Detailed Narrative of Workflow

Preparation of Test

Generally, the requirement for pressure testing shall comply with local regulations, governing codes, or specifications. The equipment that has been pressure tested at the Manufacturer/Supplier's works should not be re-tested after installation, unless required by local regulations or if there is any reason to suspect the integrity of the equipment, e.g., due to damage during transport or after service, open for intrusive inspection. Whenever pressure testing notified, the ***Pressure Tester*** shall prepare the work package for execution include with the following essential document,

- P&ID with makeup location of spading and device isolation by ***Plant Operation***
- Assembly Drawing / Isometric Drawing covered all of test loop.
- Design Datasheet / Calculation sheet
- Inspection Test Plan (ITP) to specify the test method, test medium, and test pressure by ***Inspection Engineer.***

Different classifications exist for pressure tests used in the selection process. A pressure test can be done in two ways: hydrostatic and pneumatic. A hydrostatic test uses water as the test medium, while a pneumatic test uses air, nitrogen, or other nonflammable and nontoxic gas as the test medium.

Each type of pressure test is designed to ensure that pressure tests are carried out safely and effectively. The test method shall be chosen by the inspection Engineer according to Appendix 6.2.

When decided to **proof strength and integrity test at site by use pneumatic test** method, the specific Job Safety and Environmental Analysis (JSEA) shall be prepared and review by discipline team to ensure that equipment can be withstand a catastrophic failure of the static equipment or piping under test pressure, including safety distance for the pressure wave projectiles, and finally **shall be got the reviewing and approval from *Plant VP (to be Sign the JSEA)*** to allow testing conduct.

For the static equipment or piping is to be pressure-tested in the installed position, it shall be ensured by ***Project Engineer*** that all parts of the assembly, including the supporting structure, can withstand the extra weight of loading resulting from the pressure test. Where necessary, temporary supports may be considered to erected prior conduct to pressure testing.

Conducting of Test

Prior start to conduct, ***Pressure Tester*** might be ensuring that all repairing work, non-destructive testing, and stress relieving shall be completed with acceptable results and shall consider the following subject also for.

- Testing shall not be performed in wet weather. Screens or other wind protection shall be provided if the test would otherwise be impaired.
- On all vessels or tanks, there must be sufficient vent relief to assure that they cannot be subjected to a vacuum by draining test fluid or by sudden cooling. With storage tanks, the rate of emptying shall be controlled to avoid buckling of shell or roof. (Shall be open vent)
- New welds or repaired welds subjected to an initial test shall not be painted prior to pressure testing.
- Items that are to be exempted from the test shall be positively isolated from the circuit.
- The spring supports shall be gagged and locked in the cold set position. And the expansion joints such as bellow shall be temporary restraints to restrict the movement of joints during testing.
- It is essential that details such as blinding points, filing and venting points be agreed between ***Maintenance*** and ***Plant Operation*** prior commencement of the work. Filling point shall be at the lowest possible point while vents must be installed at the highest points possible to vent air or gas from the test loop during filled with the test medium.
- Valves should not generally be used for isolation of equipment being strength tested. Blinds of thickness specified in **Appendix 6.8** or in accordance with ANSI B16.5/16.47 shall be used. All flanges that are blanked for the purpose of the test must have a full complement of bolting of the same quality specified for service.

- Testing through valves is acceptable only if approved by the ***Inspection Engineer***. Testing is possible through normal valves if they are fully back seated. As part of the test package, the P&ID/PEFS must show all valves in the circuit to be tested and checks that can be carried out.

All fittings, connections, and hoses must be of suitable rating and be marked to show that the rating exceeds the system maximum test pressure by at least 50%. All hoses and fittings shall have been pre-tested prior to use. They must be properly connected to compressors and equipment to be tested (full complement of bolts, etc.). ***All fittings shall be wrought carbon steel or stainless steel***

Only approved/calibrated gauges shall be used. All gauges shall be calibrated at regular intervals (maximum 6 monthly with accuracy at +/- 1.0%). Calibration certificates shall be available at the worksite, calibrated against a standard or master gauge of with tolerance of less than 5 % error, range shall be from zero to between 1.5 and 4 times the intended test pressure. Digital reading pressure gauges having a wider range of pressure may be used, provided the readings give the same or greater degree of accuracy as obtained with dial pressure gauges. The gauge shall be located at the highest point of the test system. Every test circuit shall include minimum two independent pressure gauges, one of which must be mounted on the equipment to be tested. A cock or drain valve shall be provided between the gauge and the tested equipment to be able to change the gauge, should it malfunction. For pressure classes 150 and 300, pressure gauges must have a nominal diameter of at least 100 mm (4 inches), and for pressure classes 600 and beyond, at least 160 mm (6 inches). In some cases, a pressure recorder may be used to record during pressure testing that depends on the decision and approval of the Inspection Engineer. The accuracy of a pressure recording device should be +/- 1 psi. This is the accuracy of a typical deadweight tester, which will be utilized for the test. A typical “clock” type chart recorder can be used for documentation purposes but should not be relied upon for providing actual pressure data that will be used in post-test calculations.

Prior start to conduct, ***Plant Operation*** shall be ensured that all instrumentation, Control Valve, Check Valve, Metering, PSV's, and other equipment not capable of withstanding the test pressure shall be removed or isolated from the system under test. Piping links between systems of different pressure ratings shall be isolated when testing the higher rated system.

