


 <b>PDIL</b> पी डी आई एल <b>ENGINEERING THE FUTURE</b>	<b>TITLE: PURGE GAS RECOVERY UNIT</b> <b>PLANT: AMMONIA-II; NFL, VIJAIPUR</b>	PC65/E01/P-II/Annx4	0	 <b>नेशनल फर्टिलाइजर्स लिमिटेड</b> एन.एफ.एल. <b>NATIONAL FERTILIZERS LIMITED</b>
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## **ANNEXURE-4**

### **DESIGN PHILOSOPHY**

### **STATIC EQUIPMENTS**

<b>0</b>	<b>11.07.2013</b>	<b>11.07.2013</b>	<b>ISSUE FOR OWNER'S COMMENT</b>	<b>VB</b>	<b>BS/AKG</b>	<b>PCC</b>
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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### LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
APPENDIX - 1	GUIDELINES FOR DYNAMIC WIND ANALYSIS	2
APPENDIX-2	PAINTING SPECIFICATION (STATIC EQUIPMENT)	2

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## 1.0 GENERAL



### 1.1 Scope

- 1.1.1 This document defines the design philosophy to be applied to the design of various types of static equipment's required for Purge Gas Hydrogen Recovery Unit Package at Ammonia-II plant NFL Vijaipur.
- 1.1.2 The complete mechanical design, material of construction/fabrication (shop/site as applicable), inspection, testing, painting, supply, transportation, erection and commissioning of equipment etc. at project site shall conform to the specifications, drawings and internationally accepted codes / standards duly accepted by the Owner. In addition, all statutory rules & regulations shall also be complied with.
- 1.1.3 All works described in this package shall be performed in accordance with the design basis, specifications, drawings, and other requirements of bid package and shall be subject to Owner's review and approval.

### 1.2 Codes and Standards

- 1.2.1 The equipment shall be designed & constructed as per the latest edition of the following codes and standards:

Code	Description
ASME Section VIII Div 1 & 2	Rules for construction of Unfired Pressure Vessels
TEMA	Standards of Tubular Exchangers Manufacturer's Association / For Shell & Tube Heat Exchanger
API 662	Plate type Heat Exchangers
IBR	Indian Boiler regulations
API 650 /IS803	Welded Steel Tanks for Oil Storage
API 941	Steels for Hydrogen Service at Elevated Temperature & Pressure
ASME Section II A&B/ ASTM	Materials Specifications
ASME Section II PART C	Specification for welding rod, electrode & filler metal
ASME SEC II PART D	Properties
ASME Section V	Non-destructive Examination
ASME Section IX	Welding Qualification
EJMA *	Standard of Expansion Joint Manufacturers Association
NACE	National Association of Corrosion Engineers
ASME B 16.5	For flanges
ASME B 16.47	For large diameter flanges
ASME B 16.20	For gaskets
ANSI	Pipes, Flanges, Fittings and Valves
IS: 875/SITE DATA	For wind load consideration
IS: 1893 (Part 4):2005 / SITE DATA	For seismic design consideration
Factory Act, 1948 BS CP 3003 (Part 1)	Factory Act & State Govt factory rules Code of Practice on lining of Vessels and equipment for Chemical Process.

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- \*- Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA standard.

**Notes:**

1. LSTK Contractor may select DIN, BS or any other well known international materials as Substituted materials to ASTM/ASME ones, if they are equivalent or superior to ASTM / ASME ones. The chemical & mechanical properties of such equivalent or superior offered materials preferably comparison w.r.t. ASTM materials shall be furnished along the bid. LSTK Contractor shall also submit the references of past supplies of similar type of equipment w.r.t. the proposed materials offered by them in their bid.
2. Process licensors guidelines / standards may be adopted complying minimum requirements of this design philosophy of static equipment required for Purge Gas Hydrogen Recovery Unit Package. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

### 1.3 Regulations

Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations such as Indian Boiler Regulation and Department of Explosives, Nagpur, India together with Local by Laws for the state including statutory requirements as applicable. Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with.

**Publications:**

- WRC Bulletin # 107      Local Stresses in Spherical & Cylindrical Shells due to External Loadings.
- WRC Bulletin # 297      Local Stresses in Cylindrical Shells due to External Loadings on Nozzles

### Site Conditions



- 1.4.1 Climatic and other site conditions as defined elsewhere.

### 1.5 Operating Duty

- 1.5.1 Service shall be twenty-four (24) hours per day, seven (7) days per week, and fifty-two (52) weeks per year. The equipment design life shall be 20 years.

### 1.6 Design Documentation

- 1.6.1 Detailed design calculations considering different loadings shall be made as per code/standards and the additional requirements as mentioned below:-
- 1.6.2 Design of equipment inside the purge gas recovery unit shall be in accordance with the Process Licensor's data sheets and specifications.
- 1.6.3 LSTK Contractor shall consider the interfaces with other engineering disciplines w.r.t.
- Piping Layout/Location Drawings
  - Civil / Structural Drawings

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- P & ID's
- Materials
- 3D PDS Model for Piping and Equipment Layout
- Hazardous Area Classification

1.6.4 Design philosophy of other disciplines shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria

## 1.7 Safety

1.7.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable to this criterion. (Job Hazard and Operability [HAZOP] as per ISO-18001 & Factory Act shall be done during design stage the equipment)

1.7.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

- Ladder cages
- Safety chain across platform access
- Step-off platforms with Hand Railing where necessary
- Platform grating with adequate thickness
- Toe plates

## 1.8 Equipment Fabrication

1.8.1 Equipment design shall be based on maximizing shop fabrication and assembly where deemed practical.

1.8.2 The LSTK Contractor shall comply in all respects with the provision of the applicable codes / standards and specification during fabrication

1.8.3 Impact test, when required as per code and specifications, shall be carried out on parent metal, weld and HAZ.



1.8.4 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

1.8.5 In case of equipment involving site assembly/fabrication the entire site job including loading & unloading at site, fabrication, radiography, heat treatment, Inspection & testing etc. shall be included in the scope of supply.

