Base Load Power Hub (BLPH)

Hydrostatic test procedure for Water treatment package A-50000
(Duplex piping)

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PRESSURE TESTING PROCEDURE

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1 SCOPE

This instruction defines methods and requirements for pressure testing of :

1) piping systems
2) pressure vessel
3) reactor
4) exchanger
5) filter
6) tanks

The code requirements are summarized in the end of this procedure

For each project the checklist with applicable code, types of testing and deviations based on client specifications shall be prepared. This checklist is part of the Quality Plan.

The testing scope and pressures are based on the line list.

2 FIELD OF APPLICATION

Proof strength and leak testing of equipments fabricated by FCM

3 PURPOSE

To assure correct and safe testing of equipments fabricated by FCM

4 BASE DOCUMENTS

- Quality Management System
- ASME VIII Div. 1
- ASME B 31.1: Power Piping
- ASME B 31.3: Process Piping
- ASME B 31.8: Gas Transmission and Distribution Piping Systems
- EN 13480: Metallic Industrial Piping
- PED 2014-68 EU

5 DESCRIPTION OF THE ACTIVITY

5.1 PRE-TESTING OPERATIONS

5.1.1 Documentation: Test packages:

FCM shall prepare test packages, minimum standard content is:

a) As-built isometric(s)

b) Piping list(s)

c) List with items to be removed during the test

d) Pressure test certificate

e) Leak test certificate (if applicable)

f) Post test check list (if applicable)

g) Pneumatic / gas testing checklist (if applicable)

h) Safety distance and test step chart, for pneumatic leak tests (if applicable)

5.1.2 Preparation of the test system

The test package contains a list of items which must be removed for testing

- **Instruments**: Before pressure testing, all instruments that might be damaged shall be removed, isolated or protected
  - Internals of strainers and filters shall be removed
  - Orifice plates or rupture discs shall not be installed until flushing and testing is completed.
- **Valves**: Safety, thermal relief and control valves shall be removed
  - All in-line valves shall be in the fully open position during the flushing and testing, with the exception of ball valves, which shall be partially open during testing
  - Piping and associated components containing check valves shall have the check valve disc removed or jacked open
  - Valves may be used to isolate provided valve closure is suitable for proposed test pressure
  - For on-valves with packed glands, it may be necessary to tighten the gland nuts to retain test pressures. If so, these shall be readjusted after the test to maintain operating conditions
- **Painting of welds before testing:** See the contract if this is allowed for the specific project
- **Other test systems:** Piping with lower maximum allowable test pressure shall be isolated from the test system
- **Pressure gauges**: One pressure gauge shall be installed, in principle at the highest point
- **Expansion joints:** Expansion joints shall be provided with temperature restraint if required for the additional pressure load under test, or they shall be isolated during system test
- **Spring hangers and pots:** Spring hangers and pots shall be blocked (in cold position)
- **Gas & vapor piping**: Piping designed for vapor or gas shall be provided with additional temporary supports, if necessary
- **Test temperature:** Tests shall be made at a temperature that will minimize the possibility of brittle fracture (an elevated test temperature may be required for systems designed to operate at high temperatures). Test pressure shall not be

applied until system and pressure fluid is at approximately same temperature. The minimum test temperature (of water and steel) is 5°C

5.1.3 Test limits

The allowed methods will be determined per project, and described on the checklist Piping system test limits can be done by:

- Valves: A valve may be used for test system limitation, provided it is suitable for the test pressure
- Blind flanges and spades: Suitably rated blinds and spades shall be used to contain the test pressure (thickness to the applicable pipe class).
-
- Caps and flat plates: Pneumatic testing shall always be performed against caps, never flat plates. Pressure testing against flat plates shall only be allowed, if fully documented and approved, on a case by case basis. Approval shall be based on verification calculation. Every fabricated cap / flat plate shall be identified and added to a list after visual and ultrasonic inspection of the circumferential weld (s). When end caps / flat plates need to be welded to the piping system, they shall be identified and listed in order to use the appropriate end cap / flat plate for the intended pressure.
- Each weld shall be welded by a qualified welder, using a qualified welding procedure specification. In all cases, the welds shall be full penetration welds, also when flat plates are used. The sacrificial pipe material directly connected to the tested component shall be from the same material
- Test plugs: test plugs shall be suitable for the test pressure. Plugs are subject to the regular inspection and certification system. Plugs are allowed for hydro-testing only.

5.1.4 Test equipment

◆ **Pressure test gauges**:

- Calibration certificates are available for review
- Pressure gauges shall be calibrated every 12 months
- Temperature recorders shall be calibrated annually
- If the system cannot be observed during the test, pressure recorders may be used

◆ **Pumps, hoses etc**:

- Testing equipment must be clean
- Testing equipment must be suitable for the test pressure, for pressures above 100 bar and for pneumatic testing this shall be checked

5.1.5 Combining test systems

FCM may combine test systems based on maximum allowable test pressure,which is based on the maximum design pressure/temperature of the pipe specification. If FCM

applies higher test pressures, the test system shall be verified for non standard pipe specification items.

