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GENERAL

Project:	**P-25 Project, Panipat**			Job No.:	**B269**		
Owner:	**M/s IOCL**			Site:	**IOCL, Panipat, Haryana**		
Purchaser:				Unit:	**PRU**	Unit No.:	**454**
Item No.:				Service:	**Between Centrifugal Comp. & E.Motor**		
No. reqd.:	**1**	Working: **1**	Standby: **None**	Driver Type:	**Electric Motor**	Driven Eqpt.:	**Compressor**
Applicable to:		■ Proposals		☐ Purchase		☐ As Built	

■: Scope, Option & Information specified by Purchaser. ☐: Information required from and options left to vendor. Vendor to cross (☒) the selected option.

Manufacturer: | Model:

■ RATING REQUIREMENTS				☐ BASIC DATA				
Driven Eqpt. Power (kW):	Nor.:		Ma	Mechanical rating:		kW @		rpm
Driver Power (kW):	Rated:		Ma	Full load power loss (kW):				
Mechanism rated power (kW):				Mechanical efficiency (%):				
Torque @ Max. Cont. Speed (kg-m):				Pitch line velocity (m/s):				
Max. Torque:		kg-m @	rpm	Tooth pitting index, "K":	Actual:		Allowable:	
Rated speed (rpm):				Tangential load, "W_t" (kg):				
- Input	☐ Specified	☐ Nominal		Bending stress number S_t "W_t"	Pinion		Gear	
- Output	☐ Specified	☐ Nominal		Actual:				
Allow variation in gear ratio:	∀			Allowable:				
Max continuous speed (rpm):				Material index no.:				
Trip speed (rpm):				Anticipated SPL:		dBA @		m
Gear service factor (Min.):				Journal static weight loads:				
Pinion Hardness:				Pinion:		kg	Gear:	g
Shaft assembly designation:				WR^2 referred to LS shaft (kg-mm²):				
- HS shaft rot. facing coupling end	☐ CW	☐ CCW		Breakaway Torque (kgf-m) @ LS shaft:				
- LS shaft rot. facing coupling end	☐ CW	☐ CCW						
HS shaft end:	☐ Cylindrical	☐ Taper	☐ 1-Key	☐ CONSTRUCTION FEATURES				
☐ 2-Keys	☐ Hydraulic taper		☐ Integral flange	**Type of Gear**	☐ Reducer	■ Increaser		
LS shaft end:	☐ Cylindrical	☐ Taper	☐ 1-Key		■ Single stage	☐ Double stage		
☐ 2-Keys	☐ Hydraulic taper		☐ Integral flange		☐ Single helical	☐ Double helical		
External loads:					☐ Epicyclic	☐		
Other operating conditions:				**Teeth**				
☐ INSTALLATION DATA				Number of teeth: Pinion:		Gear:		
☐ Indoor	☐ Heated	■ Under roof		Gear ratio		Center Distance (mm):		
■ Outdoor	■ Unheated	■ Partial sides		Pitch Dia: Pinion (mm)		Gear (mm):		
☐ Grade	■ Mezzanine	☐		Finish (RA):				
☐ Winterisation Required		■ Tropicalization Required		AGMA Geometry factor "J":				
Electrical Area Class:		Grp:	Div.	Pinion:		Gear:		
Max. allow. SPL: **85**	dBA @	**1**	m	Helix angle (E):				
Elevation (m):	Barometer (kg/cm²A):			Normal pressure angle (E):				
Range of ambient temperatures:				Net face width, "Fw" (mm):		Pinion L/D:		
	Dry Bulb	Wet Bulb		Normal Diametrical Pitch:		Backlash (mm):		
Minimum	EC	EC		Tooth plating: ☐ Recommended ☐ Not Recommended				
Normal	EC	EC		**MANUFACTURING METHODS**				
Maximum	EC	EC		Teeth generated by the:		Process		
Unusual Conditions	■ Dust	■ Fumes	☐ Others:	Teeth finished by the:		Process		
☐ ADDITIONAL REQUIREMENTS				Teeth hardening method:				
MOUNTING PLATES				Gear to shaft: ☐ Integral ☐ Shrunk-on				
■ Mechanism furnished with:				Rim attachment:				
■ Baseplate	☐ Soleplate(s)	☐ Subplate(s)		☐ RADIAL BEARINGS				
☐ Mounting plate(s) furnished by:					Pinion		Gear	
■ Equipment(s) on base plate: **E. MOTOR, GEAR UNIT & COMPRESSOR**				Type				
■ Baseplate with levelling pads:				Diameter mm				
■ Baseplate suitable for column mounting:				Length mm				
■ Grout type:	■	**Epoxy**		Journal Velocity m/s				
☐ **PAINTING**:	■ Mfr. Std.	☐		Loading kg/cm²				
APPLICABLE SPECIFICATIONS				Clearance (min-max) mm				
■ API Std. 613, 5th Ed.				Span mm				
■ Other: **Job spec. , API 670**								

61	**MISCELLANEOUS**				**☐ THRUST BEARING(S)**		
62	■ Undamped critical analysis report:	■ Yes	☐ No			Pinion	Gear
63	☐ With damped rotor response analysis report				Location		
64	■ Torsional analysis by (2.6.1.8)	☐ Gear Vendor	■ Other:Comp Vend		Manufacturer		
65	☐ Spare set of gear rotors				Type		
66	■ Gear case furnished with inlet purge connection				Size		
67	■ Orientation of oil inlet and drain connection				Area mm²		
68					Loading kg/cm²		
69	**■ VIBRATION DETECTORS**				Rating kg/cm²		
70	**Radial:**				Int. thrust load N (∀)		
71	■ Manufacturer **Rem. 2**				Ext. thrust load N (∀)		
72	■ No. at each shaft bearing	**2**	Total No.:	**4**	**■ COUPLING & GUARDS**		
73	■ Oscillator-Demodulators supplied by **Comp. Mfr.**					High Speed	Low Speed
74	■ Manufacturer **Rem. 2**				Coupling Manufacturer		
75	■ Monitor supplied by **Comp. Vendor**				Coupling Furnished by	**Comp Vendor**	**Comp Vendor**
76	■ Location **Rem 3** Enclosure				Coupling Type	**Fleximetallic**	**Fleximetallic**
77	■ Manufacturer **Rem 2**				Coupling Model		
78	■ Alarm ■ Shutdown				Coupling rating kW/100 rpm		
79	■ Shutdown time delay seconds				Coupling Lubrication	**Non Lube**	**Non Lube**
80	**Axial:**				Taper mm/m		
81	■ Manufacturer **Rem. 2**		No. reqd.:2 per brg		Taper guage furnished by		
82	■ Location	Rem. 3			Limited end float	**As Reqd.**	**As Reqd.**
83	■ Oscillator-Demodulators supplied by				Mount coupling halves	■	■
84	■ Manufacturer **Rem. 2**				Cplg. gear pitch dia mm	☐	☐
85	■ Monitor supplied by **Compr. Mfr.**				Cplg. pressure angle E	☐	☐
86	■ Location **Rem.3** Enclosure				Cylindrical / 1-key	☐	☐
87	■ Manufacturer **Rem.2**				Cylindrical / 2-keys	☐	☐
88	■ Alarm ■ Shutdown				Tapered / 1-key		
89	■ Shutdown time delay seconds				Tapered / 2-keys		
90					Tapered / keyless		
91	**Accelerometer: Casing (X & Y)**				**☐ PIPING CONNECTIONS**		
92	Manufacturer **Rem 2** No. Required **2**					No.	Size / Type
93	Location **Rem 2**				Service		
94	Monitor supplied by **Comp. Vendor**				Lube oil inlet		
95					Lube oil outlet		
96	**■ INSTRUMENTS**				Casing drain		
97	☐ Mercury Thermometers ☐Other instruments				Vent		
98	■ Bearing metal temperature sensors : **Rem. 2, 3, 5**				Casing purge		
99	**☐ CONTRACT DATA**						
100	■ Vendor's Representative at site						
101	■ Test data prior to shipment				**■ LUBRICATION REQUIREMENTS**		
102	■ Progress reports				■ Oil System Furnished by **Compr. Vendor**		
103	**■ SHIPMENTS**				☐ Oil Visc.: cP @ 40°C	cP @ 100°C	
104		Contract unit	Spares		Min. start-up oil temperature		°C
105	Export boxing	■	■		Unit oil flow(total)		m³ / hr
106	Domestic boxing	☐	☐		Unit oil pressure		kg/cm²g
107	Outdoor strg. for 12 months	■	■		Oil flow, Mesh		m³ / hr
108					Oil flow, HS Bearings		m³ / hr
109	**MATERIALS**				Oil flow, LS Bearings		m³ / hr
110	Gear Casing		Oil Seals		Oil flow, Thrust Bearing(s)		m³ / hr
111	Radial Bearings				**Additional Requirements**		
112	Thrust Bearing(s)				Filter breather location		
113	HS Shaft		LS Shaft				
114	Pinion(s)		Hardness				
115	Gear Rim(s)		Hardness				
116	Low Temp. Operation						
117	REMARKS:						
118							
119							
120							

	■ SHOP INSPECTION AND TESTS				
		Reqd.	Observe	Witness	Test log
	Shop Inspection	■	■		
	Cleanliness inspection	☐	☐	☐	
	Hardness verification Insp	■	■	☐	■
	Dismantle-Reassembly Insp.	■	☐	■	
	Contact check	■	■	☐	☐
	Contact check tape lift (2.5.2.2)	☐	☐	☐	☐
	Journal runout check	■	■	☐	■
	Axial stability check	☐	☐	☐	☐
	Rotor balancing machine	☐	☐	☐	☐
	Sensitivity Check				
	Residual Unbalance Check	☐	☐	☐	☐
	Mech. run test	■	☐	■	■
	Mech. run test (Spare rotors)	■	☐	■	■
	Add'l mech. Test	☐	☐	☐	☐
137	Part or full load and full speed test	☐	☐	☐	☐
	Full torque slow roll test	☐	☐	☐	☐
	Full torque static test	☐	☐	☐	☐
140	Back-to-back locked torque test	☐	☐	☐	☐
	Sound level test	■	☐	☐	■
	Add'l gear tooth test	☐	☐	☐	☐
	Use shop lube system	■	☐	■	
	Use job lube system	☐	☐	☐	
145	Use shop vibration probes, etc.	☐	☐	☐	
146	Use job vibration probes, etc.	■	☐	■	
	Other:	☐	☐	☐	
	Final assembly maintenance &	■	☐	■	☐
	running clearance				
	Oil system cleanliness	■	■	☐	
151	Oil system casing joint tightness	■	■	☐	
152	Warning and protection devices	☐	☐	☐	

	☐ GEAR DATA			
	Power loss each HS bearing			
	Power loss each LS bearing			
	Power loss each thrust bearing			
			Pinion	Gear
	Outside diameter	mm		
	Root Diameter	mm		
	Center Groove Diameter	mm		
	Durability Power			
	Strength Power			
	Face overlap ratio			
	Transverse contact ratio			
	Length line of action	mm		

☐ WEIGHTS & DIMENSIONS						
Net Weight:						
Mechanism:	kg	Auxiliaries:	kg			
Max. Maintenance Weight [Identify]:		kg				
Total Shipping Weight:		kg				
Total Shipping Dimensions:	L:	m	W:	m	H:	m

REMARKS:

1. The mechanism rated power shall be, as a minimum, equal to the installed power of the driver i.e. Motor Nameplate Rating
2. The make and model of bearing temperature monitoring system , vibration and axial displacement monitoring system shall be as per Instrumentation specification forming part of inquiry document.
3. The location of bearing temperature monitoring system , vibration and axial displacement monitoring system shall be as per Instrumentation specification forming part of inquiry document.
4. The oil system for mechanism unit shall be common with the main equipment i.e. Centrifugal Compressor and Electric Motor.
5. Hydrodynamic radial bearings shall be fitted with at least two (2) temperature probes & Hydrodynamic thrust bearings shall be fitted with at least two (2) temperature probes each on active and inactive side.