1.8.6 All nozzle connections up to DN 8" size shall be made of seamless pipes. For sizes above DN 8" nozzles connection may be rolled from plates with full radiography of welds.

### 1.8.7 Miscellaneous



1.8.7.1 All parts fabricated shall be smooth, true, clean and free from burrs, grease and dents. Openings for passage of workman must have exposed edges rounded.

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- 1.8.7.2 All support rings, bolting bars, beams support brackets and other components which are integral and therefore welded to the column shell inside, shall be supplied and installed by column fabricator.
- 1.8.7.3 Total draw-off trays shall be designed for zero leakage construction and may be seal welded (if required) at site to attain zero leakage.
- 1.8.7.4 Seal welds shall have a throat thickness at least equal to the specified corrosion allowance.
- 1.8.7.5 All stainless steel tray assemblies/internals and their components (e.g. Bubble caps, valves etc.) shall be pickled and passivated. Pickling and Passivation shall be as per ASTM 380.
- 1.8.7.6 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.

## 1.9 Construction & Erection

- 1.9.1 LSTK Contractor shall follow standard established procedures for handling storage, construction & erection. LSTK Contractor shall strictly follow Manufacturer's/Owner's instructions, approved drawings and procedures for construction & erection and satisfy Principal in all respects of storage, handling, construction & erection of Package. All erection work shall conform to the working/erection drawings (to be prepared by LSTK Contractor) and shall be in conformity with codes & standards as applicable. The LSTK Contractor shall supply & arrange all necessary construction & erection tools and tackles, machinery, scaffolding etc.
- 1.9.2 LSTK Contractor shall perform the following:
- Before installing the equipment, the foundations shall be checked and wherever necessary, chipping shall be done by the LSTK Contractor. All grouting materials, packing plates/ wedges required for the levelling and alignment of equipment, structures & pipelines etc. shall be provided.
  - Top of the foundations shall be thoroughly cleaned to the satisfaction of Principal / LSTK Contractor before placing base plates.
  - All equipment & structure etc. shall be checked and inspected for its proper levelling and granting (grouting) shall be done with suitable grouting material as required.
  - After tightening the foundation bolts, the final level / alignment shall be rechecked and redone, if required.
  - Installation of all supports and hangers, including concreting or welding as necessary.
  - To check correctness of the piping, instruments and other connecting points in the equipment and piping installed.
  - The welding joints shall be stress relieved wherever necessary as per applicable codes, standards & specifications.
- 1.9.3 The following shall be arranged and supplied by LSTK Contractor for completion of job. Any other item whatsoever required shall also be included by LSTK Contractor in their scope.

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- i) All construction & erection materials, equipment & machinery, scaffolding, consumable, and test equipment etc.
- ii) Cranes/Hydra, temporary lifting beams and spreaders etc.
- iii) Procedures for site assembly, construction & erection including lifting methodology for Owner/Third party approval.

1.9.4 As a minimum contractor shall comply the requirements indicated below:

- i) Fabricate, erect and align the equipment & internals as per applicable codes, standards & specifications. All internals shall be inspected before and after installation.
- ii) Carry out all NDT"s required. (The Personnel performing NDT"s should have a minimum qualification as "NDT LEVEL-II" in the relevant Technique, certified by American Society for Non-destructive Testing)
- iii) Perform non-operating field pressure tests and leak tests on field fabricated equipment in accordance with the applicable codes, standards and specifications, ensuring disposal of test media in accordance with instruction/recommendations.
- iv) Notify Owner / Third party of the test schedules for witness the tests by concerned inspector.

## 1.10 Material of Construction



The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under specific process design guidelines. However superior materials as per the recommendation of Process Licensor"s may be selected which shall be indicated in the Bid by the LSTK Contractor.

- 1.10.1 All materials, whatsoever, required to complete the supplies shall be procured by LSTK Contractor and all such materials shall be covered with due identifiable material test certificate.
- 1.10.2 Materials used in low temperature service shall be impact tested (charpy V) if required as per design code & specification. Impact test & energy value shall be in accordance with code requirement, unless specified otherwise.
- 1.10.3 For coarse grained & high tensile materials in carbon steels ( UTS>45 Kg/mm<sup>2</sup>) & low alloy steel, guaranteed impact strength shall be ensured at a temperature 15 °C below envisaged hydraulic test temperature as a precaution against brittle fracture during hydraulic test.

## 1.10.4 Heat Treatment

Heat treatment of formed parts shall be carried out as per following:

- a. Cold formed dished ends of carbon steel or knuckles up to 16 mm nominal thickness shall be stress relieved.
- b. Cold formed dished ends of carbon steel or knuckles above 16 mm nominal thickness shall

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be normalised.

- c. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.
- d. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.

- 1.10.5 All CS & LAS materials including forging used for pressure parts shall be procured in fully killed and normalized condition.
- 1.10.6 All SS plates shall be hot rolled & solution annealed and pickled as per SA 480.
- 1.10.7 All plates above 50 mm thickness shall be examined by UT as per ASTM-A435 at mills for both at surface & edges.
- 1.10.8 Cladded plates shall be supplied as per ASTM A264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A578 level S8.
- 1.10.9 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after machining as per ASTM A 275.
- 1.10.10 Tube sheet and Girth flanges shall not have any segmental weld joint.
- 1.10.11 Unless more restrictive prescription given by material specification the max. content for carbon steel used for fabrication as shown by ladle analysis shall be 0.23% for plates, pipes & tubes 0.25% for forging.
- 1.10.12 Top portion of skirt (min. 500 mm height) welded to the bottom dished head shall be of same material as that of shell /head for LAS & SS materials.
- 1.10.13 In order to minimise the effect of temper embrittlement for material to 2¼ Cr 1 Mo specification in the temperature range of 375-575°C, the embrittlement factors 'X' & 'J' shall be limited to:

$$X = (10P + 5Sb + 4Sn + AS) / 100 \leq 15$$

The elements above are expressed as ppm

$$J = (Si + Mn) (P + Sn) \times 10^4 < 160$$

The elements above are expressed as percentages

A stimulated PWHT followed by step cooling shall be performed on a sample of material. Acceptable toughness shall be demonstrated by means of a Charpy V Impact Test.