When the quantity of test water to be drained to the oily water sewer is large, as may be the case with a tank or pressure vessel, the rate of drainage shall be confirmed with the ***Plant Operation*** that drainage rates shall be such as to maintain effluent discharge within the licensed flow limits.

Prior start to conduct, ***Area Safety*** shall ensure with the following general precaution that on site condition safety for testing.

- All persons who will work surrounding the test area must be informed of the hazards and the necessary precautions.
- Only person essential to conduct the test shall be in the vicinity of the equipment or piping under test. This applies particularly to testing of exchangers where the Maintenance Supervisor shall see that everybody other than the Inspection engineer is kept away (about 15 meters) from the immediate vicinity of the ends of the tubes and test ring packing. The witness himself shall observe this precaution during 'strength' tests and in all cases where pressure is first applied.

  Be Remind**:** where tubes are plugged and the pressure applied, the tubes could shoot out.

- Pneumatic test by use ***Nitrogen gas*** must be aware when release pressure to atmosphere can be affected personal who working around testing area that possible to ***deep breath with low oxygen can make personal asphyxiate.***

- The witness shall be responsible for his own safety while making inspections on any equipment under test.

- Shall not be carried out the Hammer testing on pressured systems.

- The pressurized equipment shall be bounded with ropes and warning signs during the test and never leave pressurized test unattended.

- For pneumatic test, the minimum exclusion zone distances shall be considered, to keep the other personal away by measured as a radius distance from all pressure containing components of the test circuit, which shall be established follows the **Appendix 6.9.**

Then start to pressurize the static equipment or piping according to the type of pressure test, the pressure shall be raised to the maximum test pressure by means of a hand operated or pneumatic driven pump. An electric-driven pump for the high-pressure loop and boiler loop may be used. Under the supervision of an inspection engineer with specific JSEA. ***For Hydro Blast Machines with Diesel Engines Driven pump are not permitted.*** The pump shall be positively isolated from the system except when being used for pressurization and the pump discharge gauges must be visible to the pump operator throughout the duration of the test.

When reach the holding time, ***Pressure Tester*** shall be call ***Inspection Engineer*** or ***Witness Authorize Person*** to perform witness test examination for leakage of the joints and connections and of all regions of high stress, such as head knuckles, regions around openings, and thickness transition sections. Any leaks that are present shall be identified, corrected, and retested by ***Pressure Tester*** in accordance with the applicable repair procedure until have an acceptable result.

After testing, the equipment shall be drained and dried to prevent corrosion. ***Do not leave systems filled with water.*** During draining, a vent valve shall be opened at the highest point of the equipment to prevent vacuum.

- If equipment is dried by blowing, drains or vents shall be opened to avoid pressuring the equipment.
- If equipment or piping is to be left idle longer than one month, it shall be preserved in accordance with **P-(T-RE)-OEMS-15 Preservation of Idle Equipment**.

Appendix

Terms and Definitions

Unit of Pressure	For the purposes of this procedure, pressure in Kg/cm^2g and Barg are regarded as equivalent.
Design Pressure	The maximum theoretical operating pressure, at a designated temperature, which is allowed by the code of construction.
MAWP	The Maximum Allowable Working Pressure, at a designated temperature, which is less than the design pressure.
S.F.	Material allowable stress at test temperature.
S.D.	Materials allowable stress at design temperature.
Pressure Test	Pressure Test, which is carried out where the objective to test the strength, integrity, or leak tightness of the pressure component on pressure vessel and piping. A pressure test may be performed liquid (hydrostatic test), gas (pneumatic test), or a combination thereof.

Strength Test

Strength testing, which is generally for new pressure vessel; new piping; major repairs; law and regulation is carried out by apply pressure to induce a stress level greater than in service condition, but less than that which would cause damage in fabricated component.

1. The hydrostatic strength test shall be in the range 1.3~1.5 x MAWP for vessels and 1.5 times design pressure for piping. When performing an annual boiler test, use a pressure that is not less than 1 time or more than 1.25 times the maximum permissible pressure (MAWP) and inspect for leaks while maintaining pressure until the leak check is complete.
2. The pneumatic strength test shall be at least 1.1 times the design pressure of vessel and piping. The approval of the plant VP is required for pneumatic strength testing.

Integrity Proof Test

The integrity proof test will be performed to ensure that the static equipment or piping is still in suitable condition and is safe to use in operation. Integrity proof is carried out where the objective is not to test the strength of the equipment, but by the application of a pressure differential, to detect leakage (and sometimes leakage rates). The maximum test pressure at any point of the test section cannot exceed the design pressure. The test may be performed hydrostatic test or pneumatic test. The approval of the plant VP is required for pneumatic integrity proof test.

Leak Tightness Test

Leak tightness testing is carried out where the objective is not to test the strength or integrity proof on pressure vessels and piping. The test may be performed to detect leaks from pneumatic testing. The Leak Tightness Test pressure shall be less than the design pressure and not exceed 1.1 time of the operating pressure. However, any leakage detection point may be evident at much lower pressures when using sensitive leak detection methods, such as helium test or bubble test. It is not necessary to obtain approval from the plant vice president for pneumatic leak tightness testing.

Furthermore, in the case of regulation pressure vessel needs to be leak tightness test after intrusive inspection. It shall be done by the operation team and their procedure to specify the test pressure and test medium.