DATE	REV	PREPARED BY	CHECKED BY	APPROVED BY

NOTES TO BIDDERS:

1. Prototype Gear Box model/ model series shall not be considered.
2. It is mandatory that all references furnished for Gear Box model/ model series should have similar parameters.

DESCRIPTION OF MODEL DESIGNATION: _____

S. NO.	PARAMETER	INFORMATION ON PROPOSED MODEL	INFORMATION ON REFERRED EXISTING INSTALLATIONS			REMARKS
			Ref.- 1	Ref.-2	Ref.-3	
1.	2.	3.	4.	5.	6.	7.
1	**GENERAL**					
1.1	Cross reference to manufacturer's Standard Reference list	----				
1.2	Make / Model					
1.3	No. of Units supplied					
1.4	Type of Driver / Driver Rating (kW x rpm)					
1.5	Driven Machine					
1.6	Shop where Gear Box is designed, manufactured and tested with location and address					
2	**GEAR BOX DETAILS**					
2.1	Codes / Standards followed (API-613/API-677/ Others)					
2.2	Gear Box Rating (kW)					
2.3	Speed (input/output) (rpm)					
2.4	Maximum continuous speed (input/output) (rpm)					
2.5	AGMA / API S.F.					
2.6	Pitch Circle Diameter (Pinion / Gear) (mm) / Pitch line velocity (m/sec.)					
2.7	Gear Ratio / No. of stages					
2.8	Center to Center distance between high speed & low speed shafts (mm)					
2.9	Tooth profile					
2.10	Type of Gears : Single helical / Double helical / Herringbone					

Place:
Date:

[Signature of Authorized Signatory]*

Name:
Designation:
Seal:

S. NO.	PARAMETER	INFORMATION ON PROPOSED MODEL	INFORMATION ON REFERRED EXISTING INSTALLATIONS			REMARKS
			Ref.- 1	Ref.-2	Ref.-3	
1.	2.	3.	4.	5.	6.	7.
2.11	Type & No. of Bearings (Radial)					
2.12	Gear Shaft					
2.13	Pinion Shaft					
2.14	Type & No. of Bearings (Thrust)					
2.15	Gear Shaft					
2.16	Pinion Shaft					
2.17	**MATERIAL OF CONSTRUCTION :**					
2.18	Casing					
2.19	Pinion					
2.20	Gear					
2.21	Shaft (high speed / low speed)					
2.22	Bearings					
3	**OTHER INFORMATION ON INSTALLATIONS**					
3.1	Date of supply and commissioning					
3.2	Whether one year of successful field operation completed after commissioning as on bid due date					
3.3	Purchaser's Name, Address, Contact No. & email ID					

Place:
Date:

[Signature of Authorized Signatory]*

Name:
Designation:
Seal:

1	**GENERAL**											
2	Project:	**P-25 Project**					Job No.:	**B269**				
3	Owner:	**M/s IOCL**					Site:	**IOCL, Panipat, Haryana**				
4	Purchaser:						Unit:	**PRU**		Unit No.:	**454**	
5	Item No.:						Service:	**Coupling b/w Comp & GB, GB & Motor**				
6	No. of Units:		Working:		Standby:							
7	Applicable to:		■ Proposal		☐ Purchase		☐ As Built					
8	■: Scope, Option & Info specified by Purchaser. ☐: Info required from and options left to vendor. Vendor to cross (☒) the selected option.											
9	■ Driver:	Type:				Manufacturer:				Model:		
10		Nameplate Power (kW):				Service Factor:		S.No.:		Tag No.:		
11	■ Driven Unit:	**Centrifugal Compressor**				Manufacturer:				Model:		
12		Serial No.:							Tag No.			
13	Coupling Type:	■ Flexible Element (**Rem. 1**)		☐ Gear		☐ Quill Shaft		☐ Other:				
14	☐ Manufacturer:			Model:		Size:		Assy. Dwg. No.:				
15												
16	☐ **CONDITIONS CONSIDERED FOR COUPLING SELECTION**					☐ **RATINGS**						
17	Conditions		Torque (kgf-m)	@ rpm			Torque (kgf-m)	@ rpm	Serv. Factor			
18	Normal					Normal						
19	Driven Rated Load					Peak						
20	Maximum Steady State					Momentary						
21	Maximum Transient					Shaft Juncture (Driving)						
22	Trip Condition					Shaft Juncture (Driven)						
23	Continuous Cyclic											
24	Other:											
25	☐ Frequency of Transients (Events/Time):					☐ Non-synchronous exciting frequency:						
26	■ Coupling Minimum Required Service Factor, SF: **1.5 (Rem.4)**					☐ Actual SF						
27	■ Ambient Temperature (^{0}C):		Maximum:			Minimum: (**Rem2**)						
28	Environment:	☐ Hyd. Chloride	☐ Hyd. Sulphide		■ Other: **Dust, Fumes and Refinery Atmosphere**							
29	**LUBRICATION**											
30	☐ Continuous	☐ Batch	☐ Non-Lubricated		☐ Viscosity:		cP @	^{0}C				
31	☐ Filtration Microns:				☐ Pressure (kg/cm^{2}g)		☐ Temp. (^{0}C):					
32					☐ Flow (m^3/hr)							
33	**COUPLING DATA**											
34	☐ Shaft Separation (including thermal growth) (mm B.S.E):											
35		@ Ambient Temp.:		@ Normal Operation:			@ Maximum Transient:					
36	☐ Motor Rotor Float (mm):			☐ Limited End Float (mm):								
37	☐ Marine Type Required			☐ Flex-Hub Type Required			☐ Electrically Insulated					
38	☐ Required Misalignment Capability:											
39		Steady State:	Angular (^{0}):	Parallel Offset (mm):			Axial (mm):					
40		Transient:	Angular (^{0}):	Parallel Offset (mm):			Axial (mm):					
41	☐ Maximum Allowable Misalignment:											
42		Steady State:	Angular (^{0}):	Parallel Offset (mm):			Axial (mm):					
43		Transient:	Angular (^{0}):	Parallel Offset (mm):			Axial (mm):					
44	■ Component Balance	-**OR**-	■ Component Balance & Assembly Check Balance	-**OR**-	☐ Component Balance with Assy. Balance							
45	☐ Residual Unbalance Check of Assembled Couplings				☐ Balance Repeatability Check							
46	☐ Max. Allowable Residual Unbalance	g-mm	Driver End:		Driven End:							
47	☐ Max. Actual Residual Unbalance	g-mm	Driver End:		Driven End:							
48	☐ Torsional Stiffness (kg-mm/Rad):											
49	☐ WR^2 (kg-m^2):		Driver End:		Driven End:							
50	☐ Spacer Lateral Natural Frequency:		☐ Torque Capacity of Hub/Shaft Interface for keyless fits (kgf-m):									
51	**Flexible-Element Coupling:**											
52	☐ Initial Deflection (mm):		☐ Pre-Stretch	☐ Compression	☐ Max. Axial Deflection (mm):							
53	☐ Calculated Axial Natural Frequency:				☐ Test of ANF:		☐ Actual ANF:					
54	☐ Maximum Enclosure Temperature at Max. Continuous speed (^{0}C):											
55	REMARKS:											
56	1. Coupling shall be of non-lubricated, metallic (SS), flexible element (Diaphragm or Disc) type with spacer.											
57	2. Refer Process Data Sheet for Site and Utility Data..											
58												
59												
60												

61	**MATERIALS**				
62	Component	Drive End Materials		Driven End Materials	
63	Hub / Flange				
64	Spacer				
65	Sleeve				
66	Flexible-Element				
67	Flexible-Element Guard				
68	Bolts				
69	Nuts				
70	■ Protective Coating:		■ Vendor Standard	☐ Other:	
71	☐ Internal Teeth Hardness: Rockwell C		Drive End Actual:	Driven End Actual:	
72	☐ External Teeth Hardness: Rockwell C		Drive End Actual:	Driven End Actual:	
73	**COUPLING HUB MACHINING**				
74				Drive End	Driven End
75	☐ Type (Integral / Cylindrical / Taper)				
76	■ Hydraulically Fitted				
77	■ Taper (Rem-3)				
78	☐ Keyway Dimensions and Number				
79	☐ Nominal Bore Diameter (mm)				
80	☐ Interference Fit (mm): Max. | Min.			|	|
81	■ Puller Holes				
82	■ Trim Balance Holes				
83	**COUPLING GUARD**				
84	■ Co-ordinator: **Compressor Vendor**			☐ Purge Gas:	☐ Dry Air Purge:
85	■ Flanged Cylindrical:	☐ Base Mount:		☐ Purge Connection Size & Type:	
86	☐ Air Tight:	☐ Oil Tight:		☐ Purge m^3/hr Required:	
87	■ Spark Resistant			☐ Oil Mist Cooling	☐ Gas Cooling
88	☐ Transparent Window for Each Oil Spray Point:			■ Contract Guard to be used during Shop Test	
89	☐ Vent Connection:			☐ Additional Guard Details:	
90		☐ 1 inch NPT with Filter Breather			
91		☐ 1 inch Flanged, Rating & Facing:			
92	**ACCESSORIES**				
93	■ Prime Eqpt. Supplier to furnish one set of Plug & Ring Gauges (Appe. D)			■ Hydraulic Installation/Removal Tooling (To include Hand Pump(s), Pressure Gauge(s), Fittings & Hose(s)) By:	
94	☐ Lapping Tools				
95	☐ Drill Template for Internal Flanged Hubs by:			■ Coupling Manufacturer	☐ Purchaser
96		☐ Coupling Manufacturer	☐ Purchaser	■ Puller By Coupling Manufacturer	
97	☐ Two-Piece Stop Rings by Coupling Manufacturer			■ Moment Simulator	☐ Solo Plate
98	**APPLICABLE SPECIFICATIONS**			**PREPARATION FOR SHIPMENT**	
99	■ API 671, Special Purpose Couplings, 4th edition			■ Outdoor Storage for **12** months	
100	■ Others: Spl. Job requirements			☐ Expected Storage Time (Months): months	
101	☐			■ Shipping ☐ Domestic	■ Storage ☐ Indoor
102	☐ Coordination Meeting Attendance Required			☐ Export	■ Outdoor
103	REMARKS:				
104	3. 1^0 included angle / ½ dia. Inch. per foot length / ¾ dia. inch. per foot length				
105	4. Service factor shall be over the driver rating.				
106	5. Vendor shall fill separate Data Sheet for each coupling and submit the same during detailed engineering stage.				
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108					
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116					