- 1.10.14 Unless otherwise specified copper or copper alloys shall not be used. Copper content up to 0.4% are acceptable in carbon steel and 0.6% in stainless steel.
- 1.10.15 Material for Pressure Vessels shall be procured with following minimum requirement:



#### CS and LTCS Material

Carbon content shall not exceed 0.23%

Carbon equivalent shall be restricted to 0.40% max. (Ni ≤ 0.2%, Sulphur ≤ 0.002% for plates and 0.01% for tubes, pipes and forgings)

Hardness for plates and pipes shall be ≤ 200 BHN.



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Hardness for forging shall be  $\leq$  187 BHN.

#### LAS Material

Use of C-1/2 Mo is prohibited as per API-941 in hydrogen service.

LAS tubes hardness test shall performed on outside of tubes as per SA-450.

#### SS and other High Alloy Material

All SS material shall be fully annealed and pickled conditioned. All stabilized grades (SS 321, SS 347etc.) shall be given stabilization heat treatment.

All SS (300 series) plates shall be hot rolled and shall have No. 1 finish on both side.



- 1.10.16 The following inspections shall be carried out in addition to, but not be limited to, the requirements of ASME Code.

#### Material

- 1) The following materials for the pressure parts shall be inspected by ultrasonic examination method in accordance with SA-578 Level B of ASME Code, Section II. Test results shall be described in mill test reports.
  - (a) Carbon steel plates of 50 mm (2 inches) thick and over
  - (b) Low-alloy steel plates of 25 mm (1 inch) thick and over
  - (c) Low temperature service carbon steel plates of 19 mm (3/4 inch) thick and over
- 2) Pressure Parts having thickness from 16 mm to 50 mm shall be ultrasonically tested as per SA 435. The following inspections shall be carried out in addition to, but not be limited to, the requirements of ASME Codes.

### **1.11 Quality Assurance & Control**

- 1.11.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests, measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.
- 1.11.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that Equipment leaving LSTK Contractor's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.
- 1.11.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.
- 1.11.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.
- 1.11.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.

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## 2.0 EQUIPMENT DESIGN BASIS

### 2.1 General

- 2.1.1 Design conditions for all equipment shall be in accordance with the Process Licensor's data sheets/specifications.
- 2.1.2 Design pressure is normally specified at the top of vertical vessel or at the highest point of horizontal vessel. The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.
- 2.1.3 Wind analysis shall be performed as per IS-875 (Latest Edition). Wind speed of 160 km/hr shall be considered in design. Wind forces shall be increased by 20% to cater for the effect of piping system, platforms and ladders etc. Vertical vessels with height/diameter ratio equal to or greater than 10 shall be analyzed for vibration due to vortex shedding when critical wind speed does not exceed 30m/s. For guidelines of Dynamic Wind Analysis refer **Appendix-I**.
- 2.1.4 Forces and moments acting on nozzles shall be considered in the equipment design. The exact forces & moments shall be indicated after piping layout which shall be considered by equipment supplier with out any commercial implication to Owner.
- 2.1.5 All Carbon Steel (CS) and Low-Alloy Steel (LAS) pressure parts shall have 1.5 mm corrosion allowance unless specified otherwise. All internal CS & LAS parts shall have at least 1.0 mm Corrosion Allowance on either side. No corrosion allowance shall be considered for SS. In general, the recommendation of Process Licensor shall be adopted for construction.
- 2.1.6 Design of supports and anchor bolts considering soil and importance factors shall be performed for compressive and tensile loading. In no case shall diameter of anchor bolts be less than M24 for skirt support and M16 for other type of support.
- 2.1.7 Lifting lug shall be designed with shock factor 2.
- 2.1.8 Bolt of size M48 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner. The bolts shall have an extra threaded length at one end of approximately 1 bolt diameter, and shall be provided with threaded projection caps. Hex nuts shall have suitable holes for manual tightening. The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be considered by LSTK Contractor as per mechanical design of the equipment.

### 2.2 Inspection and Testing

- 2.2.1 Equipment shall be inspected by TPIA (Lloyds/BV/TUV). The Inspection and testing shall be in accordance with the relevant codes, standards, specifications. All equipment & bought -out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LSTK Contractor and shall duly approved by Owner/ It's authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed under Inspection & Testing clause of the design philosophy.
- 2.2.2 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor.

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2.2.3 The following NDT requirements are mandatory in addition to code /spec requirements:

a) **UT examination:**

- i) All butt-welds in thickness greater than 50mm as supplement to radiography.
- ii) FPW of nozzle attachments of thk. above 50mm as supplement to radiography
- iii) Clad Plates and formed heads from clad plates in all thicknesses

b) **MP/PT examination**



- i) All edges of plates and opening in shell of CS having thk. above 40mm and LAS/SS having thk. More than 25mm
- ii) Root and final layer of all butt welds
- iii) Fillet welds of 3.5% Ni & SS
- iv) Each layer of weld deposit in SS overlay
- v) Knuckle surfaces of dished ends, expansion bellows and pipe bends

c) **Radiography:**

- i) All weld seams of formed head, if made in more than one segment shall be fully Radiographed after forming.
  - ii) All the welded T- Joints shall be fully radiographed.
  - iii) When spot radiography is specified all T-joints & min. 10% of total weld length excluding T-joints shall be radiographed
  - iv) Radiography of welds in C- 1/2 Mo & Cr- Mo - Steel preferably is carried out after heat treatment
- d) Hardness test on welds of Cr-Mo, Materials after final heat treatment. The value shall not exceed to:
- i) 215 HB for steel having Cr content less than 2%
  - ii) 240 HB for steel having Cr content more than 2%

2.2.4 All completed equipment shall be tested hydraulically as per the requirements of specification/codes in presence of the inspecting authority. Pneumatic test of completed equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 30 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. Duration of test shall be 1 hour minimum. After hydro testing stainless steel vessels shall be dried thoroughly, immediately after draining to prevent the possibility of evaporation & concentration of chlorides.

