SAFETY ASPECTS

HANDLING HIGH PRESSURE EQUIPMENT

SAFETY IN PRESSURE TESTING

INTRODUCTION

1. Accidents, sometimes fatal, occur during the pressure testing of closed vessels when the energy contained in the vessel is released with explosive force.
2. Pressure testing carried out using a liquid, usually water, as the pressurising medium (hydraulic testing) is by far the safest method and should be used wherever practicable. Pressure testing using gas, steam or air as the pressurising medium (pneumatic testing) is potentially dangerous and should only be carried out where the use of hydraulic testing is not possible. At the pressure ranges most frequently encountered, the energy contained in compressed air is more than 200 times the energy contained in the same volume of water at the same pressure.
3. This note summarises the methods used for pressure testing and gives advice on the precautions necessary to avoid conditions likely to result in danger. The advice given is limited to general principles and does not detail precise procedures. In this document the use of the word 'vessel' may also be take to mean any other component.
4. The size and type of vessel and the material of construction are factors which have a bearing on the degree of danger involved and the precise nature of the precautions to be taken. For example, the precautions required when pressure testing a hollow iron casting that could fragment will be different from those required for pressure testing a finned ductile tubular heat exchanger.
5. Pressure tests referred to in this document are defined as follows:

   (a) Proof Pressure Test: This is carried out where the required thickness of all the pressure parts cannot be calculated. The pressure should be applied gradually until the standard test pressure corresponding to the expected design pressure is reached or until significant yielding of any part of the vessel occurs (see para 7(k)). Proof pressure testing should only be carried out hydraulically.

   (b) Standard Pressure Test: This is used when the required thickness of all pressure parts has been calculated. This test is carried out at a pressure above the design pressure followed by thorough examination with the object of providing the mechanical strength and integrity and as a final check of construction and quality

assurance. A standard pressure test is used to confirm that the vessel may be safety subjected to its design pressure. This test is also usually a hydraulic test.

(c) Leak Test: This test (could also be pneumatic) may be carried out at a pressure not exceeding 1.1 times the design pressure on a vessel that has satisfactorily passed the standard pressure test above. A leak test is intended to detect leaks at such places as expanded, riveted or bolted joints, valve seals and welded seams and defects in the material, for example porosity in castings.

HYDRAULIC TESTING

6. This refers to methods using water or other liquids as the pressurising medium. This method of testing is safer than pneumatic testing and should always be used where practicable. Before hydraulic testing an assessment should be made that the vessel and its supports and foundations are capable of withstanding the weight. It is recognised however, that under certain circumstances. Hydraulic testing may be unacceptable for technical reasons. For example, the contamination of the interior of a vessel by water or other hydraulic fluid may not be acceptable because of its intended service.

7. Precautions for hydraulic pressure testing include the following:

(a) The risk of failure by bottle fracture or by collapse under the test conditions should be assessed at the design stage. This may affect the choice of materials of construction and the temperature at which test should be carried out.

(b) To avoid the risk of freezing, the temperature of the water securing the test should not be less than 7ºC (45º).

(c) Where a pressuring medium other than water is used care should be taken to identify any additional hazard associated with the fluid. A leak of a flammable liquid for example, could lead to a sencus tire. It is also necessary to consider the purity of the testing medium, particularly where complete drainage of the vessel after test may not be possible. For example stress corrosion cracking of some stainless steels could result if chlorides are present.

(d) Steps should be taken to ensure that blanking devices and items such as screwed plugs or connections are not liable to be ejected during testing, particularly as the result of thread failure.

(e) The vessel being tested must be totally filled with liquid and property vented to exclude air pockets.

(f) +ve care should be taken to not overstress the vessel during the test. In the absence of any appropriate standard or code, test pressures should be limited to ensure the weakest part is not subjected to stresses greater than the equivalent of 90% of its yield or proof strength at the hydraulic test temperature.

(g) A vessel should not be subjected to any form of shock loading such as hammer testing whilst undergoing a pressure test.

