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KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	START-UP SEQUENCE AND GENERAL COMMISSIONING PROCEDURES (PROJECT STANDARDS AND SPECIFICATIONS)	

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SCOPE

This Project Standards and Specification covers minimum process requirements for plant start-up sequences and general commissioning procedures for Non-Licensed Units or facilities. For Licensed Units, instructions given by the Licensor shall be followed.

Although, the start-up sequences and commissioning procedures differ to some extent from process to process, the basic philosophy and general aspects shall conform to the concepts of this Standard.

However, considering the general commissioning and all activities to be performed prior to initial start-up as outlined in this Standard, feed introduction to the Unit shall be according to the stepwise start-up procedure provided by the Contractor in the Unit Operating Manual.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. API (AMERICAN PETROLEUM INSTITUTE)
API Std. 650, "Welded Steel Tanks for Oil Storage", English Edition Latest Edition
2. ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)
ASME Code, Section VIII

DEFINITIONS AND TERMINOLOGY

Contractor - The persons, firm or company whose tender has been accepted by the "Employer", and includes the Contractor's personnel representative, successors and permitted assignees.

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Licenser or Licensor - A company duly organized and existing under the laws of the said company's country and as referred to in the preamble to the contract.

Project - The equipment, machinery and materials to be procured by the "Contractor" and/or "company" and the works and/or all activities to be performed and rendered by the "Contractor" in accordance with the terms and conditions of the contract documents.

Unit or Units - One or all process, offsite and/or utility Units and facilities as applicable to form a complete operable refinery/ and or plant.

SYMBOLS AND ABBREVIATIONS

<u>SYMBOL/ABBREVIATION</u>	<u>DESCRIPTION</u>
DN	Diameter Nominal, in (mm).
LPG	Liquefied Petroleum Gas
OGP	Oil, Gas and Petrochemical.
ppm (by mass)	Parts per million, in (mg/kg).
PSV	Pressure Safety/Relief Valves.
SSU	Saybolt Universal Seconds.

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

GENERAL REQUIREMENTS

1. Commissioning shall start from the point at which steps are taken to bring the Unit/facility up to operating pressure and temperature and to cut in the feed. It shall be complete when the Unit/facility is operating at design capacity and producing products to specification.
2. For a project involving a number of process Units and offsite facilities, it shall be agreed between the Contractor and Company in the earliest stages of a

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project the sequence of the commissioning of the Units. It shall be necessary to commission utilities and some of the Units in advance of others, because of their interdependence from a process point of view.

3. The responsibilities of the Contractor and Company during commissioning stage should be clarified for the provision of labor, operators, specialists and service engineers, and also for the correction of faulty equipment, etc.
4. The general requirements outlined in this Standard for testing of equipment/lines shall be followed. The detail procedures for testing of equipment and lines and other precommissioning steps are not included in this Standard and shall be prepared in accordance with the Company's Engineering Standards by the Contractor and submitted to the Company for approval. However, on completion of testing, vessels, equipment and piping should be vented and drained, and where necessary cleaned and dried to the satisfaction of the Company.

Spades, blanks and other equipment installed for testing shall be removed on completion of testing. Wherever a flange joint is broken after testing, e.g., on heat exchangers, pipework, fired heaters and at machinery, then the joint rings or gaskets must be renewed. Particular attention must be given to heat exchangers employing solid metal or filled gaskets, and great care should be taken to ensure that all gaskets renewed after testing of heat exchangers and are correctly fitted before tightening flanges.

Where required, valves are to be repacked with the appropriate grade of material.

Any temporary bolting which has been used shall be replaced and any temporary fittings which may have been installed to limit travel, e.g., in expansion joints and pipe hangers, shall be removed.

5. Prior to commissioning, each item of equipment should have its name, flowsheet number and identification number painted and/or stamped on it according to the Company's Specifications.