2.2.5 When specified equipment shall be dispatched with N<sub>2</sub> filling. In case of equipment assembled and welded at site, it shall be filled with N<sub>2</sub> after testing at site. Dry Nitrogen shall be filled at a pressure of 0.5 Kg/cm<sup>2</sup>g and equipment shall be fitted with a pressure gauge and valve.

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2.2.6 Equipment under preview of statutory bodies shall be inspected during various stages of fabrication by their authorised inspecting agency. It is the responsibility of the LSTK Contractor to get the design calculations and fabrication drgs. Approved by concerned statutory bodies before commencing fabrication.

2.2.7 All raw materials shall be inspected at source and test certificates to enable proper identification shall be submitted.

2.2.8 Unless otherwise stated gasket during testing shall be same as specified for operating conditions. After testing, gaskets used during testing shall be replaced by new gaskets.

2.2.9 All completed equipment shall be tested hydrostatically as per the requirements of specification/codes in presence of inspecting authority. Pneumatic test of completed equipment shall be carried out only when specifically mentioned.

2.2.10 The temperature of test water shall comply with the construction code, but not less than 7 °C.

## 2.3 Painting

2.3.1 All external surfaces of shop fabricated equipment shall be painted in the vendor's shop. For guidelines of painting refer **Appendix-2**

## 2.4 Pickling and Passivation

All SS material shall be Pickled & Passivated as per following procedures:

### 2.4.1 Pickling

Aqueous pickling solution shall be as follows:

Nitric acid (Tech grade)-10 to 25% plus Hydrofluoric acid-1 to 8% (to be used only for stabilized SS grades). Temperature 50 to 60° C for 10% Nitric acid and 20° C for 25% Nitric acid. When size and shape of product permit, total immersion in the pickling solution is preferred. Where immersion is impractical, pickling may be accomplished by wetting the surface by



- Swabbing or spraying
- Partial filling the item with pickling solution and rotating or rocking so that the entire surfaces receive the required chemical treatment.

The maximum period for which the pickling solution shall be allowed to remain on the surface is 30 minute. During pickling removal of oxides may be hastened by brushing with a hard fiber or SS wire brush. Over pickling shall be avoided.

The pickling agent shall be washed off with plenty of water so as to leave no trace behind.

### 2.4.2 Passivation

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10 weight % and KMnO<sub>4</sub> 4 weight % shall be used for neutralizing pickling solution. This shall be followed by thorough water rinsing.

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Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

## 2.5 Fire proofing

2.5.1 Fire proofing, if required shall be considered as per Process Licensor's recommendations.

## 2.6 Insulation

2.6.1 The equipment shall be insulated as defined in Piping Design philosophy.

## 2.7 Operability and Maintenance

2.7.1 Equipment design and layout shall provide for ease of access, operability and maintenance.

## 3.0 SPECIFIC REQUIREMENTS

### 3.1 Vessels

3.1.1 Vessels shall conform to the requirements of ASME Section VIII Division 1 & 2 Pressure Vessels codes and Technical Specifications mentioned in the design criterion.

3.1.2.1.1 Design of vessel skirt shall be based on seismic/wind/thermal considerations and fireproofing/insulation requirements

3.1.2.1.2 Vessels will be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads. Minimum inside diameter shall be 500 mm. Top cover shall be flanged if the ID is equal or less than 900 mm.

#### 3.1.2.1.3 Head / Dished Ends



- a) Dished ends shall be of seamless construction. However, dished ends with one chordal weld seam are acceptable. In such cases, the chordal seam shall preferably be in the middle one third of the blank. Intermediate heat treatment, if considered necessary, shall be carried out by the LSTK Contractor.
- b) Whenever a dished end is made of more than two plates, it must have a crown plate. Whenever a nozzle or a manhole is positioned at the centre of the dished end, the crown plate should be larger than the nozzle /manhole reinforcing pad.

3.1.3 Vessel skirts for carbon steel vessels shall be designed from the same material as the shell or the head. Vessel skirts for other than carbon steel vessels shall be the same material as the shell or the head for the top 500mm. All skirt supported equipment shall be provided with templates.

3.1.4 All nozzles above 24" NB shall comply with ASME B16.47 Series B (API 605).

3.1.5 Local vessel stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.

3.1.8 Vessels with skirts having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be an annulus 10mm (minimum) thickness and 150mm (Minimum) wide, with bolt holes equal to bolt diameter plus 3mm, stack drilled with the skirt base plate.

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3.1.9 Design of supports and anchor bolts considering soil & importance factors shall be performed for compressive & tensile loading. In no case, diameter of anchor bolts shall be less than M24 for skirt support & M16 for other type of support.

3.1.10 The lifting lug shall be designed with shock factor 2.

3.1.11 Maximum permissible deflection for tall vessels/columns when subjected to design wind loadings shall not exceed  $0.005 \times \text{Vessel height}$ . For guidelines of Dynamic Wind Analysis refer Annexure-I.