Hydrostatic Test

Pressurized test by use incompressible fluid such as Portable Water, Utility Water, Process Hydrocarbon that generally apply in strength, integrity or leak tightness testing of the pressure containment applied for all hydrocarbon services and streams in which hydrocarbons may be present, steam pressures above 1000kPa, Acid, caustic, toxic chemical streams or otherwise hazardous services.

Pneumatic Test

Pneumatic testing is potentially more dangerous than hydrostatic testing and should only be advised by Inspection Engineer if hydrostatic testing is impossible. Pneumatic test by use compressible fluid, nonflammable and nontoxic such as air, process gas, and inert gas (Nitrogen) that normally apply on flare lines, internally insulated vessels, and refrigeration equipment.

Service Test	Testing which carried out by detect leakage after process from startup until turn to normal, generally for non-critical service. • Service testing is permitted for lines in non-critical services (ASME B31.3 Category D fluids). General described for the process that service: Air, non-combustible/toxic gas, water, lube mist, and low-pressure steam when flange rating on piping system is 125 or 150 lb. • The test pressure for testing shall be at the (maximum) operating pressure. • Service testing is normally witnessed by Operations. In the event that leaks are found during the test, the Inspection Engineer shall be notified.
Reinforcing Pad Test	Each reinforcing pad or Segment shall be tested to a pressure of 1.0 kg/cm²G with air for at least 5 minutes. The test shall be carried out before Hydrostatic Test of the Vessel. The Tell-Tale Holes and Weep Holes shall be left open during Hydrostatic Test.
Witness Authorized Person	Witness Authorized Person (WAP) simply means a person approved and qualified by Integrity and Reliability Department which to delegated responsible performs witness pressure test.
Pressure Tester	Maintenance Team or Project Team who is responsible for pressure testing for piping or static equipment.
Golden Weld	Weld joint that waving for pressure test by unavoidable reason of field condition that may need to proof the integrity by additional NDT examination and approval from all concerned party prior startup or commissioning.

Requirement of Testing

The purpose of performing a pressure test shall be applied to equipment and piping (including isolation valves) designed to operate above atmospheric pressure that;

(a) Before it is initially placed in service.

(b) After repairs or alterations which may affect the strength of the equipment or whenever considered necessary by Inspection Engineer.

(c) At scheduled intervals as specified by regulatory requirements or as directed by Inspection Engineer.

(d) Whenever considered necessary or advisable by the Inspection Manager or Specialist.

(e) Test Type Selection Appendix 6.2

Hydrostatic Testing Exclusions

A pressure testing shall be performed hydrostatically unless one of the following conditions apply:

(a) The equipment, piping, and/or supports, including foundations, cannot adequately support the liquid weight.

(b) The equipment or piping cannot be dried and traces of the test liquid may result in contamination of the system or its contents after returning to service.

(c) The equipment or piping contains internal linings that could be damaged by the test medium.

Hydrostatic Test

Test Medium

- The test medium for Ferritic steel components shall be potable water or utility water. Brackish or seawater may be substituted if the Inspection Engineer has approved the substitution whenever have limit of the landscape. If potable water is not used, the test water shall be completely drained and the equipment flushed with provided potable water immediately after testing and thoroughly dried with air or steam.
- The test medium for Austenitic steel components shall be any water (demineralized water or boiler feed water, utility water, etc.) that has a chloride content less than 30 ppm. After test completed, all water shall be drained as soon as possible and not allowed to concentrate by evaporation. Within 36 hours of draining equipment, it shall be swabbed with dry clean clothes or dried with passage of ambient temperature dry air.
- The selection of suitable test medium for the other special material might be reviewed by Corrosion Engineer for susceptibility failure mechanism as shown on the **Appendix 6.7**
- Testing with flammable liquids by considered only when contamination with water is unacceptable and pneumatic testing considered being too dangerous is discretion. Flash point shall be not less than 49°C(120^{0}F). Normal restrictions to prevent ignition shall apply. ***Specific JSEA preparation prior testing shall need to be reviewed and approval by the relating team.***
- Hydrocarbons may be used is cases where contamination is to be avoided. Test media shall be free of sediment. This must be accompanied by JSEA.

Test Temperature

- The metal temperature of the equipment and testing medium during hydrostatic test shall be maintained at a minimum of 17°C (30°F) above the minimum design metal temperature (MDMT) ; but need not exceed 49°C (120°F), to minimize the risk of brittle fracture. The metal temperature shall be recorded in Pressure Test Record Form.
- Account shall be taken of embrittlement that might occur during service in thick walled low alloy (Cr-Mo) steel equipment. The risk for brittle fracture and the minimum

pressurization temperature required shall be evaluated before the test is carried out.

- For the pressure containment that have been subjected to hydrogen charging (i.e. equipment in H_2 or wet H_2S service, etc.) and not subsequently stress relieved, the minimum test temperature shall be reviewed and confirmed by the Inspection Engineer.

Conducting of Test

- All hydrostatic test pressure shall be provided by Inspection Engineer that justify depend on mandatory and testing requirement.
- Before testing to be prepare, prior final assembly all part must be ensured that are cleaned and free from any debris.
- Ensuring the vent point at a high position and it was opened which is to be tested to purge possible air pockets while the vessel and piping are filling.
- All warning notices, marker tapes, protective barriers, and other safety equipment have been positioned and the appropriate authorities have been informed.
- All relevant personnel at the affected stations have been informed of the commencement and duration of the hydrostatic pressure test.
- Prior testing on very low-pressure systems must be ensured that the utility water pressure (typically operating at about 2 barg) will not cause over pressure during filling.
- After the opening of top nozzle, water filling shall be carried out to top level and it shall be confirmed that air shall have been deflated. And then, the top manhole/nozzle/vent shall be closed.
- Equipment filled with testing medium shall not be allowed to stand unsupervised for any length of time without venting it to atmosphere as temperature changes may build up an excessive pressure or vacuum, either of which may damage the equipment.
- To avoid the temperature effects from sunlight to make a misinterpretation in test pressure, the testing equipment should be carried out in the shading area to minimize thermal heating of the fluid. Before application of hydrostatic test pressure, the temperatures of the test fluid and the material of the testing equipment should be check and record by *pressure tester*.