PREPARATION PRIOR TO INITIAL START-UP

The procedures described in this Section shall be carried out at the completion of construction and before initial operation of the Unit. Appropriate phases should be repeated after any major repair, alteration, or replacement during subsequent

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shutdowns. The phases of preparation for initial start-up shall be according to the following steps:

- Operational checkout list.
- Hydrostatic testing.
- Final inspection of vessels.
- Flushing of lines.
- Instruments.
- Acid cleaning of compressor lines.
- Breaking in pumps.
- Breaking in compressors.
- Dry-out and boil-out.
- Catalyst loading.
- Tightness test.

Operational Check-Out

1. Check line by line against flowsheet and locate all items.
2. Identify the location of instruments.
3. Indicate the location of all critical valves including valves at critical vent and drain locations.
4. Check control valves, valves, and globe valves to see that they are installed properly with respect to flow through their respective lines. Special attention must be given to check valves regarding their direction of flow.
5. Review all piping and instrument connections for steam tracing.
6. Check that the following facilities have been installed so that the plant can be commissioned and put on stream:
 - Start-up bypass lines.
 - Purge connections.
 - Steam-out connections.

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- Drains.
 - Temporary jumpovers.
 - Blinds.
 - Check valves.
 - Filters and Strainers.
 - Bleeders.
 - Etc.
7. Check pumps and compressors for start-up.
 8. Check sewer system for operability.
 9. Check blowdown systems.
 10. Check heater for burner installation, refractories, stack damper controls, burner refractories, etc.

Hydrostatic Testing

1. Hydrostatic pressure testing of the Unit shall be performed to prove strength of the materials and weld integrity after completion of the construction. The tests shall be made on new or repaired equipment and pipings. The initial testing is ordinarily done by the Contractor in the course of erection.
2. Detail procedure for testing the equipment and lines shall be prepared by the Contractor and submitted to the Company for approval.
3. Fresh water containing a corrosion inhibitor which meets the Company's approval shall be used for hydrostatic test purpose unless otherwise specified in this Standard. In systems where residual moisture can not be tolerated, e.g., in SO₂, acid, ammonia and LPG service, and where certain catalysts are used, oil is the preferred test medium. If the water has to be used, the system should afterwards be dried out with hot air. Special attention should be given to the points where water may be trapped, such as in valve bodies or low points.
4. If for any reason it is not practical to carry out a hydraulic test, a pneumatic or partially pneumatic test may be substituted subject to prior agreement with the Company. Full details, including proposed safety precautions, will be

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required. The following are usually excluded from hydrostatic testing, and are usually tested with compressed air and soap suds:

- a. Instrument air lines (test with dry air only, if possible).
 - b. Air lines to air-operated valves (test with dry air only).
 - c. Very large (usually over DN 600 or 24 inches) gas or steam overhead lines.
 - d. Pressure parts of instruments in gas or vapor service.
5. When austenitic or austenitic acid clad or lined equipment and piping are tested, the test fluid chloride ion content shall meet the following conditions:
- a. If the piping and equipment metal temperature never exceeds 50°C during commissioning, operation or nonoperation, water containing up to 30 ppm (by mass) chlorides ion shall be used. The chlorides ion content might be increased up to 150 ppm (by mass) if the equipment or piping can be thoroughly washed out using water containing less than 30 ppm (by mass) chlorides ion as soon as testing is complete if allowed by the Company. In any case, the water must be drained and the equipment thoroughly dried immediately thereafter.
 - b. If the piping and equipment metal temperature exceeds 50°C during commissioning, operation or nonoperation, the piping shall be tested using condensate water, demineralized water or oil with minimum flash point of 50°C.
6. The testing medium should not adversely affect the material of the equipment or any process fluid for which the system has been designed. Reference should be made to the applicable codes in the case of pressure vessels to determine the minimum ambient and fluid temperatures at which testing may be carried out. If it is desired to test vessels, tanks or piping at temperatures below 16°C, attention shall be made to the danger of brittle fracture occurring in carbon steels and ferritic alloy steels unless the materials have adequate notch ductility properties. For any equipment or piping, water should not be used for testing, when either the water temperature or the ambient temperature is below 5°C. Hydrostatic testing at temperatures below this value may be carried out using gas oil, kerosene or antifreeze solution at appropriate strength, provided that, the fluid used to be agreed with the Company. When flammable liquids including gas oil or kerosene are to be

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used, appropriate safety measures must be observed and a work permit shall be required.