3.1.12 For vessels, the minimum thickness of shell & heads, including corrosion allowance shall be as indicated below:

S. No.	Shell Diameter (mm)	Thickness (Min.) mm	
		CS / LAS	HAS
1	ID < 500	5	3
2	501 < ID < 1200	5	4
3	1201 < ID < 2000	6	5
4	2001 < ID < 2600	8	6
5	ID > 2600	10	8
CS = Carbon Steel LAS = Low-Alloy Steel HAS = High-Alloy Steel			

3.1.13 Vessel man-ways shall be shown on the data sheets. Minimum man-way size shall be equal to 24" nominal pipe size.

## 3.2 Internals



3.2.1 For Tray design worst of the following conditions shall be considered:

- For tray design minimum loads of 100 kg/m<sup>2</sup> in active areas and 320 kg/m<sup>2</sup> in down comer area shall be considered.
- For atmospheric, pre flash & vacuum distillation columns for trays under flash area uniform load of 500 kg/m<sup>2</sup> shall be considered. This loading shall be applicable to first three trays above flash section.
- A concentrated live load of 150 kg at any point on the installed assembly independent of other design live loads.
- Maximum horizontal deflection at effective tray loading shall not exceed  $1/900$  of the span or 7 mm. whichever is less.
- Corrosion allowance shall be added to both sides of trays, support rings and other fixed internal non pressure parts.

3.2.2 All internal bolting shall be of corrosion resistant material.

3.2.3 Support for packing and internal shall be designed for the worst condition. In the condition of packing liquid hold up of minimum 20% of packing volume shall be considered. Tray support



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beams shall have height not exceeding 20% of distance between trays for diameter up to 2400 mm and 15% of the distance between trays for higher diameters.

3.2.4 Each tray shall be so designed as to ensure liquid tight construction. Each tray shall be provided with a man-way suitable for opening both from top and bottom unless otherwise specified.

3.2.5 Minimum thickness of internals shall be as follows:

S. No.	Parts	CS & LAS (MM)	HAS (MM)
1.	Chimney tray	10	6
2.	Tray decks partition, down comers, weirs pans etc.	3.5	2.0
3.	Tray support rings & bolting bars	6.0	6.0
4.	Bubble caps	3.5	1.5
5.	Valves for trays	1.5	1.5
6.	Non-integral main & secondary supporting beams	5.0	2.0

Note: - 1) All bolting size shall be minimum of M10. All nuts shall be hexagonal.

2) Allowable stress criterion for design of internals shall be as per ASME Section VIII Div. 1

3.2.6 All necessary approval on Hydraulic design and internal drawings shall also to be obtained from Process Licensor as applicable.

3.2.7 All internals shall be designed so that they can pass through the vessel man-way internal diameter.

3.2.8 The LSTK Contractor shall meet the process and hydrodynamic guarantee of towers along with their internals. All instruments including of special instruments required to verify the above requirements shall be arranged by the LSTK Contractor.



### 3.3 Shell and Tube Heat Exchangers

3.3.1 Mean metal temperature of tube & shell be considered in the design of fixed tube sheet exchangers.

3.3.2 Parts such as tubes, tube sheets, floating heads etc. which simultaneously come in contact with both shell side and tube side fluids, shall be designed considering pressure acting on one side only or the combination of pressures, whichever results in higher thickness of parts.



3.3.3 Attachment of tube to tube sheet will be rolled and expanded, strength welded or seal welded as specified on data sheets.

3.3.4 Process Shell and Tube Exchangers will comply with the requirements of ASME SEC VIII Div I & TEMA Class „R“. TEMA Class „C“ may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.

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- 3.3.5 ASME Section VIII, Div. 1, Appendix “S” shall be considered mandatory for bolted flange connections. All mandatory requirements are covered under Appendix-2 for different loading conditions.
- 3.3.6 All tube sheet for the exchangers shall be designed as per ASME Sec VIII Div 1 & also comply the requirement of section UHX of ASME Code.
- 3.3.7 Tube sheets in vertical exchangers shall be provided with drain and vent arrangement with threaded plug seal welded.
- 3.3.8 Exchanger saddle and foundation design shall include additional loadings generated from bundle pulling. The load shall be 1.5 times the bundle weight.
- 3.3.9 Shell side “hot” nozzles shall be located at the top of the shell at the channel end whenever possible.
- 3.3.10 Lifting lugs for heads or bonnets shall be specified where frequent dismantling is required.
- 3.3.11 Saddle wear plate material shall be the same as the shell material.
- 3.3.12 All heat exchanger tubes shall be seamless, cold drawn and formed from single length. CS tubes shall be normalized. LAS tubes shall be normalized and tempered.
- 3.3.13 The mean radius of U tubes shall be not less than 2xOD of tube. Thickness of 2 inner most rows will be higher than other rows with minimum difference of 2 gauges.
- 3.3.14 For U tube bundle, the following requirements shall also be met:
- Each U tube shall be formed from a single straight length.
  - All U tubes shall be cold bent.
  - All C.S, C-Mo, Cr-Mo tubes shall be annealed after bending.
  - Bent portion of all U tubes shall be examined by PT and hardness check on four opposite points of bent portion shall be carried out.
  - Unless otherwise specified, after bending each tube shall be tested hydraulically.
- 3.3.15 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm<sup>2</sup> g wherever specified leak testing with halogen shall be carried out.
- 3.3.16 All SS tubes shall be subjected to non-destructive examination like eddy current or ultrasonic test at mill. CS & LAS tubes shall also be subjected to such examination when design pressure exceeds 100 Kg/cm<sup>2</sup>g.
- 3.3.17 Unless otherwise stated inlet nozzles on shell side shall be provided with impingement baffle plates as required TEMA.
- 3.3.18 For stack type of heat exchangers, nozzles shall be designed to carry the loads of shells after installation in operating conditions. Saddles shall be used for erection purpose only.