- For new fabrication, an indicating gauge shall be connected directly to the vessel or with a pressure line that does not include intermediate valves according to construction code.
- For in service, existing block valve can be allowed but it need to be verified in open position.
- The minimum number of gauges at least two pressure gauge used in hydrostatic testing shall be installed at the highest point equipment or piping system to be tested and another at the discharge of the test pressurizing pump.
- Pressure gauges used for hydrostatic testing shall have a scale range from 1.5 to a maximum of 4 times the test pressure.
- The rate of pressurisation should be constant and not exceed 7.0 Kg/cm2ga (100 psi) per minute and shall be held at 50% of test pressure for at least 5 minutes before any further increase in pressure.
- If pressure increases very slowly with the test pump running the system could still contain trapped air. This should be vented.
- Care shall be taken to avoid over-pressuring the system due to thermal expansion of the test fluid. If this is a possibility, then a watchman shall be assigned at a bleeder point with a pressure gauge to release excess pressure. Stand unsupervised without any venting shall not be allowed.
- The Maintenance Supervisor shall ensure that no leakage, or any indication of deformation or elongation occurs whilst pressure is being applied. If it apparent at any time while increasing the pressure, The test pump shall be stopped and disconnect, then depressurized system and notified the responsible Inspection Engineer. If the pressure increases very slowly with the test pump running the system could still contain trapped air. This should be vented.
- The required test pressure shall be maintained for not less than 30 minutes for the sufficient time to allow the temperature and strain to stabilise, in some case The Inspection Engineer or WAP may require a longer duration dependent on equipment under test and condition. But no any case to be allowed to held pressure less than the required time.
- If the specified test pressure could not be maintained due to a passing valve (for example,

in a boiler or high-pressure loop), the pressure source is allowed to continuously supply the pressure and hold it for at least 30 minutes. This case shall be verified and approved by a Technical Authorized Inspection Engineer (TA2).

- During strength testing, the pressure should be lowered by design test pressure before inspecting for leaks. At no stage shall equipment be approached for close inspection until the pressure has been positively reduced to a level lower than that previously attained.
- Witness Hydrostatic Test, normally performed by Inspection Engineer and sometime may delegate to the others such as Witness Authorized Person who have been suitably trained as delegated responsible persons to witness in common testing.
- The following pressure recording equipment shall be used during a hydrostatic test base on judgment of the Inspection Engineer. A pressure recorder should be installed so that localized surges from the test pump or bleed lines do not interfere with the readings.
- Hydrostatic test shall be accepted by responsible Inspection Engineer which the appearance of pressure on gauge shall not less than the hydrostatic pressure of the equipment. Furthermore, any abnormal deformation, elongation, and leak of test medium shall not be appeared on any surface and connection of equipment or piping.
- In the event of a leak through the pressure envelope the system shall be completely depressurized and remain vented while repair work is being carried out.

Depressurizing and Preparation for Service

- Venting shall be to a safe location. Depressurizing shall be done gradually, to avoiding the pressure shocks.
- On completion of the hydrostatic test, release of the pressure shall be from the highest point of the equipment. Depressurizing of the system shall be achieved by opening the vent and drain valves or cocks provided. The witnessing party shall ensure the correct method of pressure release is used to gradually reduce until ***all gauges return to zero.***
- Care shall be taken to ensure that sufficient vent area is available to prevent the possibility of drawing a vacuum. As a rule, the vent area should be greater than the drain area. This particularly important in the case of large thin-walled vessels, to prevent collapse.

- Wherever possible the system shall be completely drained and, if required, dried with air or hot air. ***Subject to Operations and Process Engineer approval, the drying step may be omitted providing any remaining water will have no adverse effect on the process.***
- After completion of the testing, the system shall be reinstated as per drawings and specifications. This includes, but is not limited to:
  (a) Removal of all temporary materials such as spades, blinds, gaskets, pipe spools, temporary supports, etc.
  (b) Replacement of all damaged gaskets and all test gaskets
  (c) Re-positioning of spectacle blinds to the correct operational position
  (d) Reinstatement of all items removed for hydrostatic testing.
  (e) Reinstall all unions downstream of instrument block valves that had been removed.
  (f) Inspection of the complete system for the correct flow direction of instruments, check, and control valves, etc.
  (g) The 'stop' of pipe support springs shall be removed during commissioning.

Waiving for Hydrostatic Test

It is normal practice to carry out a hydrostatic pressure test after repairs and modifications are carried out to the pressure-containing envelope of pressurised equipment. However, there may be some exceptional circumstances when it is not possible or reasonable to carry out such a test. In this event, the rationale for not carrying out the pressure test should be made.

Alternative means shall be sought to verify the integrity of the workmanship. This may include additional NDT examination. There must always be good justifiable reasons for not carrying out a hydrostatic test.