5.1.6 Verification and release of test systems

Piping systems will be checked (punched out) and released by FCM QC inspectors

Leak testing of reinforcing plates

If specified by the Customer, reinforcing plates (or each segment thereof) and similar attachments shall be tested with air.

5.2 HYDROSTATIC TESTING

5.2.1 Performance

- Ensure the air is out of the system as much as possible
- Ensure that the pressure shall not be higher as the test pressure + 5%
- During hydro-testing, the pressure shall be monitored continuously.

5.2.2 Testing above 100 bar/P*V>10000 m3bar

For testing above 100 bars or in case Pressure*volume is >10000 m3bar, additional safety precautions are applicable.

- A safety distance shall be respected. This safety distance shall be marked, no people, except pressure testing operators or inspectors are allowed in the safety zone!
- The pressure shall be gradually increased

5.3 PNEUMATIC TESTING

Testing with air or gas is dangerous

The compressed gas stores a lot of energy which may cause explosion-like effects when a leak or rupture occurs

The hazard can be split into two main effects: A shockwave effect and a missile effect.

The shockwave effect is the pressure wave, which will occur when a lot of gas is released at once

The missile effect will occur when objects are launched by the gas release; this is further called the UFO effect

Both effects shall be controlled by the sequence:

Priority	Control method	Shockwave effect	UFO effect
1	**Eliminate the risk**	Inspection of piping system, test equipment	Inspection of all possible items which may be launched
2	**Shield the effect**	Locate the test crew at the opposite side, compared with the test system	Locate the test crew at the opposite side, shield and attach items (if possible)
3	**Protect personnel**	Keep safety distance. Limit the number of personnel	Cover up personnel. Limit the number of personnel

A work permit shall be established by HSE department after verification of the safety protections put in place, especially for pneumatic testing.

For pneumatic testing the checklist (attachment VII) shall be put in the test package and verified and signed by the relevant persons.

For each test package, the safety distance (safety area) and test step chart shall be prepared by the work preparation department.

The safety area shall be marked with signs.

All control shall be performed outside the safety area.

The pressure shall be controlled as per pressure test diagram

In case P*V>1000 m3 bar a safety valve shall be installed

The use of air for testing shall be limited to a maximum pressure of 20 barg

Above this pressure nitrogen shall be used, and a kick-off meeting organized

Only necessary test personnel shall be permitted within a safety radius of the piping system which is to be tested

The inspectors will check the system during test preparation and identify objects which may be launched after a collapse of the system (UFO's)

Based on the analyses of possible UFO's the test equipment should be repositioned in a safe area (test system at the opposite side of the test) and/or items may be shielded.

During testing a HSE officer will be on site

The expression used in the calculation of safety distance and waiting delays

$$L=\text{MAXIMUM}\left[30 \text{ or } 3{,}6 \sqrt[3]{V\{ (Pt+1) - (Pt+1)^{0.714} \}}\right]$$

T= MAXIMUM [10L or 300s]

in which :

L = safety distance (m)

V = volume in m3

Pt = test pressure in bar

T = waiting delay (s)

The formula to calculate the safety distance and the waiting delays is based on the Dutch Rules for pressure vessels. The formula is based on: Assuming an adiabatic explosion of the gas filled space then following the equation with data on explosives the average damage at the indicated distance is limited to windows and doors.

5.4 FLUSHING

Hydrostatic tested lines shall be flushed after testing if applicable

On request of the Customer, piping shall be high pressure water jet cleaned. High pressure jet cleaning shall not be made through any sensitive equipment i.e. soft sealed valves and instruments etc.

Pneumatic tested lines may be flushed during pressure release at pressures lower that 6 barg

5.5 DRAINING AND REINSTATEMENT

5.5.1 Draining

The water has to be drained out completely after hydrostatic testing

Hydrostatic tested piping shall be drained (taking care to vent adequately avoiding any vacuum conditions).

The systems shall be blown out and dried as defined in the Customer's specification.

5.5.2 Reinstatement

All temporary connections, spools and blanks shall be removed

All other items removed for testing shall be reinstalled

All temporary restraints, supports and blocks on variable supports shall be removed and the system shall be checked out for completeness and compliance with the Customer's drawings and specifications

If the Customer's specification requires replacement of gaskets or test gaskets have been used, the correct gaskets shall be installed after testing

Test pressure equipment shall be removed and all vents and drains shall be plugged (if any)

Flanged joints broken during the test shall be made up using new gaskets. Ring type joint type gaskets, except API BX type, may be re-used if undamaged.