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3.3.19 For stack type Heat Exchangers, complete assembly shall be hydraulically tested as a single unit except when the test pressures for individual heat exchangers are different.

3.3.20 Removable tube bundle shall be provided with pulling York and suitable sliding arrangement.

3.3.21 For utility fluids, following fouling factors shall be considered -

- Cooling Water - 0.0004 h.m<sup>2</sup>.oC/Kcal
- Steam - 0.0002 h.m<sup>2</sup>.oC/Kcal
- BFW - 0.0002 h.m<sup>2</sup>.oC/Kcal
- Following minimum fouling factors, if not specified otherwise, shall be used based on heat exchanger type :

Shell side fouling (h.m <sup>2</sup> .oC/Kcal)	Tube side fouling (h.m <sup>2</sup> .oC/Kcal)	Heat Exchanger Type
> 0.0002	> 0.0002	Floating
< 0.0002	> 0.0002	Fixed T / sheet
> 0.0002	< 0.0002	U-tube bundle
< 0.0002	< 0.0002	Fixed T/sheet or U-tube

3.3.22 For all water-cooled heat exchangers, back-flushing facilities shall be provided with a minimum size of 4". Return Water line from each cooler shall be provided a globe valve and a water sample connection

### 3.4 Plate Type Heat Exchanger

3.4.1 The plate type exchanger shall be designed in accordance with" API 662"

3.4.2 All plates shall be pressed from a homogeneous single metal sheet in one placing and normal thickness of plate being pressed shall not be less than 0.5 mm

3.4.3 Nozzle neck attachments shall be with full penetration weld. Set on nozzles are not permitted.

3.4.4 Lock washers shall be provided for all rotated nuts.



### 3.6 Tanks

3.6.1 The following design codes shall be adopted for tank design as applicable:

a) API 650/IS803:- Welded Steel Storage Tanks for Oil Storage.

3.6.2 For Storage tanks the minimum thickness shall be based on stability considerations. Minimum thickness for roof & shell shall be 5 mm, and bottom plate 6 mm, excluding corrosion allowance.

3.6.3 Storage tanks up to 4meter in diameter shall be shop fabricated items. Tanks with diameters greater than 4 meter shall be field erected.

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#### **4.0 SPARE PARTS**

##### **4.1 Commissioning Spares**

4.1.1 All commissioning spares shall be included by LSTK Contractor in their scope of supply and shall be part of the main equipment.

##### **4.2 Spares for 2 Years Operation**



4.2.1 2 years operation spares shall be supplied by the contractor as per Section-10 of ITB.

#### **5.0 DOCUMENTATION SCHEDULE**

5.1 Documents shall be submitted as per “Documentation schedule” in Section-9 of ITB

#### **6.0 VENDORS LIST**

All equipment shall be procured/fabricated as per approved vendor list. For Non-critical items, LSTK Contractor may include the name of local vendors. Any equipment for which vendor list is not enclosed, the LSTK Contractor may furnish a list of their proposed vendors along with their references for supply of similar type of equipment along with bid. However all the additional proposed vendors shall have well proven track record and shall be subjected to consultant/owner's approval.

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**APPENDIX-1**  
**CALCULATION METHOD**  
**DYNAMIC WIND ANALYSIS (GUIDELINES)**  
**FOR VERTICAL EQUIPMENT**

Check of the towers for dynamic wind moments due to vortex shedding shall be performed based on following assumptions:

$$V_{cr} = f * D / St$$

T6

$V_{cr}$  = Critical wind velocity

D = Outside diameter of tower

F = First natural frequency of tower considering foundation complete rigid (s-1)

St = Strouhal number, may be taken as 0.15 for  $Re > 10^6$  and 0.2 for  $Re < 10^6$

Re = Reynolds number at critical wind velocity

For  $V_{cr} < 30$  m/s following shall be considered :

The tower shall be checked for additional moments due to vortex shedding in 2 cases.

1. Operating condition
2. Shut down condition

Dynamic wind moment shall be calculated as follows:

$$M_d = P_d * C_k * S * \pi / d * H$$

$P_d$  = Wind pressure at critical velocity =  $0.5 * \rho * (V_{cr})^2$

$C_k$  = Crosswind oscillatory force coefficient may be taken as  $0.5 + (4 - \log_{10} Re) / 5.7$  for  $Re < 10^6$  and 0.17 for  $Re > 10^6$

d = The logarithmic decrement of damping. For towers with trays or packing it is estimated 0.035

S = Surface on which dynamic wind forces are acting (height \* diameter)

H = Height from base ring of point of application for dynamic wind force

$\pi$  = 3.14

$\rho$  = Density

For tapered construction only the tip diameter shall be considered in calculation.

Moments to be considered for dynamic wind :

$$M_{res} = \sqrt{(M_d)^2 + (M_{st})^2}$$

$M_{st}$  = Static wind moment at critical wind velocity

Only if  $M_{res}$  exceeds moments due to static wind or earthquake moments, it shall be considered for equipment design