Waiving of the pressure test requires the approval of the Inspection Manager and Operation Manager (golden weld RCR). Refer to QA/QC for Construction and Maintenance Welding Procedure.

The relevant Inspection Engineer shall be consulted in each case before any work on the system begins and advised of the reasons for waiving the hydrostatic test. Work should not begin before confirmation of waiving of the hydrostatic test has been obtained (See QA/QC for

Construction/Maintenance Welding Procedure Section for retrospective 'Golden Weld' requirements).

Radiography of fillet welded joints in lieu of hydrostatic testing is not practical, and will not be a suitable substitution without other appropriate NDT applied such as visual inspection by welding inspector, PT, MT, Phase Array, etc.

Note: For routine maintenance to cleaning the equipment such as Heat Exchanger which have not repairing work on the pressure part, waiving to performed hydrostatic test due to process impact of moisture contaminate shall be justified by Inspection Engineer to select the other proper test method.

Hydrostatic Test Requirement on Specific Equipment

Certain types of equipment require specific attention because of their design and construction.

Fired Heaters

Normally testing is to confirm the leak tightness of the coil. In some cases, strength testing is required, e.g., when tubes or sections have been renewed. If testing in-situ, careful consideration should be given to methods for filling and emptying the furnace tubes, especially for top-hung hairpin tubes. For some fixed heaters inaccessibility of the convection zone for inspection may require a pressure/leak test in lieu of visual inspection.

Storage Tanks

Tanks are not normally subjected to testing except on commissioning and in special circumstances such as after major repairs, moving to a new site, or re-leveling. It is recommended that checks are made after testing to ensure differential settlement has not occurred as a consequence of hydrostatic testing.

Heat Exchangers

After the period of cleaning and inspection were done, heat exchanger shall be required to pressure test or leak tightness testing at less, when it did not have any repairing or need to integrity proof.

Normally, the test pressure will be separated to 3 steps; 1st step for shell side with test ring for detect the leakage at tube and tube to tubesheet joint, 2nd step for tube side to detect the leakage at gasket of tube side, and finally 3rd for shell side to detect the leakage at gasket of shell side. The responsible to witness the pressure test is inspection engineer or delegate to witness authorize person (WAP). If any step of test pressure needs to waive, it shall be written approved and take the respond by Plant Operation Manager.

Care should be taken when hydrostatic testing the shell side of heat exchangers with any tubes which have been previously plugged refer GCRP010. The vapor in such tubes can become compressed, causing the plug to shoot out. Also, when conducting pressure tests on tubular heat exchangers especially in those in high pressure duty (such as reactor feed/effluent circuits) where the tubesheet is designed for a limited differential pressure. To detect tube or joint leaks, separate tube-side or shell-side tests should be conducted, but within the limitations of the differential pressure rating of the tubesheet (ensured with the manufacturer design).

(For a strength test, a combined pressure test should be made with pressure on both sides of the exchanger, but care should be taken that the pressure difference does not exceed the design code limits at any time. This requires a maximum applied pressure equivalent to 1.3-1.5 x the design differential pressure where the tubesheet design is limiting.)

Tube-side tests must be carried out:

- when the floating head has been removed
- when modifications have been made to the floating head, channel (channel cover)
- before disassembly if the tube bundle is suspected of leaking in service.

Shell-side tests must be carried out:

- when modifications have been made to the shell or shell cover
- when a complete or partial tube renewal has been carried out

Such a test should also be considered whenever the bundle has been pulled and is in poor/suspect condition or where hot bolting might pose an unacceptable risk in service.

Special Heat Exchangers

For other design of heat exchanger (other form of shell and tube type) such as Packinox, Ziepack, Spiral heat exchanger, Plate heat exchanger, Compabloc, etc. shall be pressure test by following the manufacturer standard of each type, design, and year of construction (need to understand each equipment manual). Clarify the pressure test instruction to contractor who responsible in special heat exchanger shall be done before the activity of test was began. Test shall be conducted with stringent to the manufacturer recommend for prevention any failure from pressure test.

Pressure Vessels

The Integrity and Reliability Division, via the responsible Inspection Engineer, shall supply the hydrostatic test pressure for equipment including pressure vessels. For new equipment and after major repairs, the test pressure is based on 1.3-1.5 x the design pressure corrected for design temperature. Particular care should be taken regarding static head contribution when applying a hydrostatic test to a vertically mounted vessel that may have been tested in the horizontal plane initially. Also, those vessels normally in gas service have foundations that are designed to support the full load to enable hydrostatic testing to be carried out safely.

Flare Lines

Many flare lines are not designed for in-situ hydrostatic testing. This should be taken into consideration for individual lines when specifying testing.

Laboratory Sample Bombs

Periodic pressure tests should be made at the intervals set out in the appropriate regulations e.g., BS 5430. Refer to Regular Periodic Inspection/Testing of sample bombs Procedure for Laboratory Gas Sample Cylinder (Sample Bomb) Inspection.

