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KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	<b>SPECIFICATION FOR INSPECTION AND TEST OF VESSEL AND HEAT EXCHANGERS</b>  <b>(PROJECT STANDARDS AND SPECIFICATIONS)</b>	

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## SCOPE

This Project Standard and Specification shall apply to shop inspection and test of towers, shell and tube type heat exchangers, etc. (herein and after referred to as vessels).

## INSPECTION AND TEST RECORDS

### Test Records

Vendor shall submit to Owner the following records for each vessel:

- Material mill test certificate
- Hydrostatic and pneumatic test
- Dimensional inspection
- Non-destructive examination
- Post weld heat treatment
- Welding procedure qualification
- Production weld test
- Other inspection and tests, where specified

Vendor shall provide the following information in the first part of all the records of inspection and tests:

- Name of Owner (end user)
- Job No., Item No., and name of vessel
- Name of Vendor
- Date of manufacture and inspection
- Short specification of vessel

## INSPECTION AND TEST ITEMS

### General

Unless otherwise specified in the Owner's specification or drawings, the application of the inspection and tests for each vessel shall be as shown in the list of inspection and test items which are provided for each classification of vessel.

Where the application of any item in the list is considered impractical, the Vendor shall submit a suggested alternative in detail to Purchaser/Owner for approval. Inspection and test items specified in the codes and standards shall govern where applicable.

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### Classification of Vessel

Pressure vessels are classified as shown in the following table:

Material and Service	Classification	
	Design Pressure	
	Up to 50 kg/cm <sup>2</sup> g	50 kg/cm <sup>2</sup> g and over
Low alloy steel for high temperature service ½ Mo. Cr-Mo, Mn-Mo-Ni	A1	A2
Carbon steel for high and medium temperature service C, C-Si, Si-Mn (design temp.: -10°C over or equal)	B1	B2
Carbon steel for low temperature service (Design temp.: from -50°C to -11°C)	C1	C2
Low alloy steel for low temperature service 2.5 Ni, 3.5 Ni (design temp.: from -105°C to -51°C)	D	
Austenitic stainless steel Austenitic clad steel	S	
Multi-layer cylindrical sell	M	

### Illustration of Welded Joint Locations Typical of Categories

The categories of the welding joints indicated in the attached list of inspection and test item, are illustrated as Fig 1-1 and 1-2.

### INSPECTION & TEST PROCEDURE AND ACCEPTANCE STANDARDS

#### Material Test

1. Vendor shall submit the mill test certificates for the followings:

- Shell, head, nozzle
- Tube sheet, channel cover, flange
- Tube, tray made of alloy steel\*
- Pressure retaining bolt and nut, and alloy steel\* bolt and nut

Note: \*Including high and low alloy steel such as C-Mo, Cr-Mo, 3.5 Ni steel, etc.

2. Submittal of mill test certificates for materials may be exempted for any of the followings:

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- Materials conformed with ASTM A-36 Rolled Steel for General Structure and their equivalent.
  - Stocked materials shall not be used in pressure retaining parts. Stocked materials used in pressure retaining parts, but not main parts, where their mill test certificates are not readily obtainable. In such cases Vendor's certificates may be substituted for the original mill test certificates.
3. Vendor shall, prior to fabrication of the vessel, check the charge number and the following items for the materials:
    - Chemical compositions
    - Mechanical properties
    - Heat treatment
    - Other items specified in the applicable codes and standards
  4. Materials shall be free from injurious defects, such as surface flaw and lamination and these shall be visually inspected.
  5. Material conformed with ANSI (Austenitic stainless steel containing molybdenum) or their ASTM equivalent not used in major parts of any vessel and without mill test certificates shall be checked for molybdenum content by qualitative analysis.
  6. As type 316 and 316L stainless steel (plate, pipe, forging material and welded deposit), examination for molybdenum detection shall be done.

#### **Impact Test of Material for Low Temperature Service**

1. Test procedure shall be in accordance with ASTM A370.
2. Test specimens of 2mmV (ASTM A379 Type A) shall be used.
3. Test temperature shall not be warmer than the minimum design temperature.
4. Acceptable impact energy are:
  - Average for three specimens: 15 ft-lb and over
  - Minimum for one specimen: 12 ft-lb

#### **Welding Procedure Qualification**

Test procedure and acceptable standards of the welding procedure qualification shall be in accordance with the applicable codes and standards.

#### **Inspection and Tests of Welds**

1. Welders who participate in the welding operation of the main seams of vessels, such as longitudinal and circumferential welding seams, nozzle-to-shell welds and other pressure retaining welds, shall be checked for their

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qualification licenses. Purchaser/Owner may request Vendor re-qualification of the welders, when necessary.

2. Prior to or during welding, the following items shall be inspected:

- a. Dimension of welding groove
- b. Alignment tolerances of plate edges

Normal Plate Thickness t (mm)	For Circumferential Joint (mm)
$t \leq 45$	1.0
$4.5 < t \leq 6$	1.5
$6 < t \leq 20$	$t \times 0.25$
$20 < t \leq 38$	5
$38 < t$	$t \times 0.125, \text{max.}6$

Normal Plate Thickness t (mm)	For Longitudinal Joint (mm)
$t \leq 4.5$	1.0
$4.5 < t \leq 6$	1.5
$6 < t$	$t \times 0.25, \text{max.}3$

Note: for clad steel, alignment tolerances of both longitudinal and circumferential joints shall be 1.0 mm.