**APPENDIX-2**  
**PAINTING SPECIFICATION**

S. No.	Application	Generic Coating System	Minimum DFT	Surface
1.0	Uninsulated C.S. to 400 °C where topcoat is not required. (to 120 °C if surface is repaired)	Primer: Inorganic ethyl zinc silicate primer  Repair of damaged paint surface: Two component, metallic zinc rich epoxy primer.	Primer: 75 micron Repair: 75 micron Total: 75 micron	As per SA 2½ (Min.)
2.0	Uninsulated C.S. to 83 °C where topcoat is required. (intermittent to 120 °C )	Primer: Epoxy zinc phosphate  Finish: Recoat able high-build Epoxy	Primer: 75 micron Finish Coat: 150 micron Total: 225 micron	As per SA 2½ (Min.)
3.0	Uninsulated C.S. to 260 °C where topcoat is required.	Primer: Inorganic ethyl zinc silicate primer.  Finish: High Temperature Silicone Acrylic	Primer: 75 micron 1st Coat: 40 micron 2nd Coat: 40 micron Total: 155 micron	As per SA 2½ (Min.)
4.0	Uninsulated C.S. 201 °C to 540 °C where topcoat is required.	Primer: Inorganic ethyl zinc silicate primer.  Finish: Modified Silicone Aluminium 2 coats	Primer: 75 micron 1st Coat: 25 micron 2nd Coat: 25 micron Total: 125 micron	As per SA 2½ (Min.)
5.0	Insulated CS normally to 200 °C, or having cyclic, intermittent or dual operating temperatures up to 230 °C.	Primer: High Temperature Phenolic Epoxy  Finish: High Temperature Phenolic Epoxy	1st Coat: 100 micron 2 <sup>nd</sup> Coat: 100 micron Total: 200 micron	As per SA 2½ (Min.)
6.0	Insulated C.S. up to 540 °C.	Inorganic Zinc Primer	Total : 75 micron	As per SA 2½ (Min.)
7.0	Structural Steelwork with operating temperature upto 90 °C	Hot Dip Galvanising		
8.0	High Temperature equipment	Primer/Finish Coat : Intetherm 50 or Equivalent (Total 3 coats)	Total : 75 micron	As per SA 2½ (Min.)

## Annexure-4.2

# DESIGN PHILOSOPHY ROTATING EQUIPMENT

0	15.07.2013	15.07.2013	ISSUED FOR ENQUIRY	YKG	ASR	PCC
P	05.07.2013	05.07.2013	ISSUED FOR ENQUIRY (DRAFT)	YKG	ASR	PCC
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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7.0	Vendor List
8.0	LSTK Contractor/ Vendor Documentation

## LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
	Inspection & Testing Guide Lines – Rotating Equipment	1

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## 1.0 SCOPE

### 1.1 General

1.1.1 This philosophy covers the requirements for the design, fabrication, installation, inspection & testing, painting, transportation and supply, erection, commissioning, Guarantee test run etc of rotating equipments for **installation of PGR Unit at Ammonia-II for M/s NFL-Vijaipur.**

1.1.2 In addition, all statutory rules & regulations shall also be complied with.

## 2.0 DESIGN PHILOSOPHY FOR MACHINERY

### 2.1 Codes and Standards

The latest edition of codes and standards as listed below shall be followed for design and manufacturing of different machinery items. Generally the manufacturer will comply with these codes and standards as indicated therein with minor deviations that are normally adopted by manufacturer and are reasonably accepted as per good engineering practice.

A list of such deviations, if any, shall be furnished by the LSTK Contractor along with offer.

Code	Description
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industry
ANSI/ ASME B 73.1 M	Horizontal, End Suction centrifugal Pumps for Chemical Process
API 614	Lubrication, Shaft-Sealing, and Control Oil System for Petroleum, Chemical and Gas Industry Services
API 674	Positive Displacement Pumps-Reciprocating
API 675	Positive Displacement Pumps-Controlled Volume
API 676	Positive Displacement Pumps-Rotary.
API 682	Shaft sealing Systems for Centrifugal and Rotary Pumps.
ISO / DIN	Centrifugal Pumps for smaller size & Non Critical Services.
<b><u>Performance Testing (ASME Codes)</u></b>	
PTC 8.2	Centrifugal Pump

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## 2.2 Design Life

All equipment shall be designed for a minimum service life of 20 years and at least 3 years of uninterrupted operation under normal operating conditions. This requirement excludes specialised components requiring periodic maintenance and replacement.

## 2.3 Essential Project Reference Documents

The following documents shall be observed, and relevant aspects incorporated into specifications and datasheets:

- Process Description, Specifications and Data Sheets from Licensor
- Hazardous Area Classification
- Electrical and Instrumentation Design Criteria

## 2.4 Regulations

Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations together with Local by Laws for the state including statutory requirements as applicable.

## 2.5 Site Conditions

Site conditions shall be as defined elsewhere.

## 2.6 Material of Construction

Generally Materials of construction shall be as per the process licensor's recommendation; However the API guideline may be adapted to the extent applicable.

Use of equivalent & superior material may be selected & shall be furnished with the offer along with chemical composition.

## 2.7 Quality Assurance & Control

- 2.7.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests , measurements, checks & calibration which are to be carried



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out may be compared with the actual specified characteristics of the equipments/unit /system.

- 2.7.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that The Machines & Associated auxiliaries leaving LSTK Contractor's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.
- 2.7.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.
- 2.7.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.
- 2.7.5 QA/QC system shall cover all products and services required for the complete machine unit as per scope of work including job sub contracted by the LSTK Contractor.

### **3.0 DESIGN REQUIREMENTS**

#### **3.1 General**

- 3.1.1 All machines shall be directly coupled to their prime movers. Gears/any other forms of transmission shall be avoided. If not, specifically mentioned, the drivers shall have rated output at least 10% greater than the power requirement at design operating condition of the driven equipment.
- 3.1.2 All process pumps shall have Mechanical Seals. Single seals will be used in most cases, however, for ignitable or hazardous fluids, double, or Inside Wet and Outside Dry running seals will be used. Built in Mechanical Seal shall not be used

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- 3.1.3 Special tools and wrenches required for installation and maintenance shall be provided.
- 3.1.4 LSTK Contractors have to submit the reference list for similar equipment's models (minimum 2 nos.) supplied in past for similar duty conditions. Reference list must contain at least the following: Fluid handled Capacity, Suction Pressure, Discharge Pressure, Model No., Power consumption, Client Name, Address, and Year of supply.
- 3.1.5 The maximum allowable sound level (pump & driver combined) is 90 dB(A) 1 m apart from the equipment surface, unless otherwise specified.