(h) The vessel at pressure should not be approached for close examination until a reasonable period of time has elapsed. The pressure at which the vessel can be approached for close examination should be specified in the test procedure. For the safety of persons it may be necessary to consider remote viewing procedures rather than close physical examination.

(i) Hydraulic testing should be carried out by a person trained for the purpose or by one in training who is under the direct supervision of a person competent to carry out such tests.

(j) The pressure should be applied gradually or increased by steps of approximately 10% until the required test pressure is reached. At this stage the pressure should not be further increased.

(k) When proof pressure testing, the onset of yield should be determined by the use of strain gauges or other suitable means.

PNEUMATIC TESTING

8. This refers to tests carried out using air, steam or inert gas as the pressuring medium. This method of testing is potentially more dangerous because the energy stored within the pressure system could be released explosively in the event of failure under test. Pneumatic testing should be avoided unless there are sound technical reasons for it. If such pneumatic testing is unavoidable, it should be carried out only after hydro-static testing as described above.

9. Precautions for pressure testing using air, steam or other inert gas:

(a) Before testing, an assessment of the vessel should be made and a detailed inspection should be carried out. The assessment should include consideration of the design and material specification. In the case of pressure vessels, the inspection should normally include radiographic or other non-destructive inspection followed by any necessary repairs and post weld heat treatment. Previous ultimate strength tests or prototype tests which verify the principles of the design should be considered.

(b) Pneumatic testing of vessels constructed of materials liable to brittle fracture under the test conditions should be avoided.

(c) Where practicable, steps should be taken to reduce to a minimum the internal volume of the system to be tested. This has the effect of reducing the consequences of a rupture under test. It may be practicable to isolate sections of the complete system and to test them separately, followed by reassembly and leak testing.

(d) Local chilling during filling and emptying of the vessel should be reduced by exercising sufficient control to avoid sudden changes in flow rate across inlet and exhaust control valves or nozzles. The temperature of the gas entering the vessel should not be lower than the agreed test temperature.

(e) The possibility of condensation occurring within the vessel due to the effect of pressure and temperature changes on the relative humidity of the test gas, must be considered. Condensation within the vessel would defeat the object of pneumatic testing when it was used rather than hydraulic testing to avoid contamination of the interior.

(f) Care should be taken to ensure that the methods used for sealing openings in the vessel under test are suitable (see para 18). The full number of studs or bolts provided for blanking flanges should always be used. Any studs and bolts with worn or damaged threads should be replaced.

(g) The test gas supply should be controlled by using reducing valves and other valves that regulate the flow of test gas into the vessel. Pressure and, if necessary, temperature gauges should be located where they can be easily seen by the operator.

(h) Safety valves of adequate size, properly set, sealed and marked with the set pressure, should be installed in the test supply line to prevent the test pressure from being exceeded.

(i) Flexible pipes and their connections should be regularly examined to reduce the risk of failure. The risk of injuries to persons nearby may be reduced by the use of safety restraints attached on either side of the connection.

(j) Vessels undergoing pneumatic tests should be isolated or enclosed to ensure the safety of persons in nearby building, public roads or open areas. If the vessel is not safety isolated it should be contained within the blast pit, retaining walls or substantial enclosures demonstrably capable of withstanding the blast or flying project that could result from vessel failure. The air, steam or gas suddenly released by failure should be exhausted safely.

(k) A vessel should not be subjected to any form of shock loading such as hammer testing whilst undergoing a pressure test.

(l) The vessel at pressure should not be approached for close examination until a reasonable period of time has elapsed and the pressure has been reduced. The pressure at which the vessel can be approached for close examination should be specified in the test procedures.

LEAK TESTING

10. Pneumatic leak testing should not be carried out before the integrity of the vessel has been confirmed by a standard pressure test.

11. It is sometimes necessary to carry out preliminary leak testing before the standard pressure test especially for underwater testing. The pressure used for a preliminary leak test using air, steam or gas as the test medium should not exceed 10% of the design pressure. In many cases the preliminary leak test pressure may not need to exceed 0.5 bar g.