- c. Suitability of welding procedure, such as selection of welding rod or electrode, pre-heating, etc.
  - d. First pass weld shall be back chipped and then inspected by magnetic particle or liquid penetration method.
  - e. Neither slag inclusion or crack shall be found at the finish of each welding pass.
3. After completion of welding, the following items shall be visually inspected to be within the acceptance criteria:

Crack	Not permitted, remove if any
Overlap	Not to exceed 1.5 mm
Undercut	Not to exceed 0.3 mm
Bead with uniformity	Not to exceed 5 mm
Bead height un-uniformity	Not to exceed 1.5 mm
Incomplete penetration	Not permitted and lack of fusion
Insufficient toe	Add welding length of fillet weld
Crater	Remove
Bead dripping	Remove
Spatter	Remove

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Slag and porosity	Not exposed
Fittings and welded spots	Remove
For temporary assembly	
Eccentricity of weld seam	Not abnormal
Deformation due to welding stress	Not abnormal
Thickness of reinforcement	Not to exceed the following values

Plate Thickness t (mm)	Allowable Thickness of Reinforcement
$t \leq 12$	1.5
$12 < t \leq 25$	2.5
$25 < t$	3.0

### Production Weld Tests

Procedure and acceptance standards of the production weld test shall be in accordance with applicable codes and standards.

### Post Weld Heat Treatment

Vessels shall, prior to post weld heat treatment, be carefully inspected by visual and non-destructive examination for dimensionless and any defect, so as to avoid welding repair after completion of heat treatment.

Vendor shall submit to Purchaser/Owner the time-temperature chart of post weld heat treatment.

### Visual Inspection

The visual inspection shall be carried out as follows:

1. The vessel and its parts to be assembled at the job site shall be temporary assembled and checked, where necessary, at the Vendor's shop.
2. Direction and orientation of nozzles and other fittings of vessels shall be checked.
3. Deformation of vessels shall be checked.
4. Machined surfaces shall be checked.
5. Internal cleanliness of vessels shall be checked.

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### Dimensional Inspection

1. Dimensions of the vessel and its parts shall be checked to meet Vendor's drawing as approved by Owner, and their record shall be submitted to Purchaser/Owner.
2. Actual wall thickness of pressure retaining parts shall be measured, and shall not, as a rule, be thinner than the calculated thickness. However, actual plate thickness may be 0.25 mm thinner than the calculated thickness.
3. The inside diameter shall be measured at four or more positions for each selection at a distance of about 100 mm from each side of a circumferential welded seam. When direct measurement of the inside diameter is impractical, the external circumference may be measured and inside diameter calculated.
4. The chamber of shells shall be measured in accordance with the following procedures:
  - a. Place the tower horizontally on tower supports so that deflection of the shell is kept at a minimum.
  - b. Stretch a piano wire along the shell parallel to the tower support level.
  - c. Measure the distance between the piano wire and the external surface of the shell at four positions on the circumference corresponding to each 90 degree arc of the shell section.

### Hydrostatic and Pneumatic Test

1. Scope of apply shall be as follows:
  - a. Hydrostatic test shall normally be carried out for all vessels by use of water. Pneumatic proof test may be used in lieu of the hydrostatic test, when filling with water is considered impractical due to design, construction, and service of the vessel. The pneumatic test pressure will be specified separately.
  - b. Pneumatic test shall only be carried out for any of following cases:
    - Shell side of shell and tube type heat exchanger (to check leakage from tube to tube sheet plate)
    - Reinforcing pad of nozzle
    - Line vessel, when necessary
2. Test pressure and holding time shall be as follows:
  - a. The hydrostatic test pressure shall be as specified in the approved Vendor's drawing, and it shall be held for at least half an hour.
  - b. Pneumatic test
    - The test pressure shall be as indicated in the approved Vendor's drawing but higher than the operating pressure.

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- For reinforcing pads and linings, the test pressure shall be from 5 to 7 kg/cm<sup>2</sup>g and held for at least 5 minutes.
  - For shell and tube type heat exchangers, tube to tube sheet joints shall be tested for tightness with air in the shell side, unless otherwise specified, the test pressure shall be the design pressure of shell side or 6 kgf/cm<sup>2</sup> whichever is less.
3. The jacketed vessel shall be tested before mounting the jackets.
  4. Water temperature of the hydrostatic test shall be determined in consideration of ductile-brittle fracture. Unless otherwise approved by Owner, for vessels constructed of steel whose resistance to brittle fracture at low temperature has not been enhanced, test temperature above 7°C shall be provided to minimize risk of brittle fracture during hydrostatic test.
  5. The pneumatic test of heat exchangers which are to be stacked, shall be carried out in the stacked condition.
  6. Special vessel shall, where specified, be leak tested by use of halogen gas, and test procedures and pressure will be indicated separately.

### **Radiographic Examination**

1. Degree of radiographic examination shall be as shown in the Engineering Drawings.
2. Portions to be radiographed shall be as follows:
  - When full radiography is specified, main longitudinal, circumferential welding seams and butt welded joints of nozzles made of steel plate shall be 100 percent examined.
  - When spot radiography is specified, at least one spot for each welded seam and every cross longitudinal to circumferential welded shall be examined.
3. Radiographic examination shall be performed in accordance with ASME Code Section VIII, Par. UW-51 & UW-52.
4. Acceptance-rejection standards shall be as follows:
  - a. Porosity shall be per paragraph Appendix 4, Section VIII.
  - b. Other defects show any of the followings which are specified in paragraph UW-51 of Section VIII shall be judged unacceptable.
    - i) Any crack and incomplete penetration
    - ii) Any elongated slag inclusion which has length greater than
      - 6 mm for t up to 18 mm
      - t x 1/3 for t from 18 mm to 54 mm
      - 18 mm for t over 54 mm
Where, t is thickness of the weld