### 3.2 Centrifugal Pumps

The process pumps shall be designed as per API 610, Latest edition. The pumps shall be of robust design to ensure long service life and minimum maintenance requirement. The pumps shall be designed for easy access for inspection and maintenance. All continuously running pumps shall have a spare pump.

In addition to codes & standards, following points shall also be applicable:

- 3.2.1 All pumps shall have continuously rising head curve from any specified operating point to shut off point. Pumps running in parallel shall have equal head rise to shut off point.
- 3.2.2 All pumps shall be designed for 20% overload.
- 3.2.3 The pumps should have stable operating characteristics. The pump head at shut off shall be approximately 110% of head at rated capacity and not exceeding 120%.
- 3.2.4 Best efficiency point shall be as close as possible to normal operating point.
- 3.2.5 Impellers of multistage pumps shall be secured positively against axial movement.
- 3.2.6 For multistage pumps, a lateral critical speed analysis shall be carried out.

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- 3.2.7 Pumps with centre line support shall be provided for pumps handling fluids of operating temperature more than 177<sup>0</sup>C.
- 3.2.8 The maximum calculated axial load shall not in any operating condition exceed 50% of bearing manufacturer's load rating.
- 3.2.9 Only Metastream / diaphragm type of coupling shall be provided. Coupling guard shall be non-sparking for pumps located in hazardous area.
- 3.2.10 Mechanical seal of Flowserve / EagleBurgmann make only shall be provided. Only balanced mechanical seal shall be used. Auxiliary piping for Mechanical seal flushing shall be in SS-304 or higher grade only.
- 3.2.11 For pumps with forced lubrication system, the lubrication system shall be designed as per API 610.
- 3.2.12 Bearing protector / Labyrinths shall be non contacting type seals of Lab tecta or equivalent make.
- 3.2.13 Assembled rotors of pumps running at 1400 RPM or over shall be dynamically balanced as per applicable standard.

### 3.3 Reciprocating Pump / Metering pumps

Reciprocating pump shall be designed as per API 674 and metering pump shall be designed as per API 675.

- 3.3.1 The metering pumps shall be suitable for continuous capacity variation from 0 to 100%. The capacity variation should be possible while the pumps are working.
- 3.3.2 All continuously running pumps shall have a spare pump.
- 3.3.3 Hollow pistons / plungers shall not be used. Repacking should be possible without removing piston from the cylinder.
- 3.3.4 Valves and seats shall have a minimum hardness of 150 BHN if constructed of carbon or low alloy steel and 225 BHN if of 13% Cr Steel. The difference in hardness between valves and seats shall be 50 BHN minimum.

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- 3.3.5 For liquid end pressure containing parts like cylinders, valve chambers and suction & discharge manifolds corrosion allowance shall not be less than 3.0 mm for carbon & low alloy steels.

## 4.0 INSPECTION & TESTING

Machines shall be inspected by Third Party Inspection Agency (Lloyds/BV/TUV/PDIL). The Inspection and testing shall be in accordance with the all relevant codes, standards, specifications, including the minimum guide line given herein.

- 4.1 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor.
- 4.2 In general, following tests shall be conducted for all rotating equipments:
- Material test for major Parts
  - Non-destructive test
  - Hydrostatic test for all the pressure containing parts
  - Dynamic balancing of rotor
  - Over speed test of impeller if applicable
  - NPSHR test for pumps
  - Performance Test
  - Disassembly Test

The tests required to be conducted and witnessed shall be specified in the equipment data sheet. Disassembly test for small Pumps can be waived-off in case no problem occurs during mechanical / performance Test.

## 5.0 SPARES

- 5.1 All erection & commissioning spares shall be supplied by LSTK Contractor & cost shall be included in the cost of main equipment.
- 5.2 2 years operation spares shall be supplied by the contractor as per ITB.

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## 6.0 PAINTING

- 6.1 All exterior non-stainless steel surfaces subject to atmospheric corrosion with the exception of machined surfaces shall be epoxy painted.
- 6.2 All exterior machined surfaces shall be coated with suitable rust preventives.

## 7.0 VENDORS LIST

All equipment shall be procured/fabricated as per approved vendor list. Any equipment for which vendor list is not enclosed, the LSTK Contractor may furnish a list of proposed vendors along with their references for supply of similar type of equipment along with bid. However all proposed additional sub-vendor shall have well proven track record and shall be subjected to consultant / owner's approval.

## 8.0 LSTK CONTRACTOR/VENDOR DOCUMENTATION:

Drawings & Documents of machinery items shall be as per ITB.

## INSPECTION & TESTING GUIDE LINES

### 1.0 SCOPE

This document covers the minimum guide lines for the Inspection & Testing for the rotating Equipments.

All rotating Equipments shall be inspected by Third Party Inspection Agency (Lloyds/BV/TUV/PDIL). The Inspection and testing shall be in accordance with the all relevant codes, standards, and specifications as specified in Specification sheet.

### 2.0 PUMPS AND DRIVERS

- 2.1 Pump casings to be identified against foundry test certificates and thickness checked to conform to approved drawings.
- 2.2 Witness hydrostatic test on casings.
- 2.3 Dynamic balancing of rotor
- 2.4 Witness running tests on pumps including N.P.S.H. where applicable.

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- 2.5 Non- destructive test
- 2.6 Strip inspection of pumps on completion of running tests. Wearing surfaces to be checked and recorded. As a general principle, mechanical seals will not be dismantled after running tests. This necessity will be discussed on a case to case basis if abnormal noise or temperature has need records during testing. All materials to be checked against test certificates or VENDOR'S bill of materials.
- 2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).
- 2.8 Heat run or standard abbreviated tests, as specified, to be witnessed on electric motor drives.
- 2.9 Final inspection and dimensional check to be carried out on motor drivers.
- 2.10 Check all test certificates.

Inspection of electric motor as for pump drivers.