12. Precautions for leak tests using air, steam or other gas:
    (a) The precautions set out in paragraph 9 should be considered.
    (b) All articles or vessels should be carefully inspected before being subjected to leak testing. A visual inspection may need to be supplemented by radiographic or other non destructive tests.
    (c) The leak test pressure should be kept as low as possible and means provided to ensure that the intended test pressure is not exceeded.
13. When leak testing pipe work systems of known mechanical integrity, the pressure css over a measured time may be used to verify that the maximum permissible rate of leakage is not exceeded. The test gas supply should properly controlled, see para 9(g) and (h). Careful purging procedures may be required during commissioning before normal use.

UNDER WATER PNEUMATIC TESTING

14. Underwater testing is often used to combine a standard pressure test with a leak test. The test tank should be property designed and tested to safety withstand any sudden release of pressure. Deep immersion of a vessel or article in water does not provide protection if the tank itself is neither capable of withstanding the hydraulic shock of an explosion, not of venting the volume released to a safe place. Control of water temperature and depth is also required.
15. Safeguards should be provided which have an interlocking system of high integrity. This system should ensure complete immersion of the vessel under test and prevent access into the danger zone while the standard pressure test is being carried out. Close observation of the vessel for leaks should only be permitted:
    (a) before a standard pressure test, when the leak test pressure does not exceed 10% of the design pressure, or
    (b) after a successful standard pressure test when the pressure does not exceed the design pressure.

PERSONAL PROTECTION

16. There is a risk of injury from particles of dirt and high velocity jets ejected during a hydraulic test at high pressure. A much greater risk exists during a pneumatic test. Personal protection including eye protection should therefore be provided and used by persons required to work within the pressure test facility.

SYSTEMS OF WORK

17. Supervisors and operators of pressure test facilities should receive specific training and instruction. Additionally, a permit to work system should be implemented to control work procedures during pressure testing.

18. Interchangeable pressure test components such as blank flanges mounting studs, pressure gauges, pressure relief devices and flexible connections should be the subject of regular examination by an appointed person. The appointment should be confirmed in writing to the person and others associated with the pressure test facility. Pressure test components should be properly stored and identified to assist correct selection and use for the purpose intended. Their issue should be recorded.

MULTI-COMPARTMENT VESSELS

19. Special care is required when vessels with more than one compartment are subjected to leak testing. Fatal accidents have been known to occur, for instance, during inspection of the partition welds for leaks when the partitions collapsed under quite low differential pressures. No person should enter a multi□compartment vessel for leak testing until the mechanical integrity of the partition has been confirmed. The leak test pressure should be substantially below the pressure used to confirm the mechanical integrity.

20 In some cases a vessel may be constructed so that it cannot be fully flooded for a hydraulic test and the stored energy of the trapped air or gas creates a hazard. In these circumstances the precautions given for pneumatic tests in para 9 should be considered.

GENERAL

21 All pressure gauges and temperature gauges used for pressure testing should be compared regularly with a calibrated gauge and records of the comparison kept.

22 A range of air pressures may be required from a common source of supply. In order to reduce the risk of an incorrect pressure being connect, it may be advisable to have different sizes or types of connections on hose ends, and to arrange that the vessel being tested has compatible connection.

23 Where flexible tube connections are used, they should be securely fastened. Tubing simply being pushed onto a pipe or spigot on the test component cannot be accepted as a method of preventing the safe working pressure from being exceeded. Proper pressure relief devices should always be provided and used for pressure testing.

24 As it is vital that safety valves are supplied and maintained in proper working order a test of the setting is required at the initial and subsequent periodic examination, repair or replacement. Safety valves should be removed regularly and be stripped, cleaned, examined and before re□use the set pressure checked.