Date	**Rev**	**Job Engineer**	**Rev. & Approved By**

JOB SPECIFICATION FOR CENTRIFUGAL COMPRESSOR PACKAGE (SPECIAL PURPOSE PROCESS)

PROJECT : **EPCM SERVICES FOR CAPACITY EXPANSION OF PANIPAT REFINERY (P25 PROJECT)**

UNIT NO. : **454(PROPYLENE RECOVERY UNIT)**

CLIENT : **M/s IOCL, PANIPAT REFINERY**

EPCM : **M/s ENGINEERS INDIA LTD.**

JOB NO. : **B269**

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
B	28.12.21	Revised & Issued for Bids	MKY	MG	TK
A	25.10.21	Issued for MR	MKY	MG	TK

1.0 GENERAL

1.1 Scope

1.1.1 This specification describes the minimum requirements for design, engineering, manufacturing, packaging, testing, supply, supervision of erection, site testing and commissioning of Centrifugal Compressor Package (Special Purpose Process) as described hereunder and in various attachments listed in the "List of Attachments" of this material requisition.

(a) ***Heat Pump Compressor Tag No. 454-K-1001*** (Electric motor driven with variable speed control device i.e. VFD or Variable speed planetary gear mechanism)

1.1.2 The intent of these requirements is to supplement, highlight and modify the requirements as given in data sheets, specifications as listed under list of attachments and enclosed with the MR and other applicable standards referred to in data sheets and specifications.

1.2 Standards

1.2.1 The design, construction, manufacture, supply and testing and other general requirements of the compressor package equipment shall be strictly in accordance with the data sheets, this job specification, P&IDs, standard specifications etc. as listed under "List of Attachments" as well as other referenced codes, standards and recommended practices.

1.3 Precedence

1.3.1 In case of any conflict between this Job Specification and other enquiry documents, the following preferential order shall govern:

a. Process Datasheet and P&IDs
b. Mechanical Datasheets
c. Job Specification
d. Standard Specifications
e. Other Specifications
f. International Standards/Codes/recommended practices as applicable

However, any such conflict shall be brought to the notice of Owner/ Purchaser/ Consultant by the bidder, during pre- bid meeting in consolidated form and Owner's/ Purchaser's/ Consultant's decision shall be final and binding, in this regard.

Bidder to note that any conflict brought out after pre- bid meeting, **the stringent of the same shall be applicable** and the decision of the Owner/ Purchaser/ Consultant shall be final. The same shall be complied to, by the Bidder without any cost/ time implications.

1.4 Also refer Special Instructions to Bidders (Doc. No. B269-454-80-42-SI-5155) attached with the MR.

1.5 Compliance with this specification shall not relieve the vendor of the responsibility of furnishing equipment and auxiliaries of proper design, materials and workmanship to meet specified operating conditions.

2.0 SCOPE OF SUPPLY / WORK

2.1 Vendor's scope of supply/work for the compressor package shall include, as a minimum but not limited to, the items enlisted in the scope of supply/work (Doc. No. B269-454-80-42-SS-5155).

2.2 Bidder shall be the Single Point Responsibility Vendor (SPRV) for the complete Centrifugal Compressor Package including Centrifugal Compressor, Electric motor driver, variable speed control device (VFD or variable speed planetary gear mechanism) and all other associated auxiliary systems, instrumentation & Controls etc. It shall be the responsibility of the SPRV to furnish a safe operating unit. For this purpose, in case SPRV envisages additional equipment/ instruments/ control and safety devices, the same shall be offered by the SPRV and included in his scope of supply. Such additional items shall be separately listed with reasons for their inclusion.

2.3 Specific project philosophy regarding equipment tag numbering, instrument tag numbering, P&ID numbering, standard symbols and nomenclature (lines numbering, service designations, insulations, general abbreviations, instrument symbols & legend) etc. shall be provided to successful bidder, post- order. Vendor to comply these requirements.

2.4 All civil works, compressor house building including all the operating platforms (except operating platform within vendor's skid(s)) etc. are excluded from the bidder's scope of supply/work.

3.0 UNITIZATION

3.1 Compressor along with the driver and gearbox (special purpose gearbox or variable speed planetary gear mechanism) shall be unitized on the job baseplate at compressor manufacturer works.

4.0 SAFETY

4.1 All controls shall operate in a fail-safe mode.

4.2 All Electrical Devices shall meet the requirement for the specified area classification in which they are installed.

4.3 All machine/ process related trips shall be based on 2 out of 3 (2oo3) voting logic except for compressor bearing vibration and bearing temperature trips.

4.4 Sight flow glass shall be provided at each isolatable cooling water return line. Thermal relief valves shall be provided for components that may be blocked in by isolation valves (including any cooling water return circuit piping of a cooler or a jacket). Set pressure for Thermal Relief Valve shall be less than or equal to the design pressure of cooling water return header as indicated in Process datasheet.

5.0 SITE AND UTILITY DATA

5.1 For Site and Utility Data refer Annexure-A of Process datasheet (Doc. No. B269-454-80-42-SU-5155).

6.0 QUALIFICATION REQUIREMENT FOR BIDDER/ EQUIPMENT

6.1 **Bidder Qualification Criteria (BQC)**

6.1.1 Refer commercial section of this inquiry document for Bidder Qualification criteria. Filled in Bidder PTR proforma along with supporting documents shall be submitted along with bid.

6.2 **Acceptance Criteria For CENTRIFUGAL COMPRESSOR (SPP)**

6.2.1 For qualification criteria of compressor, refer CL 1.0 of Part-2 'EXPERIENCE CRITERIA' (EIL Standard specification Doc No. 6-42-0005 Rev. 3), attached elsewhere in the enquiry document.

6.2.2 Vendor shall furnish duly filled in Experience Record Proforma (Doc. No. B269-454-80-42-ERP-5155) during detailed engineering stage to justify provenness of the proposed model.

6.3 **Acceptance Criteria For Special Purpose Gearbox**

6.3.1 The gearbox vendor shall be established Special purpose gear manufacturer having adequate engineering, manufacturing and testing facilities for the same.

6.3.2 The offered gearbox models shall be of proven design and shall be from the gearbox manufacturer's existing regular production range. Each of the gearbox model offered shall be identical in terms of model series & similar in terms of size (centre to centre distance, power rating, pinion speed, bearing journal speed, pitch line velocity and tooth profile) as compared to at least ONE UNIT designed, manufactured, tested and supplied by the vendor earlier from the proposed manufacturing plant, as a minimum, this package shall have completed one year of satisfactory operation at site, as on bid due date.

6.3.3 Vendor shall furnish duly filled in Experience Record Proforma (Doc. No. B269-454-80-42-ERP-5156) during detailed engineering stage to justify provenness of the proposed model.

6.4 **Acceptance Criteria For Variable Speed Planetary Gear Mechanism**

6.4.1 The Variable speed planetary gear mechanism shall be procured from a regular and established manufacturer having requisite design, manufacturing and testing facilities and shall meet the following minimum service and manufacturing experience requirements.

6.4.2 The offered model shall be of proven design and shall be from manufacturer's existing regular production range.

Past one references (i.e. one Unit) of the offered Variable speed planetary gear mechanism model as designed, manufactured, tested and supplied from the proposed manufacturing plant, in the last TEN years, shall be similar to the present case in terms of Power rating, speed, gear ratios, type of bearing, Lubrication system, and as a minimum same reference shall have completed one year of operation at site for similar compressor drive application, as on bid due date.

6.4.3 Vendor shall furnish duly filled in Experience Record Proforma (Doc. No. B269-454-80-42-ERP-5156) during detailed engineering stage to justify provenness of the proposed model.

6.5 **Acceptance criteria for Dry Gas Seal, Dry Gas Seal Skid & Panel**

6.5.1 The offered model of Dry Gas Seal shall be field proven and similar in terms of specified process gas service, shaft diameters, speeds, sealing pressures and configuration as compared to at least Two Units designed, manufactured, tested and supplied and at least ONE of these units shall have completed at least one year of satisfactory operation as on the bid due date of main (driven) equipment.
Compressor vendor to furnish past supply experience list of the seal manufacturer for the offered model of seal and justify meeting acceptance criteria, during detailed engineering stage.

6.5.2 The offered dry gas seal skid and panel shall be field proven and similar to the specified operating parameters as compared to at least FIVE UNITS designed, manufactured, tested and supplied by the proposed manufacturer and at least TWO of these units shall have completed at least one year of satisfactory operation as on the bid due date of main (driven) equipment.
Compressor vendor to furnish past supply experience list of the seal manufacturer for the offered model of dry gas seal skid and panel and justify meeting acceptance criteria, during detailed engineering stage.

6.5.3 Dry Gas seal skid & Dry gas seal panel, including all related instrumentation, shall be procured from the dry gas seal supplier who meets the experience requirements as specified above being the single point responsibility vendor for shaft sealing system

7.0 LOADING & PENALTY CRITERIA

Refer Loading & Penalty Criteria for Centrifugal Compressor Package (Doc. No. B269-454-80-42-LP-5155) enclosed elsewhere with enquiry.

8.0 BASIC DESIGN

8.1 Compressor

8.1.1 The Centrifugal compressor and associated equipment shall conform to Part-1 & 2 of API Std. 617, 8th edition together with other specifications as listed in the List of Attachments forming part of MR.

8.1.2 The compressor shall be selected so as to fully meet the requirements specified in PROCESS data sheets and specifications as well as referred codes and standards forming part of the inquiry document.

