visibility caused from this, and then the possible back-filling of the tank with water, particularly if the cave requires a re-descent to exit. For this reason, some cave divers advocate the modification of the burst disk assembly to disable it and so eliminate the possibility of failure underwater. Modifications may include plugging the orifice in the tank valve stem, using thicker copper disks punched out of sheet copper, or using two or three burst disks in a sandwich. The decision to do any of these needs to be taken carefully, as any interference may increase the risk of failure. The implementation of any modification needs also to be done with care, as the stresses on the components can be very high.

My approach in Mexico has generally been to disable all burst disk arrangements on my principal cave diving tanks (doubles and stages), but not on my oxygen decompression bottles. The reasons for excluding the oxygen bottles are: (1) when they are not used in the water they double as first aid equipment and spend long periods in my truck in the sun, and maybe a burst disk rupture would be better than a tank rupture, (2) their failure in the water is unlikely to be fatal because for all dives I have done in Mexico so far, any oxygen decompression is carried out in or very near to open water, and (3) we do not boost oxygen into these tanks, so they are only filled to 130 or 140 bar at most. I do not know if this is the right decision, but it is what I have done.

Modification

My objective was to come up with a simple modification (so that I could do it myself) which minimised interference with the valve and retained the ability to convert the valves back to normal service. What I therefore did was tap a thread into the hollow plugs which hold the burst disks into the valve stem, screw into these a brass "grub screw" ("*tournillo prisonero*" in Mexican Spanish), and solder the grub screws into the plugs to create a strong and airtight seal. The burst disk assemblies were then re-fitted to the tank valves in the standard way, including a regular burst disk, so that the only modifications were effectively “downstream” of the original burst disks and would only come into play if one of the burst disks were to fail.

The pictures and comments below give some details of how I have done this.

Step 1 - thread size

I decided to use US size #12/24 screws, because the required pilot hole for the tap for this thread is very close to the size of the centre hole of the hollow plugs, so I would not have to drill out the centre holes (which would mean more work for me, and more metal removed from the plug). The chrome plating on the inside of the holes disappeared “naturally” during tapping. The #12 is the screw size (diameter), and /24 means 24 threads per inch.

Step 2 - tap threads into burst disk assembly

I used a set of three taps: “taper”, “plugging” and “bottom”. I started with the taper tap, then the plug, and finally the bottom (the one with the broadest end). To prevent binding the tap was completely backed off every turn or two to remove debris, and <u>no lubricant</u> was used. The taps, shown below, were made by Greenfield and bought from McMaster-Carr.

Any burrs raised by the tapping were removed with a small knife, so that they would not weaken the burst disk.

Step 3 - grub screws

I could not easily obtain grub screws in the size I wanted, so I cut them from longer regular 12/24 brass screws.

Note that the length of the grub screws was such that they would be recessed into the assembly when screwed home, like the one on the left in the photo below.

Step 4 - cleaning and soldering

The burst disk assemblies were clean enough straight from being tapped (as noted above, the tap removed any chrome from the inside of the hole and no lubricant was used), although it would probably have done no harm to clean them with a suitable detergent, rinse them, and dry them with compressed air. The brass screws were not clean enough, and had to be cleaned with “wire wool” (iron wool) and then a detergent as above before soldering. The photo below compares an attempt to solder screws with and without cleaning - the screw on the left of the photograph was not cleaned, and the solder has not properly “wetted” the metal, resulting in a dry joint which can be expected to fail immediately or over time.

Any succesful soldering requires use of a “flux”, which cleans and protects the surfaces to be soldered when heat is applied, so that the solder can wet the surface. There are two systems commonly in use: for electrical/electronic work, a rosin-based flux is commonly used, and for plumbing work a chemical flux is used. For electronic work, the advantage of using the rosin-based flux is that it is not so corrosive, so it will not damage electronic components, and it is removed by a solvent which will not damage components either. On the other hand, plumber's flux is highly corrosive and must be washed off well with water afterwards.

I tried both systems, and strongly preferred the plumber's flux (although the photos here show the use of electrical flux). The reasons are: (1) the rosin-based flux does not clear from the joint so well, particularly the deep screw thread, so one can never be quite sure how much of the joint consists of solder, and how much consists of flux (by contrast, the plumber's flux seems to burn off quickly during use), and (2) the rosin-based flux is unsightly and hard to remove without the right solvent, and I didn't have any to hand (I think acetone does the trick, although I don't know if this is the recommended solvent). I suspect that the unevenness in the photo below is a result of using the rosin-based flux - there was probably some left in the joint, and it probably "sucked back" as it contracted during cooling. This did not occur with the plumber's flux.

The solder was 50/50 or 40/60 solder with no embedded flux, and the separate flux was applied to the grub screw and the thread in the assembly before screwing home the grub screw. Heat was applied with a small blowtorch (not a soldering iron), and once the metal was up to temperature and the flux bubbling away, the solder was fed onto the top of the grub screw until a good joint had been made. After cooling, the assemblies were washed and rinsed well in water, then carefully inspected. Where a small amount of solder had spilt up onto the end of the assembly, this was removed either by reheating and wiping with a cloth, or by rotating the end of the assembly against a piece of fine wet emery paper supported on a thick piece of glass (also good for cleaning up yoke fittings on regulators).

Comments

I have modified approximately 20 tank valves in this way since end 2001, all fitted to Luxfer standard 80 CF (11 litre) aluminium tanks. These are normally filled to the equivalent of 200-210 bar when cold (but a higher "hot" pressure when filled as a fill bath is not used). They have been used almost exclusively for cave diving, mostly in fresh or brackish water, and I try to minimise the time they spend in the sun. None have exploded or leaked, although one wouldn't particularly expect them to have anyway under this usage. I have not systematically examined the modified burst disk assemblies, although I have casually checked them during tank cleaning/valve overhauls, and they seem fine. In particular I have not noticed any unusual deterioration of the copper burst disks (which is a possibility when one side of the disk is trapped in the sealed space of the plugged-up burst disk assembly), and I have not routinely replaced them, generally preferring to leave them alone.

The risk still remains that the burst disk assemblies come loose and the tank contents are lost this way. I don't know how high this risk is - my plugs are screwed in tightly, but perhaps they could loosen with thermal cycling. Perhaps using a small amount of thread locking compound down one side of the plug would reduce this risk (I would be reluctant to try to seal the whole perimeter, because I would not like the possibility of thread locking compound trying to hold 140 bar of pressure at any time).