Pneumatic Test

The following safety precautions must be taken during the pneumatic strength and integrity test:

- Specific Precaution when a hydrostatic pressure test cannot be performed a pneumatic pressure test may be performed.
- Pneumatic testing is potentially more dangerous than hydrostatic testing; compressed gas has sufficient energy to throw fragments of a failed component in a faraway distance and should only be considered if hydrostatic testing is impossible.
- Pneumatic testing shall only be considered in the following cases:
    a. vessels/piping that cannot safely be filled with liquid due to their design or supports.
    b. vessels/piping that are to be used in processes where traces of any liquid testing medium cannot be tolerated.
- The responsibilities for various aspects of conducting the test shall be clearly defined and shall be in writing. The testing shall be carried out under the direct supervision of an experienced maintenance engineer. Before testing can be carried out, a JSEA (Job Safety & Environment Analysis) has to be carried out, documented, and discussed with all involved parties with the following safety precautions must be approved from ***Plant VP (to be Sign the JSEA)***.
- The inspection records should be reviewed for thinning beyond the specified limit. If thinning has occurred beyond the specified corrosion allowance, an engineering evaluation shall be performed.
- A safety relief valve must be fitted to the system to avoid over pressuring, this shall be set to discharge at 10% above the test pressure.
- All other work on the system should cease, and notice given to other contractors or workers in the area of the intention to air test.
- All non-essential personnel shall be evacuated from within the exclusion zone of the system, a minimum of 50 meters depending on the test pressure.

- All fittings, connections and hoses must be of a suitable rating and be marked to show that rating exceeds the system maximum test pressure by at least 50%. All fittings shall be wrought carbon or stainless steel.
- All air hoses and fittings shall have been pre-tested prior to use. They must be properly connected to compressors and equipment to be tested. Full complement of bolts etc
- All personnel must be fully briefed as to the danger, and possible consequences of fittings or hose failure under pressure. All test equipment must be in first class working order.
- Warning signs must be affixed to the system during the test period and bunting tape erected and maintained where applicable.
- TEST PERSONNEL MUST BE IN ATTENDANCE AT ALL TIMES DURING THE TEST PERIOD.
- Ensure that good radio contact is maintained between the pressurizing point and pressure gauge/s during pneumatic testing operations.

Test Medium

- Nitrogen should be the test medium since it cannot support combustion. Alternatively, clean, dry, oil-free air should be used with a dew point ranging from -20°C to -70°C (-4°F to -94°F).
- For testing on instrument equipment, air that shall be considered to be used might be instrument air or inert gas such as nitrogen/helium.
- Other media may be used if approved by the Inspection Engineer.

Test Temperature

- The possibility of brittle fracture shall be considered when conducting a pneumatic pressure test at metal temperatures near the ductile/brittle transition temperature of the metal. The metal temperature during pneumatic test shall be maintained at least 30°F (17°C) above the minimum design metal temperature to minimize the risk of brittle fracture.

Conducting of Test

- Pre-check prior start to conduct pneumatic testing.

- Prior to starting, ensure that the correct documents are present, including ***JSEA, job-specific execution plan/procedure as appropriate, signed/approved.***
- Prior to the test any NDT acceptance including visual inspection shall be confirmed on relevant NDT clearance form before the test can commence. The equipment shall be thoroughly inspected prior to testing.
- All supports and anchors shall be fitted prior to testing.
- A check of the system should be made to establish that all termination/isolation points have been installed, once this has been confirmed, authority to proceed with the pressure test may be given by the Maintenance Supervisor.

- All test pressure shall be provided by Inspection Engineer, for pressure vessel and piping should be limited to 1.1 times the design pressure for strength testing and shall not exceed the design pressure for integrity proof testing.
- For low test pressures (<1 barg), hand pumps are the preferred method to apply the pressure. For higher test pressures (>1 barg), compressors, gas bottles or plant air/nitrogen can be used as long as there is provision to control/regulate the applied pressure such that it does not increase at a rate above that specified in this procedure. See calculate required air compressor capacity on **Appendix 6.9.**
- The pressurizing source must be isolatable from the system to be tested, and include a relief valve, needle valve or regulator to control the pressure applied, and a pressure gauge upstream of the block valve. For low pressure applications, an open-ended tube manometer can be used to measure pressure and act as a relief valve (maximum 10% above test pressure).
- The pressurization shall be performed in a controlled and steady manner using dry oil free air, nitrogen, or other suitable gas.
- Prior to testing, all shut-off valves between the supply and the system to be tested and the needle valve/regulator must be closed.
- Open the shut-off valve from the source, slowly open the regulator and note the pressure

increase on the pressure gauge (or the manometer). Increase the pressure slowly and note that the RV lifts at the correct set pressure (test pressure + 10%). Allow the system pressure to vent.

- If all is acceptable, proceed with the test by opening the last shut-off valve to the test system and commencing pressurisation.
- For **Test pressure at 3 Kg/cm2ga and below**
    - Pressure slowly to 50% of test pressure and hold for a sufficient length of time to allow piping structure to equalize strains (5 minutes minimum), all joints shall be checked for leaks with soapsuds.
    - After a satisfactory leak test at 50% of test pressure, pressurize to test pressure and hold for a minimum of 30 minutes or until all relevant joints have been inspected for leaks with soapsuds. Note: once at the test pressure, the test system shall be disconnected from the pressurising source.
- For **Test Pressure Above 3 Kg/cm2ga**

  In consideration of hazardous conditions present during pneumatic testing, particularly at test pressure above 3 Kg/cm2ga each such test shall be carried out in accordance with the following requirements.
    - Pressurize to 25% of test pressure and hold for a sufficient length of time to allow piping structure to equalize strains (5 mins. minimum) all joints shall be inspected for leaks with soapsuds. If leaks are discovered, release pressure, repair, and return to test.
    - Pressurize gradually to 50% of the required test pressure and hold for a sufficient length of time to allow piping structure to equalize strains (5 mins. minimum) all joints shall be inspected for leaks with soapsuds. If no loss of pressure is detected, subject to approval of the inspection engineer, proceed to next step.
    - Increase pressure in step; pressurizing gradually increase the pressure in steps of 10% until the test pressure is reached, holding the pressure at each step for sufficient time (approximately 5 minutes) to allow the temperature and strain to stabilize. Hold

at the designated test pressure for a minimum of 30 minutes. Note: once at the test pressure, the test system shall be disconnected from the pressurising source.