7. Sea water shall not be used for the testing of equipment and lines on process Units and steam generating plants. Proposals for the use of sea water for the testing of storage tanks and offsite lines shall receive Company's approval.
8. During the hydrostatic test pressure with water the system loss should not exceed 2% of the test pressure per hour unless otherwise specified. Evidence of water at valves, flanges, etc. will indicate the leaking areas to be repaired if the system fails the test. All welds and piping must be inspected for defects by looking for wet spots, therefore they should be tested before they are insulated.
9. If piping is tested pneumatically, the test pressure shall be 110% of the design pressure. Any pneumatic test shall be increased gradually in steps, allowing sufficient time for the piping to equalize strains during the test. All joints welded, flanged or screwed shall be swabbed with soap solution during these tests, for detection of leakage.
10. Vents or other connections shall be opened to eliminate air from lines which are to receive hydrostatic test. Lines shall be thoroughly purged of air before hydrostatic test pressure is applied. Vents shall be open when systems are drained so not to create buckling from a vacuum effect.
11. Relief valves must be removed or blinded prior to hydrostatic testing.
12. After completion of hydrostatic testing, all temporary blanks and blinds shall be removed and all lines completely drained. Valves, orifice plates, expansion joints and short pieces of piping which have been removed shall be reinstalled with proper and undamaged gaskets in place. Valves which were closed solely for hydrostatic testing shall be opened. After lines have been drained with vents open, temporary piping supports shall be removed so that insulation and painting may be completed.
13. Extreme care shall be taken in field testing of heater and furnace tubes, which are normally field fabricated and must be hydrostatically tested. Where possible, piping and heater tubes shall be tested together.

 Heater tubes shall be tested to manufacturer's recommended test pressure. Test shall be coordinated with heater erection Contractor
14. Vessels constructed in accordance with ASME Code Section VIII will not require individual pressure tests at site except in the following cases:

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- a. Vessels whose condition, resulting from transport, storage, handling, or for any other cause is suspect in the opinion of the Company.
 - b. Vessels which have had any site modification which in the opinion of the Company necessitate a site pressure test.
15. With the exception of the relief valves, all valves and fittings should be installed on the vessels and included in the test. Relief valves must be removed or otherwise isolated.
- On satisfactory completion of a pressure test the vessel should be drained completely, any blinds inserted for test purposes removed and these joints remade to the satisfaction of the Company.
16. At the conclusion of the test, the system must be drained. If pumps have been included, they must each be drained and refilled with oil to prevent rust forming in the seals. If fractionating columns are included, the water must be displaced with sweet gas, nitrogen, or an inert atmosphere rather than air to avoid corrosion and sticking of the valves on the fractionating trays.
17. Provided manufacturers test certificates are available, only the following pressure tests should be carried out on heat exchangers except as required below.
- a. On floating head shell and tube type exchangers, on tube side with bolted bonnets removed.
 - b. On tube-in-tube types, on both sides in conjunction with associated pipework.
 - c. On air-cooled types, the bundles are to be isolated and tested separately from associated pipework.
18. In the case of tubular exchangers whose condition, resulting from transport or other causes is suspect in the opinion of the Company, a pressure test on the shell side at least equal to the maximum allowable pressure should be carried out. Tests may be carried out individually or on groups of exchangers having similar operating conditions. Test pressure for shell and tube and air-cooled types should be not less than the maximum operating pressure in the tubes. For tube-intube types, the test pressure should be as for the associated pipework.
- After completion of test all equipment must be thoroughly drained and if necessary, dried out to prevent scaling of tubes before commissioning.

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After completion of test all bonnets and covers should be replaced, temporary blanks removed and all joints remade to the satisfaction of the Company. All compressed asbestos fibre joints should be renewed.

19. All tanks shall have bottoms, shells and roofs tested in accordance with API 650, latest edition. Shells shall be tested by filling tanks with water. Vacuum testing shall be used for all tank bottoms and roofs.