Safety Recommendations
Planning, Installing, Operating & Maintaining High Pressure Gas Equipment

Noted below are some safety recommendations when planning, installing, operating and maintaining high pressure gas equipment

1. The selection and use of high pressure gas equipment should be properly planned and budgeted for by skilled and experienced personnel. The equipment selected should be of the highest quality such that it adequately caters for the maximum pressure requirement and takes account of continuous or intermittent operation and fatigue due to pulsing and shock waves. The system should incorporate sufficient safety devices and controls and be compatible with the gas to be pressurised.
2. The choice of pressurised pipe, valves and fittings require careful consideration based on the working pressure and the duty. Remember the differential angle on male or female sealing cones is important. Always ensure it exists and is the right way round, i.e. male 58° – 59°, female 60° – 61°. Never lap the two mating parts together. Always ensure bleed holes are drilled through. Super pressure coned and threaded pipe and fittings are strongly recommended for any gas pressure in excess of 400 bar (5,000 psi) and often lower than this if local circumstances dictate. If the super pressure fitting works loose the pressurised gas will be vented through a bleed hole before the fitting comes apart. Vibration proof fittings are also available.
3. On receipt of high pressure equipment inspection should take place to ensure that it meets the required specification and is supported by authentic pressure test certificates.
4. The installation should be by trained and experienced personnel with adequate supervision and inspection. All pipes, valves, gauges, controls, etc. must be guarded and firmly supported to avoid stress or the effect of vibration. Blast walls or pits must be used where there is any possibility of a burst taking place.
5. The system must have an effective filtration system to keep it contamination free and should be flushed out with a low pressure inert gas before operation.
6. Commissioning should be done in stages so that each separate segment of the system can be slowly pressurised in sequence. Always open and close calves very slowly so that increase in pressure is controlled. Don't look for leaks and never feel for leaks with your hand. Always think and look before touching pipe work – use a pressure gauge. If a leak is detected then vent the system before inspection and repair. Never slacken

high pressure connections as a means of "letting off" pressure. Never work on a high pressure system under pressure.

7. Maintenance should be done in a clean well lit area with access to vice, tools, seal kits and spares. All parts removed for inspection should be washed in a suitable de-greasing agent such as Gramasol or equivalent. Inspect all moving parts for wear or scratches. Damaged parts should be replaced. It is recommended that all seals and O rings are replaced. Always obtain spare part components direct from original supplier do not use substitutes.
8. Ensure complete instructions, circuit drawings etc. on operation and maintenance are on display and that operation and maintenance staff fully understand them.
9. The maximum working pressure of gas system must be stipulated on bar/psi on an easily visible permanent label as near to the gas outlet as possible.
   A warning should also be displayed that equipment connected to the system gas outlet should have a working pressure equal to or greater than the maximum working pressure of the system.
10. Remember that high pressure gas contains a tremendous amount of stored energy. If incorrectly stored or transferred it can have the same ferocity as Dynamite. Please handle high pressure equipment with safety and care.
11. A detailed log book should be kept for each pressurised system to record running hours.
    Inspection, maintenance, (highlighting which components have been replaced or repaired) and records on any failed pressure components.
12. In the event that a gas system is transferred to a different location that the original site all relevant documents, certificates, log books, spare seals, manuals, special tools and literature should remain with the machine.
    Take great care in re-commissioning a second hand gas system and if in any doubt call on the services of Haskel Energy Systems Limited who will assist you in bringing the gas system back to working order. Avoid having to complete work on high pressure equipment against a delivery deadline.

LET US SIZE IT FOR YOU

If you need advice on selection and sizing of Haskel equipment kindly ask us. We might seek clarifications from you in the form of questionnaire and ask you to fill in data sheets. The effort will be to provide you with an optimal equipment that will give you long trouble free service.

GEM PRESSURE SYSTEMS (INDIA) PVT. LTD.

Office :
4-2-254, Old Bhoiguda,
Secunderabad - 500003
Phone : 040-27711742, 27700326
Telefax : 040-27711742

Factory :
5-11, Sharif Nagar
RCI Road, Hyderabad - 500005.
R. C. Dist. Telangana, India
Phone : 040-64640125, 996314448
Help Line : 076808 12266

info@gemengg.com, www.gempressuresystems.com