5.5.3 Welding after hydro test

Seal welds of vents and drains (if applicable) shall be welded after hydro test. Seal welds shall be documented on separate seal welding certificates per hydro test.

6 RESPONSIBILITIES

The Shop Foreman for prefabrication in the workshop and the Test Supervisor on site, in co-ordination with the Test Engineer and the QC Engineer, are responsible for the implementation of this procedure

Order nr.	
Project	

Nr.	**Item**	Checked:	
		Name	**Signature**
1	Test type identified on line list		
2	Test pressure/medium identified on line list		
3	Code :		
4	Number and type of pressure gauges: Calibration requirements (deviations): Location:		
5	Formal test pack release		
6	Limitations with respect to test limits		
7	Required water quality: CS/SS		
8	Painting of welds limitations		
9	Additional requirements for pneumatic testing		
10	Minimum testing temperature		

ASME B31.3

Leak test choice		Where the owner considers both hydrostatic and pneumatic leak testing impracticable : • All circumferential, longitudinal, and spiral groove welds shall be 100% radiographed or 100% ultrasonically examined • All welds, including structural attachment welds, not volumetric examined, shall be examined using the liquid penetrant method, or, for magnetic materials, the magnetic particle method • A flexibility analysis shall have been made • System shall be subject to a sensitive leak test. ASME B31.3 category D fluid : At the owner's option, a piping system in category D fluid service may be subject to an initial service leak test, in lieu of the hydrostatic leak test. ASME B31.3 category M fluid : A sensitive leak test shall be included in the required leak test. ASME B31.3 high pressure piping : None of the following leak tests may be used : • Initial service leak test • Sensitive leak test • Alternative leak test
Painting		All joints may be primed and painted prior to leak testing.
Pressure relief valves		pneumatic test : Pressure relief devices shall be provided, having set pressure less than test pressure plus the minimum of 3,45 barg or 10%.
Pre-tests		A pre-test using air at no more than 1,7 barg may be made prior to testing to locate major leaks.
Maximum test pressure		Test pressure may be reduced to the maximum pressure that will not exceed yield strength at test temperature.
Inspection pressure and inspection time		A leak test shall be maintained for at least 10 minutes. Inspection shall be done at design pressure.
Range		Use gauges between 35 and 90% of the full scale.
Test fluid		The fluid shall be water unless there is the possibility of damage due to freezing or adverse effects on piping or process. In that case, another non-toxic fluid may be used.
Hydrostatic test pressure		The test pressure at any point in the piping system shall not be less than 1,5 times the design pressure
PNEUMATIC Test	Test gas	Non-flammable and non-toxic gas.
	PRESSURE	110 % OF THE DESIGN PRESSURE
TIE-IN WELDS		Closure welds : final weld connecting piping systems which have been successfully tested need not be leak tested provided weld is examined and passes with 100% radiographic examination or 100% ultrasonic examination

R1

ASME B31.1

Leak test choice		ASME B31.1: Except for pre-testing, pneumatic testing shall not be used unless owner specifies pneumatic testing or permits its use.
Painting		ASME B31.1: All joints inclusive welds shall be left un-insulated and exposed for examination.
Pressure relief valves		ASME B31.1: If a test pressure is to be maintained during which test medium is subject to thermal expansion, pressure relief device set at 1 1/3 test pressure is recommended.
Pre-tests		ASME B31.1: A preliminary test not to exceed 1,75 barg may be executed to locate major leaks.
Maximum test pressure		ASME B 31.1: At no time during pressure test shall any part of the piping system be subject to a stress greater than 90 % of the yield strength at test temperature.
Inspection pressure and inspection time		ASME B31.1 hydro test: The test pressure shall be continuously maintained for minimum time of 10 minutes and may then be reduced to design pressure. ASME B31.1 pneumatic test: The test pressure shall be continuously maintained for minimum time of 10 minutes and may then be reduced to lesser than design pressure or 7 barg. Examination for leakage detected by soap bubble shall be made at all joints and connections.
R1 Range		Use gauges between 35 and 90% of the full scale.
Test fluid		ASME B31.1: Water shall normally be used as test medium. Further recommended precautions on quality of test water used for hydro testing of austenitic and ferritic stainless steel are in non-mandatory appendix IV.
Hydrostatic test pressure		The test pressure at any point in the piping system shall not be less than 1,5 times the design pressure
PNEUMATIC TEST	Test gas	ASME B31.1: Test medium shall be non-flammable and non-toxic.
	PRESSURE	The test pressure shall not be less than 1,2 nor more than 1,5 times the design pressure
TIE-IN WELDS		