8.1.3 The centrifugal compressor package is envisaged to be of single casing (axially split) configuration. Multiple casing configuration of compressor is not acceptable. The compressor shall be driven by VFD fed electric motor with special purpose gear box or variable speed planetary gear mechanism and VFD soft starter.

8.1.4 Compressor rated speed shall be achieved with gear box. VFD or Variable speed planetary gear mechanism shall be used for off design cases by reducing speed.

8.1.5 Electric motor offered shall be suitable for starting the compressor under specified loading conditions including against maximum settle out pressure.

8.1.6 Compressor must also be able to restart under maximum settle out pressure.

8.1.7 Spare rotors shall be dynamically balanced to same degree as the main rotor installed in the equipment. Both the spare and main rotors shall have these residual unbalance verified.

8.1.8 The compressor train shall also be designed for accidental reverse rotation case along with bearings, turning gear, lube oil system, seal system & other auxiliaries. Necessary instrumentation and controls shall be included in vendor's scope for the same to avoid any damage to the machine and its auxiliaries because of reverse rotation.

8.1.9 100% radiography shall be done in the case of connections welded to pressure castings. In addition, cast compressor casings shall be radiographed in critical areas (critical areas are generally defined as those areas where there is a major change in section thickness or direction).

8.1.10 Vendor to ensure that the loose supplied Vendor furnished (VF) piping items including **NRV** (Dual Plate type) at compressor discharge & other Instrumentation items etc., as identified in P&IDs, Datasheet and Scope of Work/ Supply or recommended by vendor for safe and smooth operation of the equipment, shall be suitable for respective design conditions (pressure/ temperature/ flow etc.). **Pressure Safety Valves** (1+1 Configuration) in compressor discharge, if applicable or if recommended by the bidder for machine/downstream system protection shall also be included in bidder's scope of supply as loose supply items along with sizing calculations.

8.2 **Dry Gas Shaft Sealing System**

8.2.1 Compressor shall be equipped with dry gas shaft sealing system. The compressor vendor shall offer Tandem (Dual, un-pressurized) with intermediate labyrinth dry gas seal for the compressor casing. Dry gas seal shall be bi-directional, interchangeable between drive end and non-drive end and of cartridge design. The dry gas seal module shall be on separate skid from the lube oil console.

8.2.2 Propylene gas shall be used as primary seal gas for Normal/ startup/ shutdown etc. For startup/ shutdown Nitrogen shall be used as a backup primary seal gas. Vendor to incorporate suitable piping, instrumentation & controls in the gas-sealing scheme to achieve the above auto change-over between gases (i.e. Propylene gas and nitrogen).

8.2.3 Nitrogen shall be supplied to the secondary seal with secondary seal leakage routed to safe atmospheric height. **The primary seal leakage rate shall be shall be guaranteed and the same shall be clearly indicated on the datasheet.** Nitrogen shall also be employed as separation gas between secondary seal and compressor bearings.

8.2.4 Seal faces lift- off speed shall always be below the compressor no load trial speed or compressor train minimum operating speed, suggested by compressor train vendor.

8.2.5 Vendor shall include in their scope a suitable seal gas booster. The seal gas pressure booster shall be suitable to meet the primary seal gas pressure requirement during normal/ startup/ shutdown/ settle out etc. The booster on/ off shall be automated using low seal gas DP/ low seal gas flow signal. Seal gas shall bypass the booster when it is idle.

8.2.6 During emergency/stand-still settle-out conditions, if the min. pressure of plant nitrogen (as mentioned in site and utility data) is not sufficient for buffer/primary and barrier/secondary seals sealing of dry gas seal (based on settle-out conditions), Vendor shall nitrogen bottle bank in his scope with auto-change-over valve(s).

8.2.7 Vendor shall indicate process gas(Propylene) & Nitrogen consumption requirements during normal, stand-still/settle-out & start-up conditions.

8.2.8 Flow meters shall be provided at N2 consumption points for knowing the N2 consumption requirements

8.2.9 Temperature gauges shall be provided in the primary vent to flare of seal gas skid to distinguish the leakage of N2 or process gas.

8.2.10 Seal gas skid shall be compact, easily operatable/maintainable and designed to ensure that

8.2.11 Dry gas seal vendor shall submit written confirmation that the spare seal shall be suitable for use without any refurbishment for at least 5 years from the date of supply. Seal vendor shall provide necessary storage conditions to comply with the above requirement.

(i) If the spare seals are not used at all before 5 years and if the vendor's design standard practice is calling for any refurbishment / revalidation / requalification, after 5 years but before 10 years period vendor shall accept to refurbish the spare seals free of charge for one time to the end customer.

(ii) If the spare seals are used before 5 years, the above Part-i is not applicable.

8.2.12 Lift off speed of seal faces shall be below the compressor train minimum operating speed including the shop speed for performance test

8.2.13 Dry gas seal skid shall be compact and design shall ensure that there is no condensate ingress in dry gas seal.

8.2.14 The seal system shall include stainless steel piping insulated and heat traced by the vendor to prevent any condensation, coalescing filters (with collection pot with vent, level monitoring & auto draining facility) with stainless steel housing and a removal efficiency of 98% (on liquids 1 micron or greater and solids 3 microns or greater) and steel bodied transfer valves with stainless steel internals. The collapse pressure of the filter elements shall be minimum 50 psi (3.5 kg/cm²) differential.

8.2.15 Vendor shall indicate the guaranteed seal leakage rate in compressor data sheet.

8.2.16 Dry gas seal shall be one of the makes specified in Vendor List attached elsewhere in the MR.

8.2.17 Dry gas seals & sealing system (Primary seal gas supply and vent) shall be designed for Compressor Casing MAWP.

8.2.18 Dry Gas seal skid shall be made amply spread-out so that operation and maintenance of valves, fittings etc., can be carried out easily.

8.2.19 Operating and spare seals shall have the following shop tests:

a. Cleanliness (No discoloration or hard particles found on 20 mesh screen after module blown for 5 minutes with 100 psig (7.0 kg/cm2 g) dry filtered gas.

b. Gas Leak at a pressure equal to settling out pressure with a mol weight gas equal or less than the seal gas

c. Functional run for minimum of one hour at operating pressure and speed. Following the test, the seal elements shall be examined for wear and general conditions.

d. Other tests as per Annexure F of API 617.

8.3 Lube Oil/ Control Oil Systems

8.3.1 The lube oil/ control oil system shall be console type & shall be common to compressor, gearbox (special purpose gearbox or variable speed planetary gear mechanism) & driver. The Lube oil/ control oil console shall be located at the grade level within the shelter.

8.3.2 The lube oil system shall be equipped with Electric motor main lube oil pump, Electric Motor driven standby lube oil pump, Electric motor driven emergency lube oil pump (on emergency AC power supply) (if required) and overhead run down tank. Design shall ensure supply of lube oil to compressor during the compressor coast down period, in the event of emergency shutdown.

8.3.3 All lube oil piping from oil consoles to the equipment including fittings, valves, instruments and supports shall be included in vendor's scope of supply. Vendor shall engineer the system and furnish detailed P&IDs as well as the piping drawings for the interconnecting piping as for purchaser's review and approval during detail engineering stage.

8.3.4 Lube oil supply header line shall be provided with analyzer capable of detecting water present in oil in forms of dissolved, emulsified and free water state. The device shall monitor the water content in the oil on continuous basis and the real- time data shall be available in DCS. For more details, refer Instrumentation specifications.

8.3.5 Reservoirs, pumps, coolers, filters and control valves shall be provided in an assembled console. Console shall have a steel baseplate with rim and drip lip for drainage.

8.3.6 Lube oil pumps shall be supplied as per datasheets attached with MR & relevant API (i.e. API 610 11th Edn. / API 676 3rd Edn.).

8.3.7 Filters and Coolers

a) Filters and coolers shall be fitted with valved- vents and drains.

b) Filters and coolers shall have valved interconnections to permit filling with oil after maintenance. Vents of the filters and coolers shall be routed to lube oil reservoir with sight flow glasses.

c) Coolers shall be water- cooled shell and tube type as per TEMA 'C' with oil in shell and water in tube. The oil side operating pressure shall be higher than water side operating pressure. The low pressure (LP) side shall be preferably with a design pressure at least equal to (10/13) of high pressure (HP) side design pressure.

d) MOC shall be suitable for the specified service and shall be in- line with API & Mechanical Datasheet requirements.

8.3.8 Vendor shall design the lube oil consoles from the point of view of easy accessibility, 800mm free space around and maintainability of the major pieces of equipment such as coolers, pumps, drivers, control valves, filters etc. Vendor to ensure easy personal movement and no criss-cross of piping in the consoles. Vendor shall not consider his standard congested consoles but shall design the layout in spread out manner. The layout shall be furnished for review and approval by the purchaser during detailed engineering.

8.3.9 One portable (trolley mounted) pump with necessary hose piping, valves, connections etc. shall be provided for emptying/filling the main reservoirs. Pump shall be electric motor driven with a motor cable of 20 m length, hose pipe of 10 m length at suction and discharge and plug to suit the area classification and motor rating.

8.3.10 One portable (trolley mounted) oil purifier/conditioner with necessary hose piping, valves, connections etc. shall be provided. Pump shall be electric motor driven with a motor cable of 20 m length, hose pipe of 10 m length at suction and discharge and plug to suit the area classification and motor rating. The capacity shall be sufficient for conditioning the total requirement in approximately 12 hrs.

8.3.11 All the piping, fittings and valve trims etc. shall be stainless steel for both lube oil and seal gas systems. Any tubing required shall be 304L/316L/321 Stainless Steel with compression type of fittings of like materials. Compression type fittings shall be of Swagelock type or approved equivalent.

8.3.12 The lube oil for the compressor package (Bearing Lubrication) shall be of M/s. IOCL make or Equivalent (Vendor to furnish the list of recommended make equivalent to IOCL oil). The flushing of the compressor during commissioning shall be with fresh IOCL or equivalent oil. However, the lube oil used for flushing shall be base lube oil (Oil without special additives).

8.4 Compressor Suction Strainers

8.4.1 The strainer shall be installed as indicated in the enclosed P&ID. Line size strainers shall be provided.

8.4.2 Strainers shall be located as close as possible to the suction nozzle.

8.4.3 Vendor shall provide suitable permanent strainer at gas inlet with spool piece arrangement to facilitate removal for each of the stages as per P&ID.

8.4.4 Vendor shall provide separate temporary and permanent strainers. Vendor shall provide a temporary strainer, which shall be housed in the same spool piece as provided for the permanent strainer for each of the Compressor stages as per P&ID. The temporary strainer in each case shall be used for commissioning of the compressor after which the same shall be removed and permanent strainer installed.