- The test pressure shall be reduced to the design pressure and all joints re-inspected for leaks with soapsuds. If no loss of pressure is detected, subject to approval of the inspection engineer, proceed to the depressurization.
- During testing if any leaking joints are found the system should be depressurised to zero before any attempt is made to correct the leak. After correction the system should be pressurized following the original procedure.

- ***Witness Test***, Inspection Engineer must conduct witness testing for pneumatic test pressure; it cannot be delegated to a Witness Authorized Person.
- The soap suds can be applied to weld joint, fitting connection or expected area possibility for leak detection, during testing if any leaking joints are found the system should be depressurised before any attempt is made to correct the leak. After correction the system should be pressurized following the original procedure.
- No personnel should be inside the exclusion zone while equipment is pressured above design pressure.

Depressurizing and Preparation for service

- After satisfactory completion of the pneumatic test the pressure shall be released to atmosphere in a controlled and safe manner.

Air Freeing after test, for air medium prior to lining up the equipment into service. The equipment should be purged with nitrogen to reduce the oxygen content less than minimum to be permitted to combustion and other potential consequence such as reactive hazard, formation of elemental sulphur shall be considered if the O_2 level exceeds 1 %v. Oxygen levels shall be measured with an intrinsically safe oxygen analyser.

Leak Tightness Test

Leak Tightness Testing is carried out where the objective is not to test the strength and integrity proof test of the equipment, but by the application of a pressure differential, to detect leakage (and sometimes leakage rates). It may also be used to search for leaks on reinforcing pads on equipment and piping, as well as bellows and pontoons in lines and equipment, and pontoons in floating roof tanks, at lower pressures (1 barg).

- A leak tightness testing may be performed to detect leaks from hydrostatic or pneumatic testing.
- Leak Tightness Testing using liquid shall be following hydrostatic test step.
- For vessels and piping, the applied *pneumatic leak tightness test* pressure does not exceed 1.1 times the operating pressure and must be authorized by the Inspection Engineer. Leakage at any stage, however, can be visible and can be examined with liquid soap.
- The testing of reinforcing pads on piping and equipment. This is generally only required on new fabrications or repairs. All reinforcing pads shall be tested with air at a pressure 1.0 kg/cm2ga. Welds shall be wetted with soapy water and examined for leakage. Pads shall be pressured for at least 5 minutes.
- The inspection Engineer can delegate witnessing of leak tightness tests on equipment and piping to Witness Authorized Person.

Pneumatic Leak Tightness Test Procedures

The pneumatic leak tightness test shall be approved by the inspection engineer and submitted for acceptance prior to conducting the testing. The procedure must be following.

(a) Prior to starting, ensure that the correct documents are present, including JSEA, job-specific execution plan/procedure as appropriate, signed/approved by discipline.

(b) Clean, dry, oil-free air should be used as the test medium, except in systems which cannot be verified as free from hydrocarbons. For this situation, nitrogen should be used as the test medium.

(c) Prior to pressurization a pre-check must be carried out to ensure all is in order. For the test any NDT acceptance including visual inspection shall be confirmed on relevant NDT

clearance form before the test can commence. The equipment shall be thoroughly inspected prior to testing.

(d) All equipment must be in position and ready to start. All warning signs must be in position and visible.

(e) The pressure gauges used, shall have current relevant test certificates and be checked that they are in good working order. They shall be located at both ends of a system under test and on the compressor.

(f) All pressurizing/filling hose connections shall be of the approved design and fit for purpose, connected properly.

(g) Minimum exclusion zone distances, measured as a radius distance from all pressure containing components of the test circuit, shall be established as follows appendix6.9:

(h) To prevent over-pressurization, a safety relief valve may be added to the device and set to discharge at 10% above the test pressure.

(i) The test temperature and medium of the test shall be following Appendix 6.5.

(j) Slowly pressurize to 50% of test pressure and hold for a long enough time to enable the piping structure to equalize strains (5 minutes minimum), then check all joints for leaks with soap suds.

(k) After a satisfactory leak test at 50% of test pressure, pressurize to test pressure and hold for a minimum of 30 minutes or until all relevant joints have been inspected for leaks with soapsuds. Hold at final test pressure and complete a thorough inspection for leakage using the gas and bubble test method specified in ASME BPVC, Section V, Article 10, or other method of equal or better sensitivity.

(l) During testing if any leaking joints are found the system should be depressurised to zero before any attempt is made to correct the leak. After correction, the system should be pressurized following the original procedure.

(m) After completion of the test, the vessel and/or piping system should be restored to its operating condition.

Test Medium for Special Material

Austenitic Stainless Steel

- Water used for hydrostatic testing austenitic stainless-steel systems shall not contain a concentration of chlorides (Cl), either present originally or resulting from evaporation, which may result in stress corrosion cracking (SCC) or pitting.
- Where water is to remain in the system for an extended period of time after completion of the hydrostatic testing (i.e., more than 1 month) the use if biocide shall be considered to manage the risk of MIC in austenitic stainless-steel systems.