EN13480

Leak test choice		EN 13480: The proof test shall be a hydrostatic pressure test except where a hydrostatic pressure test is harmful or impractical. In these instances, a pneumatic pressure test or other tests shall be performed. Pneumatic tests shall only be permitted where hydrostatic pressure test is detrimental to piping system or is not practical eg. in processes where even small traces of liquids are intolerable, following consultation at design stage on adequacy of safety precautions proposed by piping manufacturer.
Painting		EN 13480: Painting for corrosion protection shall be permitted, provided, it does not prevent the clear examination of the joint under test.
Pressure relief valves		EN 13480 hydro test: It is recommended a small pressure relief valve set to 1,1 test pressure is attached.
Pre-tests		
Maximum test pressure		EN 13480: Test pressure shall be limited to such a level that it does not generate a design stress greater than that given in EN 13480-3 for testing conditions.
Inspection pressure and inspection time		EN 13480 hydro test: Piping system shall be held at test pressure for period of at least 30 minutes. Pressure shall then be reduced to design pressure and all components and welded joints subject to a close visual examination. EN 13480 pneumatic test: Pressure shall be reduced after 10 minutes to inspection pressure (= PS * (fa / ft)), where PS = design pressure, ftest = nominal design stress for design conditions at test temperature, f = nominal design stress for design conditions at design temperature.
Range		EN 13480: Pressure gage range: 1,5 – 4 intended maximum pressure. All indicating and recording type gages used shall be calibrated to the appropriate gage standard.
Test fluid		EN 13480: Hydrostatic test may be performed with general supply water. For hydrostatic test of austenitic stainless steel piping systems, the halogen concentration of the water shall be controlled and not exceed a volume fraction of 50 ppm.
Hydrostatic test pressure		The test pressure shall not be less than the maximum of 1,25 times the maximum allowable pressure (taking into account the rate nominal stress at test temperature compared to design temperature), and 1,43 times the maximum allowable pressure
PNEUMATIC test	Test gas	EN 13480: Where a pressurizing fluid other than water is used, care shall be taken to identify any additional hazards associated with the fluid. The fluid shall be non-toxic and non-flammable
	Additional requirements	– Metal temperature at which shall be at least 25 °C above brittle fracture temperature in EN 13480-2 annex B – Non destructive examination
	PRESSURE	The test pressure shall not be less than the maximum of 1,25 times the maximum allowable pressure (taking into account the rate nominal stress at test temperature compared to design temperature), and 1,43 times the maximum allowable pressure
TIE-IN WELDS		

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ASME VIII

Leak test choice		ASME VIII : A pneumatic test may be used in lieu of hydro test only when any of the following condition exists : • When they are so designed or supported that they cannot safely be filled with liquid • When they are not readily dried are to be used in services where traces of testing medium cannot be tolerated.
Painting		ASME VIII: All joints shall be left un-insulated and exposed for examination during test. Except the weld areas which shall be left with the primer coat only.
Pressure relief valves		
Pre-tests		ASME VIII: A pressure test at pressure not to exceed 25% of design pressure may be applied to locate leaks.
Maximum test pressure		ASME VIII: The maximum test pressure shall be limited as defined in NB-6222 (NC-6222 / ND-6222).
Inspection pressure and inspection time		ASME VIII: The test pressure shall be maintained a minimum of 10 minutes. Leakage examination shall be made at pressure equal the greater of design pressure or ¾ test pressure.
Calibration		ASME VIII: Test gages shall be calibrated before each test or series of test. Series of tests is that group using same pressure test age which is conducted at same site within period not exceeding 2 weeks.
Range		Analogue manometer: not less then 1,5 times nor more than 4 times the test pressure. Digital manometer: may be used without range restriction provided the combined error due to calibration and readability does not exceed1% of the test pressure.
Test fluid		ASME VIII: Water or an alternative fluid, as permitted by the design specification, shall be used. If water temperature is below 5°C and Customer approval has been obtained, an antifreeze solution such as methanol or inhibited glycol can be added to the test water according to the Manufacturer instructions.
Hydrostatic test pressure		The test pressure shall not be less than 1,25 times the lowest design pressure
PNEUMATIC test	Test gas	ASME VIII: Gas used shall be non-flammable.
	PRESSURE	The test pressure shall not be less than 1,1 times the lowest design pressure of any component
TIE-IN WELDS		

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FCM	**PRESSURE TEST CERTIFICATE**

CERTIFICATE N°:

Project :
Customer :
Ref. Customer :
Ref. FCM :

Spec./Proc. :
Area :
Test pack :
Test Medium :
Temperature : Celsius
Test pressure : barg
Duration : hour(s)
Gauge n° 1 :
Gauge n° 2 :

ISOMETRIC or DRAWING	LINE NUMBER or ITEM NUMBER	MATERIAL SPEC.	PID	REMARKS

QUALITY CONTROL	CLIENT	III° PART		
DATE	DATE	DATE		