8.4.5 Vendor to indicate the mesh size and the pressure drop across the strainer. Maximum allowed pressure drop across suction strainer shall be as per PDS.

8.4.6 The instrumentation requirements related to suction strainer shall be in accordance with the P & IDs.

8.4.7 Strainer shall be mechanically suitable to withstand a pressure drop of 5 kg/cm2. The open area shall be at least 150%.

8.4.8 The strainer body material shall conform to the Piping Material specification of the Pipe in which the strainer is installed. The screen material shall be Type 304 stainless steel. Vendor shall furnish the details for the strainer.

8.5 Special Purpose Gear Box (if applicable)

8.5.1 The gearbox shall be in accordance with the data sheets and API Std. 613. Minimum Service factor shall be 1.7.

8.5.2 Gearbox housing shall be sealed against loss of lubricants or against the entrance of water or any foreign matter.

8.5.3 Gear shall be double-helical or herringbone type.

8.5.4 The gear mechanical efficiency shall not be less than 97% at rated load and speed

8.6 **Variable Speed Planetary Gear Mechanism for speed control (if applicable)**

8.6.1 Variable speed planetary gear mechanism shall be designed for power rating at least equal to driver rating and all speeds required to achieve various operating cases as per Process PDS, shall be achieved through this mechanism/system. The response time of the mechanism shall be fast enough to ensure that the process flow stabilizes within shortest possible time. Vendor shall confirm system response time for all operating cases.

8.6.2 Compressor, Variable speed planetary gear mechanism and motor shall be mounted on a common base plate & shall be unitized at compressor manufacturer's shop before dispatch.

8.6.3 The lube oil system shall be common for compressor, gear box and motor. The lube oil console shall be located at the grade level within shelter. Variable speed planetary gear mechanism working oil circuit shall be integrated with compressor & motor lube oil system providing same level of integrity & protection.

8.6.4 The gear unit of Variable speed planetary gear mechanism shall be designed as per API 613 to the maximum extent possible.

8.6.5 Vendor shall provide the performance of Variable speed planetary gear mechanism over its full operating range. Vendor shall furnish efficiency curves, torque curves & power curves during detailed engineering stage.

8.6.6 Vendor shall provide all required instrumentation & controls for monitoring & safeguarding of Variable speed planetary gear mechanism.

8.6.7 Variable speed planetary gear mechanism shall include a speed control facility by means of an electro hydraulic actuator by which the mechanism shall provide stepless speed control over its entire operating range from purchaser's 4-20mA signal.

8.7 **Coupling**

8.7.1 Couplings shall be of metallic (Stainless steel), non- lubricated, flexible element (i.e. either Diaphragm or Disc) type with spacer. Couplings for Centrifugal compressor shall confirm to API Std. 671, 4th edition.

8.7.2 All Coupling models shall be selected for a minimum service factor of 1.5 over driver rating.

8.7.3 The coupling shall have spacer of adequate length to enable maintenance of packing/ seal/ bearings without dismantling any equipment of the train. DBSE shall be more than seal cartridge length.

8.7.4 Removable coupling guard shall be provided which shall be fabricated from non-sparking material, and shall be open at the bottom to permit manual shaft rotation. The guard shall be sufficiently rigid to withstand deflections as a result of bodily contact

of nominally 100 kgs. Centrifugal compressors and Gas Turbines coupling guards may have vendor standard features.
Coupling guard shall have a hinge to open and inspection window to see the healthiness of the coupling shims.

8.7.5 Couplings for compressor shall comply with the requirements specified in Coupling and Compressor Data sheets.

8.8 **Baseplate for Compressor, Gearbox & Driver**

8.8.1 The compressor packages shall be mounted on a common base plate to be erected at site at Mezzanine (≈ 4.5 m elevation). However, if found infeasible due to transportation constraints, compressor driver packages can also be supplied with individual base plates which can be integrated (i.e., bolted/ dowelled) and matched at site, subjected to Purchaser's acceptance. For this, horizontal and vertical jack screws shall be provided for ease in alignment.

9.0 PIPING TERMINATION AND BATTERY LIMITS

9.1 Process Gas Piping: No process gas piping (supply / inter-stage / discharge) is included in the vendor's scope of supply. The compressor shall be supplied flange to flange.

9.2 Utility Piping

9.2.1 Besides the above mentioned termination points, the purchaser shall supply at "Piping Battery Limits for Utility Piping" near to the compressor package battery limit for the utilities namely Nitrogen supply, Instrument Air supply, Cooling Water supply/return (for all consumers), fuel gas supply for seals during start-up and flare etc.

All interconnecting piping distribution, piping to various consumption points within Vendor's Battery Limit, tubing, cabling, and supports including isolation valves at the tie-up points of vendor's battery limit shall be engineered, designed and supplied by the vendor. Pipes, tubes and cables shall be supplied pre- fabricated wherever feasible and in commercial lengths, where pre- fabrication is not possible due to general erection constraints.

9.2.2 In case requirement of vents to safe location, complete piping with valves, fittings etc. to safe elevation outside the compressor house shall be provided by the vendor.

9.2.3 Vendor shall terminate all the drains at the grade level with isolation valves for further connection to purchaser CBD system/OWS system. Vendor shall manifold all the drains (to be connected to same UG point) of each skid and terminate the same at grade level with isolation valve. Also, vendor shall terminate all the compressor-casing drains mani-folded to single connection at the grade level for further connection to purchaser CBD system/OWS system.

9.2.4 Vendor shall manifold all the flare vent connection (with necessary individual isolation valves, individual check valves, flow orifice etc.) to a single header and terminate as an interface connection at compressor package battery limit.

9.2.5 Dry gas seal piping between auxiliary skids and compressors is included in vendor's scope. Seal gas piping shall be SS304/SS316/SS321, as per API 614.

9.2.6 Lube / Control oil piping between compressor, oil console and lube oil run down tank is in vendor's scope. Lube / Control oil piping shall be SS 304/SS316/SS321, as per API 614.

9.3 Equipment nozzles, especially at Purchaser's interface, shall be as per Piping specifications, attached elsewhere in the MR. In case, non- standard sizes are unavoidable, companion flanges along with gaskets and fasteners shall be provided by the Bidder. The same shall be included and clearly indicated in the Proposal.

9.4 Sight flow glass shall be provided at each isolatable cooling water return line. Thermal Relief valve shall be provided for the components that may be blocked in by isolation valves including each isolatable cooling water return circuit of a cooler or jacket. Set pressure for Thermal Relief Valve shall be less than or equal to the design pressure of cooling water return header.

9.5 The space considered for the compressor package is indicated in the layout for Compressor attached with enquiry. The auxiliary equipment shall be so arranged within this area such that enough space is available around each equipment for ease of operation and routine maintenance. The compressor package shall be mounted on a common baseplate at the mezzanine floor level. The lube oil console shall be located at the grade level within the compressor house. The complete area around the machines at the mezzanine floor shall be covered with the working platform provided by the purchaser. Vendor is required to review the layout attached with this material requisition and furnish specific confirmation of acceptance of the proposed layout including the compressor shed sizing, span of columns, deck elevation, span for crane movement, crane hook height and crane capacity etc.

9.6 All piping inside the vendor supplied LO console skid & seal gas supply unit skid shall be as per relevant API standards. Balance piping i.e. interconnecting piping within the vendor's scope of supply shall conform to the Piping specifications and referenced codes and standards.

9.6.1 Equipment Layout: The space considered for the compressor packages are indicated in the following Preliminary layout drawings attached elsewhere in the MR:

- Scope & Indicative Layout for Compressor – B269-454-16-43-SK-5155 Rev. A

9.6.2 The auxiliary equipment shall be so arranged within this area such that enough space is available around each equipment, for ease of operation and routine maintenance.

9.6.3 The compressor packages shall be locate under- roof with side walls partially open and shall be mounted on a common base plate at the mezzanine floor. Refer Equipment Layouts referred above for elevation details**.** Vendor to check & confirm the same.

9.6.4 The lube oil system shall be common for the compressor and gearbox with control oil supply also being from the same lube oil supply system. The lube oil console and other associated auxiliaries like gland condenser etc. shall be located at the grade level (ground floor/ finished floor level) within the compressor house. The complete area around the machines at the mezzanine floor shall be covered with the adequate working platform, provided by the Purchaser, and drop out facility for maintenance. Vendor is required to review the layout attached with this Material Requisition and furnish specific confirmation of acceptance of the proposed layout including the compressor shed sizing, span, deck elevation, crane hook height and crane capacity etc.

9.6.5 Specific Acceptance/ Categorical Confirmation is required from the vendor regarding the space allocated & crane capacity/ hook height indicated in the attached layout drawings. Further, vendor shall provide Recommended Crane Capacity & hook height for Equipment Maintenance for the Compressor Package.

9.6.6 General Arrangement Drawing (GAD)/ Equipment Layout of all equipments) based on indicative layout drawing provided in the MR) shall be provided by the vendor along with the Proposal.

9.6.7 Vendor to ensure that the loose supplied piping items (like NRVs, strainers etc.) instrumentation items (like control valves, relief valves, anti- surge valve, surge controller etc.) and other instrumentations (related to pressure, temperature, flow, positioning etc.) as indicated in P&ID as **"VF (Vendor Furnished)"**, shall be suitable for respective design conditions (pressure/ temperature/ flow etc.).

10.0 DYNAMIC SIMULATION STUDY (DSS)

10.1 Vendor shall undertake a Dynamic Computer Simulation Study of complete Compressor-Packages for all load & operating conditions to verify the satisfactory response of the system to transient conditions, e.g., start- up, shut down, process variations/ upsets, trips, mechanical failure of valves, couplings, etc.

10.2 Any hardware/ software required to implement the findings of DSS is in vendor's scope of supply (excluding civil works & main process piping).

10.3 Necessary inputs required from Client/ EIL for the above Dynamic Simulation Study shall be clearly elaborated by the Bidder during detailed engineering stage. After review of requested inputs, same shall be provided to the successful Bidder by Client/ EIL to the extent possible.

11.0 INSTRUMENTATION AND CONTROL SYSTEM

11.1 All instrumentation shall conform to various specifications listed under list of attachments as enclosed in the enquiry documents. Vendor's scope of Instruments, controls, safety devices is detailed out in various data sheets and specifications. Vendor shall furnish all instrumentation and controls as specified and shall meet the requirements as detailed out in the instrument specifications, requirements as enclosed.

11.2 Operation Philosophy

11.2.1 During regular operation, control of Compressor shall be from Central Control Room (CCR), however the compressor-motor shall be started manually from local panel and provision for normal stopping of the main equipment shall be provided on the Local Control Panel (LCP) (located near the main equipment). Emergency stopping shall be possible from CCR and LCP. LCP shall have indications for minimum parameters, which are required for start-up and health monitoring of machine. Also refer to Process P&IDs for instruments & controls.