  If biological components are left in systems or introduced with the testing water, there is also the possibility of microbiologically induced corrosion (MIC). Clean systems and the use of water containing <5 ppm chlorides as the hydrostatic testing liquid will minimize the risk of this failure mechanism.

- Austenitic stainless steel shall be clean prior to final assembly and hydrostatic testing.
- The system shall be tested with the water containing <5 ppm chlorides.
- In locations where requisite water is not available (initially or permanently), temporary facilities (e.g., mobile packaged demineralization units) shall be used to prepare the hydrostatic test water.
- Austenitic stainless steel may be tested with water containing ≤30 ppm chlorides if the system is either drained and mechanically dried immediately after the testing or flushed with water containing <5 ppm chlorides after testing.

  Scheduling hydrostatic test packs can limit the time between hydrostatic testing and start-up (term of months not years), which can significantly reduce risk of pitting corrosion.

- Austenitic stainless steel piping sections and components such as valves and expansion joints that do not allow full draining or mechanical drying and that do not require field hydrostatic testing should be isolated from the system, and if still required, test separately from the system, using water containing <5 ppm chlorides.

Equipment such as shell-and -tube heat exchangers, expansion joints or bellows as part of bellows sealed valves may have crevices which prevent proper draining and mechanical drying.

- When flushing with water containing <5 ppm chlorides, all surfaces previously wetted during the hydrostatic test shall be flushed.
- The quality and velocity of the flushing water depends on the volume of the system and shall be determined in consultation with the ***Inspection Engineer.***
- Removing water or drying by blowing with heated air or gas shall not be performed unless the hydrostatic testing or flushing has been done with the water containing <5 ppm chlorides.
- To avoid the risk of exposing chloride contaminated austenitic stainless steel to heating, steam or electrically heat traced equipment and/ or piping systems, should be hydrostatically tested or properly flushed with water containing <5 ppm chlorides prior to the functional testing of the heat tracing.

Ferritic stainless steels and medium/high nickel alloys

Due to the possibility of pitting corrosion, select the testing medium as **Austenitic stainless steel** shall also apply to ferritic stainless steels and medium/high-nickel alloys.

Duplex stainless steel

Duplex stainless steel is highly susceptible to crevice corrosion when in contact with oxygen containing water. The preferred hydrostatic testing method is to use potable water and to carefully rinse the equipment immediately after the pressure test with condensate, boiler feed water or Demineralized water.

This is followed by thorough drying or dewatering of the equipment and filling with nitrogen in such a way that all oxygen is removed from the system.

9 % Nickel alloy steel

When hydrostatically testing equipment manufactured from or containing 9 % Ni steel, the water used shall be of a neutral pH value (between 6.5 - 8.5), clear and free from sulphides (less than 1 ppm) which may otherwise precipitate stress cracking of the equipment. Complete and thorough draining and drying of the equipment is required after the removal of the test water.

Aluminum and aluminum alloys

The test water shall be of a neutral pH value (between 6.5 – 8.5) and free from ions of heavy metals (less than 7 ppm in total), e.g., copper, nickel, and iron. These metals are readily deposited on the aluminum surface and cause severe pitting. The equipment shall be thoroughly cleaned and dried after removal of the test water.

Copper-Nickel alloys

When for use in hydrostatic testing of equipment manufactured from Copper-Nickel alloys shall be have a sulfide concentration less than 1 ppm.

Minimum Thickness of Inserted Blind Plate

Test Pressure Kg/cm2ga / Pipe Size in. (DN)	10	20	30	40	50	60	70	80	90	100
4 (100)	4.4	6.2	7.6	8.8	9.8	11	12	13	14	14
5 (125)	5.5	7.7	9.4	11	13	14	15	16	17	18
6 (150)	6.5	9.2	12	13	15	16	18	19	20	21
8 (200)	8.6	13	15	18	20	21	23	25	26	28
10 (250)	11	16	19	22	24	27	29	31	32	34
12 (300)	13	19	23	26	29	32	34	37	39	41
14 (350)	15	21	25	29	32	35	38	41	43	46
16 (400)	17	24	29	33	37	40	44	47	49	52
18 (450)	19	26	32	37	41	45	49	52	55	58
20 (500)	21	29	36	41	46	51	55	58	62	65
24 (600)	25	35	43	50	55	61	66	70	74	78

Unit in: mm

Remarks: Above thinness is calculated by using plate Material of ASTM A285 Gr. C or used ASME B16.48.

For pipe size or test pressure not shown in the above, thickness of blind plate will be calculated in accordance with the following equation:

$t_m = d\sqrt{\frac{3p}{16SE}}$

t_m = minimum required thickness of blind plate.

d = inside diameter face gasket for raised face flanges, or the gasket pitch diameter for ring joint and fully retained gasket flanges.

p = test pressure.

E = quality factor from Table A-1A or A-1B of ASME B31.3.

S = stress value from Table A-1 of ASME B31.3.

Pneumatic Test Exclusion Zone Distances

Minimum Exclusion Zone Distances

From	To	Exclusion Zone (m)
0.0	3.0	50
3.1	5.0	60
5.1	10.0	70
10.1	15.0	80
15.1	20.0	90
20.1	25.0	95
25.1	35.0	105
35.1	50.0	120
50.1	65.0	130
65.1	80	140
80.1	Over	***Not permitted***