Hydrotest Pressure

What is the definition of Hydrotest pressure is often a question many engineers have in their mind. Most piping engineers consider Hydrotest pressure as 1.5 times the design pressure. If Pneumatic test is to be resorted to, the test pressure is 1.3 times the design pressure. The test fluid (water in case of hydrotest, air or nitrogen in case of pneumatic test) and the test pressure is to be mentioned in the line list which is one of the important documents originating in P&ID and a part of BEP (Basic Engineering Package).

When to opt for hydrotest and when to pneumatic test itself is a common concern. It is nice to train your engineering mind to believe that hydrotest is the default and pneumatic test is carried out only if the logistics of hydrotest is complicated. ASME/ANSI 31.8 dwells on when the pneumatic test is allowed. Get your hands on the document, even old version will do, and read through the discussion on this.

Also keep in mind that if the pipe bursts during the test, pneumatic test will cause much more damage as splinters of pipe could flow as projectiles. This would not be the case with hydrotest with water as test fluid. Gas at high pressure will eject out of a crack at much higher velocity and cause more havoc than water which will ooze out at velocities which are order of magnitude less. Also, even if few drops of water exit a pressurized pipe from some crack or default in welding or joints, pressure in the pipeline would come to atmospheric levels immediately and the driving force for water to jet out will die down. This is because water is incompressible. Same is not the case with gas. The pressures in the pipe will drop based on only how much gas has come out. So, for a pipe pressurized to 25 bar with water, as soon as spoonful of water leaks out due to failure, pressures will drop to atmospheric. However, in the case of pneumatic test at the same pressure, 96% of the gas in the pipe under test will have to come out for the pressure to drop to atmospheric.

Hydrotest is intrinsically safer than pneumatic test, though the pipe failure will depend only on the pressure and not on the type of test fluid used to create such pressures. Therefore, vote for hydrotest always and opt for pneumatic test only reluctantly!

Pressure vessels is not a domain of piping engineers. However, most pressure vessels are cylindrical just as a pipe is. In fact, the design formula for pipe thickness is same as that for a cylindrical pressure vessel. It is good to know what the guidelines are for test pressure for pressure vessels.

The approach to deciding the thickness of a pressure vessel is same as that for the pipe and involves the following steps.

1. Use formula for regulation thickness relevant for the shape.
2. Add corrosion allowance to the calculated regulation thickness.
3. Increase this thickness further to account for negative mill tolerance by dividing by [1 – (% negative mill tolerance/100)]. For example, if negative mill tolerance is 12.5% as it often is for pipes, the thickness after step 2 above will be divided by 7/8 or multiplied by 8/7.
4. Recommend the next available thickness as per dimensional standards.

Because of the last step where you are forced to recommend something more than what you need, the shape you design has actually a capacity to withstand more pressure than design pressure without stress anywhere crossing the allowable stress limit.

We should know what this maximum pressure is which keeps the shape safe with as-designed thickness.

We therefore reverse the above steps to get this Maximum Allowable Working Pressure (MAWP).

1. Remove from the recommended thickness the thickness as per negative mill tolerance. For example, if recommended thickness is T and if negative mill tolerance is 12.5%, you would accept pipes or sheets with thickness (100-12.5)/100 or 7/8 of the recommended thickness T.
2. From this thickness, remove corrosion allowance as over the design life, this will be gone to the Gods of Corrosion.
3. Use the formula used to calculate the regulation thickness (Step 1 in design procedure above) with this thickness and back out the pressure. You just have to

turn that formula around to get pressure from thickness instead of thickness for a given pressure. It is a good simple exercise and you should do this transformation yourself. The pressure so arrived at is MAWP.

4. Hydrotest pressure, if carried out at design temperature should be 1.5 times of MAWP. Why this 1.5 times is an important question. This is so because Allowable Stress used in the design formula is Yield Stress divided by 1.5. By carrying out hydrotest at 1.5 times the MAWP, we are thus taking the vessel skin to yield stress threshold. We are actually telling it to fail now with only water inside than failing later with hazardous chemicals inside.
5. However, hydrotest is carried out at test temperature which is the ambient temperature. At this temperature, any material will be actually stronger than at high design temperature. To incorporate this, it is actually recommended that hydrotest pressure should be further multiplied by the ratio of allowable stress of the MoC at test temperature to that at design temperature. This ratio is obviously more than 1 and hydrotest at test temperature is thus carried out at even more severe conditions.

This is as per practices recommended by the codes who are concerned more about the people at large than the manufacturer and his economics. Damage to the third party, the people, cattle, vegetation, environment, is to be avoided by enforcing a simple test at ambient temperature which tries to simulate conditions in the vessel or pipe at test temperature with only water inside which are akin to actual operating conditions. It is an invitation to the fabricated vessel to take the test and prove that it is competent to deal with toxic chemicals at severe process conditions without failure.

Hydrotest is not to circumvent HSE considerations by manipulating things. It is actually a test which tells you whether a fabricated vessel is worthy of your trust under actual harsh process conditions.

Of course, engineers and contractors are always in a hurry and simpler definitions such as hydrotest pressure is 1.5 times the design pressure are often used. May be, our practicality forces us to compromise on safety a little.