11.2.2 Lube oil system shall be started and stopped manually from the local gauge boards located on the console.

11.2.3 Dry gas seal system shall be provided with local gauge board (GB), located on the operating floor.

11.2.4 For location of LCP, LGB, Anti-surge controllers, Machine monitoring system etc. refer to Instrumentation job specifications.

11.2.5 All controls and monitoring shall be done through centralized control system located in Central Control Room (Supplied by Purchaser).

11.2.6 Shut down and interlocks shall be implemented in PLC supplied by purchaser located in Satellite Rack Room. Necessary logic diagrams, write-up and other required inputs shall be provided by Vendor.

11.3 Anti-surge Control Systems for Compressors

11.3.1 Compressor shall be provided with anti-surge system including anti-surge controller, field instruments, anti-surge valve as shown in P&ID. Surge control system shall be as per specifications detailed in instrument section.

11.3.2 Vendor shall be totally responsible for any coordination with controller supplier in realizing the anti-surge control system for safe and reliable operation of the compressors.

11.3.3 The design/engineering, testing, supply and supervision of erection and commissioning of the complete system shall be in Compressor vendor's scope of supply.

11.4 Machine health monitoring through dedicated machine conditioning monitoring system

11.4.1 Machine health monitoring through dedicated machine condition monitoring system shall be included in compressor vendor's scope of supply. Vibration and temperature monitoring shall be provided as per latest edition of API 670, 4th edition and also as per Instrumentation specification elsewhere in MR.

11.4.2 Centrifugal compressors, Gearbox (Special purpose gearbox or Variable speed planetary gear mechanism) shall be provided with proximity probes / detector and monitors for measuring shaft radial vibration, axial position and bearing temperature etc. Set points for Alarm (alert) and shutdown (danger) shall be provided for each monitored variables.

11.4.3 Also refer Electrical /Instrumentation section attached to this MR.

11.5 Vibration Monitoring Instrumentation

11.5.1 Hydrodynamic radial bearings with forced feed lubrication shall be fitted with X-Y proximity probes.

11.5.2 Hydrodynamic thrust bearings shall be fitted with two numbers proximity type axial probes.

11.5.3 A key phasor is required for each speed change of shaft system for hydrodynamic bearing.

11.5.4 Also refer Electrical/Instrumentation section attached to this MR.

11.6 Temperature Monitoring Instrumentation

11.6.1 Hydrodynamic radial bearings shall be fitted with atleast two (2) temperature probes.

11.6.2 Hydrodynamic thrust bearings shall be fitted with atleast two (2) temperature probes each on active and inactive side.

11.6.3 Also refer Electrical/Instrumentation section attached to this MR.

12.0 ELECTRICAL

12.1 All electrical items for this compressor shall conform to the requirements of electrical specifications given in this requisition.

13.0 ALLOWABLE NOISE LEVEL

13.1 The allowable noise level of the whole package (driver + driven equipment train + auxiliaries) shall not exceed 85dBA. This shall be demonstrated at site & if the noise limit exceeds the specified value, the necessary arrangement to meet the noise criteria, shall be provided by vendor without any time/cost implication. Jackets for Noise attenuation around the suction and Discharge nozzles shall be supplied by the vendor if found necessary to limit noise level within specified limits

14.0 INSPECTION AND TESTING

14.1 Inspection and Testing requirements have been detailed out in Mechanical Datasheets, Specifications for various equipment and referred Codes and Standards. All tests which are marked as “Witness’ tests may be witnessed by Purchaser’s/ Consultant’s Inspector. Vendor shall submit details of all test procedures for approval by Purchaser. Rejections made by Purchaser’s inspector, based on inspection or tests shall be final. Acceptance by the inspector in no way release the vendor from guarantees as to materials, workman-ship, and performance of the equipment inspected.

14.2 The following tests being witnessed by Purchaser/ Consultant’s inspector, may also be witnessed by Purchaser/ Consultant’s Equipment Specialists:

- Mechanical Run Test of each Compressor at Compressor Manufacturer’s Works with Spare Rotor.
- Mechanical Run Test of each Compressor at Compressor Manufacturer’s Works with Main Rotor
- Performance Test of each Compressor at Compressor Manufacturer’s Works (as per ASME PTC- 10).
- Functional/ Simulation Test of Control Panel at Control Panel Manufacturer’s Works.
- Functional Test of Lube Oil Console at Lube Oil Manufacturer’s Works.

For the tests listed above the Purchaser shall be advised by the Vendor at least six (6) weeks in advance of the scheduled test date and firm date of testing shall be given by the Vendor at least one week in advance. For all other specified inspection and tests, the Purchaser shall be advised by Vendor at least four weeks in advance of scheduled test date and firm date of testing shall be given by vendor at least one week in advance.

Rotor Insensitivity Test in accordance with relevant Clause of API 617shall be demonstrated on either main rotor or spare rotor irrespective of the separation margin between critical and operating speeds. All actual critical speeds below the trip speed shall be verified during shop test

14.3 **Field trial test for 72 hours**

- Field trial test at site of the compressor package shall be done under the supervision of the vendor at per diem rates provided in offer. This test shall be done with available media and load to demonstrate guaranteed performance as specified in datasheet and safe, smooth, reliable operation & mechanical integrity of the complete package.

- During Field Trial Run Test, performance parameters (like flow, pressure, temperature, power, etc.) of centrifugal compressor shall be verified and measured as per the final contract/ PR. In addition to the above, mechanical parameters (like sound/ noise levels, vibration & temperature levels, etc. and utility consumption data (like cooling water, seal gas, power, nitrogen, BFW, etc.) of main and auxiliary equipment shall also be measured and verified during Field Trial Run Test.

- Modifications/additions/changes as required to resolve/correct any discrepancy/ fault in the package shall be in vendor's scope without any time/cost implications to the purchaser. No per diem rates shall be payable for such modifications/additions/changes.

- The duration of the test for each package shall be 72 hours on sustained continuous basis i.e. process interruptions shall be allowed to cumulate, however machine related interruptions shall not be counted.

- If any additional equipments/instruments are necessary in addition to those in vendor's scope of supply for the purpose of testing & measurement, vendor shall bring them to site duly calibrated and shall take them back after successful completion. All utility and safety systems shall be operating during the test.

14.4 Sound level test of the individual equipment shall be conducted during the mechanical run test at vendor's works. Sound level test of complete train shall be conducted during the field trial run test.

14.5 Vendor to note that tests are as specified in job specification and respective equipment data sheets. These are further elaborated in Inspection and Test Plans (6-81-0146) document attached to this MR. All the inspection and tests mentioned in the above documents shall be complied by the vendor.

15.0 PERFORMANCE GUARANTEE

15.1 Compressor performance shall be demonstrated during vendor shop performance test for ascertaining machine thermodynamic performance for rated point, guarantee point and all other operating cases.

15.2 Tolerance (including instrument & measuring tolerances) at Rated point shall also be as specified below:

(a) Head & capacity shall have zero negative tolerance
(b) BKW shall have zero positive tolerance
(c) Estimated Speed at rated point shall have tolerance as per Cl. No. 6.3.3.1.4 of Part-2 of Standard Specification No. 6-42-0005

15.3 Guarantee point for the purpose of Loading & Penalty shall be Rated flow (Design case) as specified in Loading & Penalty Criteria (Doc. No. B269-454-80-42-LP-5155). Head and capacity shall have zero negative tolerance at Guarantee point. Vendor shall guarantee compressor power value (BKW_G in KW) with zero per cent positive tolerance (i.e. no API tolerance is permitted) including all losses, errors in instruments and measurement, at the guarantee point.

15.4 Head and capacity shall have zero negative tolerance at all operating points.

16.0 INITIAL FILL

16.1 The initial fill of lubricants, sealing fluid & other consumables shall not be included in the scope of supply of compressor vendor. However, vendor shall furnish list of recommended IOCL OR EQV make oils for bearing lubrication & flushing oil, seal pot buffer Liquid (as applicable).

17.0 SPARE PARTS/ SPECIAL TOOLS & TACKLES

17.1 Mandatory Spares

Mandatory spares shall be as per attached Doc. No. # B269-454-80-42-SL-5155. Vendor shall quote for the mandatory spare parts as specified in the inquiry document. Cost of mandatory spares shall not be included in the base price of the equipment.

17.2 Erection & Commissioning spares

Vendor's scope of supply shall include all erection & commissioning spares (mechanical, electrical and instrumentation) for the compressor package as deemed necessary by vendor. The same shall be included in the base price of each compressor package. Vendor shall provide the list during detail engineering stage for review. Any spares required over and above these spares, during commissioning, shall be in Vendor's scope of supply and the same shall be supplied without any time and cost implication. Any un-used commissioning spares shall be retained at purchaser's end.

However, vendor to include as a minimum lube oil filter and seal gas filters as commissioning spares.

17.3 Special tools and tackles

Vendor's scope of supply shall include supply of all special tools and tackles required for erection, site assembly, commissioning and complete and easy maintenance of the compressor package. The same shall be included in the base price of each compressor package.

However, as a minimum, tools for seal and bearing removal, hydraulic assembly/disassembly device for coupling & thrust collar with low pressure and high pressure pumps & power tools required for all bolts greater than 32 mm diameter are part of vendor's scope of supply.

17.4 Two years operation & maintenance spares

Vendor shall furnish an itemised list of recommended spare parts with unit prices for two years normal and continuous operation of the complete compression unit (including mechanical, electrical and instrumentation spares), required over and above the mandatory spares.

18.0 SUPERVISION OF ERECTION AND COMMISSIONING

The vendor shall provide his services for supervision during erection and commissioning of the compressor package. Vendor's Electrical & Instrumentation engineers shall also be present along with vendor's erection and commissioning engineers, as required. The

supervisory cost of 60 man days for the Compressor package shall be considered for purpose of commercial comparison (which the vendor may decide between days for Indian/Foreign supervisors and also discipline wise, in case separate rates for different supervisors are to be quoted, number of days for each supervisor must be quoted by vendor. However total man days are fixed, as indicated above, for commercial comparison). The vendor shall indicate in his proposal the cost of providing the above services on per diem basis. However, the actual payment for supervision of erection & commissioning shall be based on actual man days consumed at site for carrying out these activities.

19.0 PARTICIPATION OF PURCHASER'S ENGINEERS DURING ASSEMBLY AND OTHER IMPORTANT ACTIVITIES

19.1 Purchaser may depute his engineers at the vendor's shop during the time of rotors assembly, balancing of rotors, performance test, main assembly of compressor and such other important activities which may be required to be performed during maintenance of machines and the associated system. The purchaser's engineers deputed in the vendor's shop shall participate in the assembly operation and other activities and shall maintain records of all the data like tolerances, clearances etc. Vendor shall have to provide all such data and records to the purchaser's engineers. Vendor shall submit a list of activities in which such participation shall be useful for future maintenance work, along with the time period of each activity and the schedule when these activities are likely to be performed.