20. The blow off (set) and blow down (re-set) pressure of all relief valves should be set to the satisfaction of the Company. After approval of the Company, a seal to be fixed to each valve. The Company's inspector shall check each valve after it has been re-installed to ensure that its seal is intact.

Inlet lines to relief valves should be cleared before the valves are finally installed.

In case where the valve exhausts to a pressure system, the downstream side should be tested to a pressure equal to the test pressure rating of the outlet system.

21. Flame arrestors and other miscellaneous equipment that does not have test pressure indicated shall be isolated from the test.

22. Certain types of instruments with their connecting process lead pipelines shall be tested at the same pressure as the main pipelines or the equipment to which they are connected. Such instruments normally include the following types:

- a. Displacer type level instruments.
- b. Gage glasses.
- c. Rotameters.
- d. Control valves.
- e. Flow meter pots.

Other types of instruments shall not be tested at line pressure, but shall have process lead lines tested to the first block valve or valves nearest the instrument. Care shall be taken that this equipment is protected by removal, or by blocking the instrument lead line and disconnecting or venting the instruments. These types will normally include the following:

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- a. Analyzers.
- b. Diaphragm Type Level Instruments.
- c. Differential Pressure Type Flow Instruments.
- d. In-Line Type Flow Switches.
- e. Direct Connected Regulators.
- f. Open-Float Type Level Indicators and Alarm Switches.
- g. Positive Displacement Type Flow Meters.
- h. Pressure Indicators Recorders and Transmitters.
- i. Pressure Switches.
- j. Pressure-Balanced Control Valves.
- k. Pressure Gages.
- l. Turbine Type Flow Sensors.

Special precautions shall be taken to insure that instruments and instrument lead lines to be tested are vented and completely filled before testing, and are thoroughly drained after test.

Final Inspection of Vessels

Before the final bolting of coverplates and manholes, vessel interiors should be inspected for cleanliness, completeness, and proper installation of internal equipment. Inspection list shall include at least the following items where applicable:

1. Tray installation; satisfactory testing (where required).
2. Internal drawoff piping.
3. Catalyst supports and screens.
4. Internal distributors.
5. Liquid entrainment separators.
6. Internal risers and vortex breakers. Thermowell location and length.

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7. Level instruments, location and range, internal float, external displacement and differential pressure type.
8. Internal cement lining.

Flushing of Lines

All fluid handling equipment particularly piping, should be thoroughly cleaned of scale and the internal debris which accumulates during construction. This is accomplished by blowing or washing with air, steam, water and other suitable medium.

Some utility systems, such as water and high pressure steam, may be satisfactorily cleaned with their normal media, introduced through normal channels. Other systems must, or preferably should, be flushed with foreign media, admitted via temporary hose or pipe connections. Thus, flushing may be accomplished on exhaust steam lines with high pressure steam or air, and on fuel oil lines with steam, followed by air. The best way to clean a typical utility or auxiliary system is to flush the supply main from source to end at first and making an end outlet by breaking a flange or fitting if necessary, than flush each lateral header in the same manner; and finally, flush the branch which take off from the headers. In some instances if required the weld-cap on the end of each header could be cut off and re-welded after the line has been flushed.

1. Steam piping
 - a. Before blowing a steam line for cleaning, an open end for a free passage of the steam and debris shall be provided. If the open end is a temporary provision, be certain the end is tied down to prevent possible whipping caused by high velocity flow. All drains must be open and the line free of water. Valving to steam traps shall be closed and the traps shall remain out of service until the line cleaning is completed. Prior to starting steam flow all safety precautions shall be taken. The area should be cleaned and guarded to prevent injury to personnel. Steam shall slowly be introduced from the source and the line heated gradually.
 - b. The steam flow rate shall be limited to the condensate drainage flow rate. Condensate must not be permitted to accumulate in order to avoid water hammer. As the piping heats and the condensate diminishes, the steam rate shall be increased. As the line heats, observe its expansion and determine that there is no binding or distortion. After the piping is