20.0 HAZOP PARTICIPATION

20.1 Bidder shall participate during HAZOP study of the compressor package. Bidder shall indicate the cost of providing the above services on per diem basis. Cost for HAZOP participation for 3 man days for the compressor package shall be added to the total cost of the package for commercial evaluation purpose. However, the actual payment for HAZOP participation shall be based on actual man-days participated by bidder. Any suggestions/ modifications raised during HAZOP review shall be implemented by bidder without any cost/time implication to the purchaser. Bidder to note that such changes shall be limited to supply of few instruments etc. and revision of documents only. However, instruments etc. essential for safety requirements, which cannot be contested by the vendor, shall be mandatorily provided and included in the scope of supply by the vendor.

21.0 3-D MODELLING

21.1 Bidder shall quote a separate lump sum cost for carrying out 3D modelling of the compressor package. Cost of the same shall be added to the total cost of the compressor package for the purpose of commercial evaluation.

22.0 CUSTOMER TRAINING

22.1 The bidder shall quote a separate lumpsum cost for carrying out training of Purchasers/owner's personnel at the site for 10 working days. The group deputed for training shall be a multidisciplinary group (comprising of process, mechanical, electrical, and instrumentation) of a maximum of 6 persons. All requisite training material like books/documents shall be provided by the vendor. Quoted lumpsum cost shall be added to the total cost of the compressor package for the purpose of commercial evaluation.

23.0 PAINTING

23.1 Painting for Centrifugal Compressor & driver shall be as per Manufacturer's Standard meeting the requirements, as applicable, specified in the 'Specification for Surface Preparation & Protective Coating', attached elsewhere in the MR. Refer Electrical, Instrumentation & Piping requirements for Painting as per the respective inputs, attached elsewhere in the MR.

24.0 PREPARATION FOR SHIPMENT

24.1 All equipment covered in the Heat pump Compressor Package shall be packed for an outside storage period of twelve (12) months.

Packaging shall be of export quality (either for domestic or export shipment) and sea-worthy (as required) to avoid damages during transportation via rail/ road/ sea.

Vendor's recommended extended storage and preservation procedure shall be furnished to Purchaser/ Owner before dispatch.

24.2 Equipment vendor to ensure the following before dispatch:

- All the openings shall be plugged & sealed condition during dispatch.
- Instruments like gauges, speed indicators, probes, oiler etc shall be removed from the main equipment and dispatched separately to avoid the damage of these components during transportation handling and erection.
- In addition to normal packing, the compressor skids shall be separately covered with transparent polythene cover with opening for piping.
- Vents shall be protected against rain etc. and shall be fitted with a screen or filter.

24.3 The spare rotor(s) for compressors and which are mechanical run tested in the job casing first, shall be separately shipped with N_2 purging and other suitable preservative measures. The compressors with performance- tested rotor shall be shipped as complete equipment with suitable protection and preservative measures.

25.0 VENDOR LIST

25.1 Refer Sub-vendor list (Doc. No. B269-454-80-42-VL-5155), attached elsewhere in the MR. Also refer the Sub-vendor list of electrical and Instrumentation discipline.

26.0 DRAWINGS AND OTHER DATA REQUIRED

26.1 The data and drawing required with the bid are detailed out under "Vendor Data Requirement (Doc. No. B269-454-80-42-VDR-5155)" and Vendor Data Required as per Electrical and Instrumentation Sections. Vendor shall ensure that complete data is furnished as required.

26.2 Over and above what is specified elsewhere, the following performance characteristics shall be furnished for compressor:

a. Discharge pressure vs Inlet capacity (i.e. actual inlet volume)

b. Polytropic head vs Inlet capacity (i.e. actual inlet volume)
c. Compressor BKW vs Inlet capacity (i.e. actual inlet volume)
d. Polytropic efficiency vs Inlet capacity (i.e. actual inlet volume)

These characteristic curves shall be furnished at min. speed, 75%, 80%, 85%, 90%, 95%, 100% & 105% of rated speed besides the operating speeds between the min. and max. governor settings for each of gas listed in compressor data sheet.

The performance shall be shown from surge limits to choke limits.

Expected surge line and surge control line (to be used for setting the instruments in anti-surge control loop) shall be shown on each performance map.
These curves shall also be furnished for various cases of operation specified in the data sheet including cases with low molecular weight & high molecular weight.

All the above performance characteristics shall be furnished for each section and also for the overall unit.

26.3 Vendor's piping and instrumentation diagrams for the compressor and auxiliary systems shall include the following:

- Process information showing flow rates, pressures and temperatures.
- All instrumentation requirements for operation showing functions range, set points etc.
- All piping sizes and equipment sizes.
- Equipment specifications e.g. exchanger duties, pump capacity and pressure etc.
- All normal operating levels and maximum high or low levels in tanks or vessels.

26.4 Any other information/ data, as required by the purchaser to carryout engineering for construction, installation and commissioning of the package shall be provided by the vendor during detailed engineering stage.

26.5 Vendor to indicate the recommended type, make and estimated quantity (litres or m3) of epoxy grout in their proposal for the erection and installation of his equipment package. Also, the same shall be indicated by the vendor in the foundation drawing.

इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम) ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

OIL SYSTEM (Scope & Attachment)

1	**GENERAL**								
2	Project: **P-25 Project, Panipat**				Job No.:	**B269**			
3	Owner:	**IOCL**			Site:	**IOCL, Panipat, Haryana**			
4	Purchaser:				Unit:	**PRU**	Unit No.:	**454**	
5	Eqpt. item no. for which Oil System is reqd.:				Service:				
6	Oil System item no.:				Mfr. of Oil System:				
7	No. of Eqpt. for which Oil System is reqd.:								
8	Applicable To	■ Proposal	☐ Purchase		☐ As Built				
9	■ Scope Option & Information specified by Purchaser		☐ Information Reqd. from & option left to vendor. Vendor to cross : the selected option.						
10									
11	**APPLICABLE DOCUMENTS**								
12	■ Local Instruments and Panel Items as per				**Instrumentation Specifications**				
13	■ Instruments Suppliers as per				**Approved Vendor List**				
14	■ Special Purpose Oil System as per				**API 614, 5th Ed. and Job Specs**				
15	☐ General Purpose Oil System as per								
16	■ Dry Gas Seal Support Modules/System as per				**Job Specification**				
17	■ Additional Documents				**Data sheets, Job Specs, EIL Specs**				
18	■ Sound level as per				**Refer Job Specification**				
19	■ Pumps as per				**API 610/676 as applicable, Data Sheets, EIL Specs**				
20									
21	■ Pump Driver (Motor) as per				**Refer Electrical Specs.**				
22	☐ Pump Driver (Turbine) as per								
23	☐ Referenced Standard as per								
24	☐ Additional Documents								
25	☐ Additional Documents								
26	**INSTALLATION DATA (Remark 1)**				**Site Data (Remark 1)**				
27	☐ General site data included in specification				☐ Ambient Condition:				
28	☐ Utility data included in specification				☐ Min./Max. Temp.(°C):				
29	☐ Space available for Oil System(LxWxH),m:				☐ Relative Humidity:				
30	■ Max. noise level not to exceed 85 dBA @ 1 meter distance.				☐ Corrosive Atmosphere:				
31	☐ Winterize	■ Tropicalize			**Utility Data (Remark 1)**				
32	■ Area Classification (**Refer Electrical Specs**)				☐ **Electrical**				
33	☐ Class				Voltage/Hertz/Phase:				
34	☐ Group				☐ **Cooling Water**				
35	☐ Division				☐ Water Source:				
36	☐ Or See				☐ Inlet Temp.(°C):				
37					☐ Max. Return (°C):				
38					☐ Pressure(Nor./Design),kg/cm²G:				
39					☐ Min. Return(kg/cm²G):				
40					☐ Max.)P(kg/cm²G):				
41	**EQUIPMENT OIL REQUIREMENT**								
42		**Normal**		**After Trip**					
43	**Lube Oil:**	Q:m^3/hr	P:kg/cm²G	Q:m^3/hr	P:kg/cm²G	☐**Steam for Drivers: HP Steam**			
44	■ Driven Eqpt.						Press.(kg/cm²G)	Temp.(°C)	
45	☐ Driven Eqpt.					Inlet: Min.			
46	☐ Driven Eqpt.					Inlet: Nor.			
47	■ Prime Mover					Inlet: Max./ Mech. Design			
48	☐ Gears					Exhaust: Min.			
49	☐ Coupling					Exhaust: Nor.			
50						Exhaust: Max./Mech. Design			
51	■ **Total:**					☐ **Steam for Heating:**			
52	**Control Oil:**						Press. (kg/cm²G)	Temp. (°C)	
53	■ Normal					Inlet: Min.			
54	■ Transient					Inlet: Nor.			
55	**Seal Oil:**					Inlet: Max./ Mech. Design			
56	☐ At:					Exhaust: Min.			
57	☐ At:					Exhaust: Nor.			
58	☐ At:					Exhaust: Max./Design			
59	☐ **Total**								
60	**Grand Total**								

61							
62	■ Oil Type & Viscosity:			**Location:**			
63	☐ Required Heat Load(kW):				■ Indoor	☐ Heated	■ Under roof
64					☐ Outdoor	■ Unheated	☐
65	■ **Preparation for Shipment:**			**Painting:**			
66	■ Install new filter and tag			■ Component supplier standard			
67	☐ Include sets of extra filter elements			☐ Unified per system supplier standard			
68	☐ Box extra sets with the system			☐ Purchaser standard per			
69	Other Parts			☐			
70	☐			☐			
71	☐			☐ **Weights (kg):**			
72	System and Components:			Console			
73		Vendor's Standard	Purch. Specification	Panel			
74	☐ Domestic	☐	☐	☐ **Dimensions (LxWxH):**			
75	■ Export	■	☐	Console			
76	■ Extended storage 12 months	■	☐	Panel			
77	Spare Parts:						
78		Vendor's Standard	Purch. Specification				
79	☐ Domestic	☐	☐				
80	■ Export	■	☐				
81	■ Extended storage 12 months	■	☐				
82							
83							
84	**Remarks**						
85	1. Refer site condition and utility data						
86							
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115	**GENERAL**									
116	Project:				Job no.:					
117	Owner:				Site:					
118	Purchaser:				Unit:			Unit No.		
119	Eqpt. Item No. for which oil system is reqd.:				Service:					
120	Oil System Item No.:				Duty:	Continuous / ~~Intermittent~~				
121	No. of units:	**One**	Working / Standby:	**One / ---**						
122	Applicable to:	■ Proposal		☐ Purchase		☐ As Built				
123	■: Scope, Option & Info specified by Purchaser. ☐:Info required from and options left to vendor. Vendor to cross (☒) the selected option.									
124	Oil system(s) for:									
125	Supplier:		Manufacturer:							
126	**Overall System Typical Schematics**			**Fig. No.**	**Option No.**	**Comments**				
127	☐ Combined lube, seal & control oil system									
128	☐ Separate seal-oil system									
129	☐ Seal Module at Equipment									
130	■ Lube / Control System			**B.10**						
131	■ Basic Oil supply module			**B.12**	**B.20**					
132	■ Lube Module at Equipment			**B.13**						
133	☐ Drawing requirements				☐ Component Review					
134	☐ Relief Valves to protect low pressure systems			☐ NO	☐ YES,	For:				
135	**SUPPLY**	**Lube Oil**	**Seal Oil**	**Combined**	**BASIC SYSTEM DETAILS**					
136	■ Separate Console	■	☐	☐	☐ Compressor Block-In time:			Minutes		
137	☐ Multiple Package	☐	☐	☐	☐ Equipment Coast-Down time:			Minutes		
138	☐ Package No. 1				☐ Equipment Cool-Off time: Driver:			Minutes		
139	☐ Package No. 2				☐ Equipment Cool-Off time: Others:			Minutes		
140	☐ Package No. 3				☐ Minimum Start-up oil temperature			^{0}C		
141	☐				■ Settling Out Pressures			kg/cm^{2}g		
142	**BASEPLATES:**				☐ Process Relief Valve settings			kg/cm^{2}g		
143	■ Point Support	☐ Grout Hole/Vent Holes			■ Shop Test Conditions					
144	☐ Epoxy Grout/Precoat				■ Field Start-up/Run-In Conditions					
145	**COMPONENTS:**				■ Other Special Conditions					
146	**Piping & Tubing:**				■ Welding & Special Fabrication Requirements					
147	■ Material	**SS304/SS316/SS321**				☐ 100% Radiography				
148	☐ Double Block & Bleeds					☐ Magnetic Particle				
149	☐ Tight Shut off					■ Liquid Penetrant				
150	☐ Tube Fittings	Mfr.:	Model:		**OIL CONDITIONERS (Remark-2)**					
151	■ Slip-on Flanges				☐ Purchaser's Item No.					
152	☐ Through Studs required				■ Service Used in	**Lube & Control Oil System**				
153	☐ Heat Tracing Reqd. by: ☐ Purchaser ☐ Vendor				■ Type	**Centrifuge**				
154	☐ Special Requirements				■ Portable, Or Mounted on	**Portable**				
155	■ Utilities manifolded to common connections				☐ Rated flow (m^3/hr) of Oil					
156	■ Air				■ Manufacturer	**ALFA LAVAL or eqv.**				
157	■ Cooling Water				☐ Model					
158	■ Other: Vents and Drains				■ Driver: For	**Electric Motor**				
159	■ Instrument Test Valves required				☐ kW & Enclosure					
160	■ Valve heads vented to Reservoir				☐ V / Ph. / Hz.					
161					☐ Water Removal Rate					
162					■ Material of Construction	**SS**				
163	**DEGASSING DRUM**				**NOT APPLICABLE**					
164	☐ Purchaser's Item No.				☐ Service Used in					
165	☐ As per Fig. No's or Other Specs.				☐ Flow Control		☐ Thermostat Control			
166	☐ Operating Temperature (EC)				☐ Material					
167	☐ Flow Rate: Normal | Max. (m^3/hr)				☐ Interior Coating		☐ Oversize Vent			
168	☐ Normal Retention Time (minutes)				☐ Vent Relief Device					
169	☐ Capacity: Normal | Max. (m^3)				☐ Omit Breather					
170	☐ Purge Gas: Type				☐ Code: Constrn.| Stamp					
171	☐ Required Flow (Nm^3/hr)				☐ Other					
172	☐ Type Heating Device				☐ Other					
173	☐ Corrosion Allowance				☐ Other					
174	☐ Design / Test Pressure (kg/cm^{2}g)									

175	☐ Other:	☐ Other:								
176	**RESERVOIR**									
177	Service Application		☐ Separate		■ Lube/Control Combined			☐ Separate Seal		
178	☐ Purchaser's Item No.									
179	■ Figure No.				**B.24**					
180	■ Include Options No.				**A, B, C, D, F**					
181	■ Heater: Steam / Electric (S / E)				**Electric**					
182	☐ Heater in Sealed Tube									
183	■ Material				**SS**					
184	☐ Normal Flow	m^3/hr								
185	☐ Free Surface	m^2								
186	■ Working Capacity	Minutes/~~Liters~~			**5**					
187	■ Retention Capacity	Minutes/~~Liters~~			**8**					
188	☐ Rundown Capacity	Liters								
189	☐ Normal Operating Range	Liters								
190	☐ Charge Capacity	Liters								
191	☐ Insulation Clips		☐		☐			☐		
192	■ Ladder with Hand-rail		☐		■			☐		
193	☐ Hand-Rails on Top		☐		☐			☐		
194	■ Non-skid Decking		☐		■			☐		
195	☐ Flanged Vent									
196	■ Oversize Flanged Vent				■					
197	☐ Pressure Relief Device: Type & Mtrl.									
198	■ Siphon Breaker		☐		■			☐		
199	☐ Top Mounted Components permitted		☐		☐			☐		
200	☐ Top Mounted Components are									
201	■ Submerged Components and Materials				No					
202	Approx. Dimensions (Tank Only): L x W X H (m)									
203										
204	**PUMPS AND DRIVERS**									
205	Service Application		☐ Lube Oil		■ Lube/Control Oil			☐ Separate Seal Oil		☐ Boost Seal Oil
206										
207	■☐ Figure No's:				**B.22**					
208	■ Including Option No's.				**A,B, C**					
209	☐ Emergency Pump System									
210	**Pump Service**	Main	Stdby	Emer.	Main	Stdby	Emerg.	Main	Stdby	Emerg.
211	☐ Pump Item No.									
212	■ Pump Type				**Screw/Cent**	**Screw/Cent**	**Screw/Cent**			
213	☐ Pump Data Sheet									
214	■ Horiz. or Vertical (H / V)				**H**	**H**	**H**			
215	☐ Driver Item No.									
216	☐ Turbine Driver for									
217	☐ Turbine Data Sheet									
218	■ Electric Motor Driver for				**Yes**	**Yes**				
219	☐ Electric Motor Data Sheet									
220	■ Other Driver: Emergency AC Electric Motor						**Yes**			
221	☐ Other Driver: Data Sheet									
222	■ Coupling Type				**Flexi metallic Spacer**					
223	☐ Booster Pumps Required									
224	☐ Booster Suction Protection									
225	■ Solenoid Trip Valve				**Yes**					
226	■ Auto Start				**Yes**	**Yes**	**Yes**			
227	■ Rotary Pump Relief Valve by ~~Purchaser~~/Vendor				**Yes**					
228	**REMARKS:**									
229										
230										
231										
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236	**COOLERS:**										
237	Service Application		☐ Lube		■ Lube / Control		☐ Sep. Seal Oil				
238	☐ Purchaser's Item No.										
239	■ Twin Units		☐		**B.20**		☐				
240	■ Include Option No's.				**A, C**						
241	☐ Water Side for Steam Heating		☐		☐		☐				
242	☐ Details on Data Sheet										
243	☐ Water Side Corrosion Allowance										
244	☐ Manufacturer										
245	☐ Model										
246	■ TEMA Class				**C**						
247	■ Fouling Factor: Water Side | Oil Side				**0.0004 / 0.0002**						
248	☐ Heat Duty	kcal/hr									
249	☐ Tube: L x OD x BWG.										
250	☐ Design | Test Pressure: Shell Side	kg/cm^2g									
251	☐ Design | Test Pressure: Tube Side	kg/cm^2g									
252	■ Code: Construction | Stamp		☐	☐	■	☐	☐	☐			
253	☐ Tube Water velocity | Capacity:	m/s | m^3/hr									
254	■ Material: Shell				**SA 516 Gr. 70**						
255	■ Material: Channel & Covers				**SA 516 Gr. 70**						
256	■ Material: Tube Sheets | Tubes				**Naval/Inhibited Adm. Brass**						
257	■ Removable Tube Bundle		☐		■		☐				
258	☐ U – Bend Tubes permitted		☐		☐		☐				
259	■ Oil Temperature Control Valve		☐		■		☐				
260	**FILTERS**										
261	Service Application		■ Lube, ☐ Seal		☐ Separate		☐ Separate		☐ Booster		☐ Separate
262			■ & Control Oil		Control Oil		Seal Oil		Pump Disch. Oil		Coupling Oil
263	☐ Purchaser's Item No.										
264	■ Twin		■								
265	☐ Second filter for Control Oil		☐								
266	■ Include Option No's.		**B.20, C**								
267	■ Filtration Level Microns (Nominal)		**10**								
268	☐ Manufacturer										
269	☐ Model										
270	☐ Design | Test Pressure kg/cm^2g										
271	■ Code: Construction | Stamp		■	☐	☐	☐	☐	☐	☐	☐	☐
272	☐ Clean / Fail) P kg/cm^2										
273	■ Material: Case & Top		**CS**								
274	☐ Material: Cartridges										
275	☐ Furnish Sets of Extra Cartridges:		☐ Per Service				☐ Per Filter (Extra over other spares)				
276	**CONTINUOUS FLOW TRANSFER VALVES**										
277	Service Application		■ Lube , ☐ Seal		☐ Separate		☐ Separate		☐ Booster		☐ Separate
278			■ & Control Oil		Control Oil		Seal Oil		Pump Disch. Oil		Coupling Oil
279	■ Separate or ~~Common~~ for Coolers & Filters		■		☐		☐		☐		☐
280	■ Tight Shut-off Reqd.		■		☐		☐		☐		☐
281	■ Type		**Two way, 6 Ported**								
282	☐ Manufacturer										
283	☐ Model										
284	☐ With Lifting Jack		☐		☐		☐		☐		☐
285	☐ Rating: kg/cm^2g										
286	■ Materials: Body		**CS**								
287	■ Materials: Plug or Ball		**SS 316**								
288	■ Materials: Trim		**SS 316**								
289											
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296	**ACCUMULATORS**				
297	Service Application	Lube Oil	Control Oil	Seal Oil	Seal Oil Booster
298	☐ Purchaser's Item No.				
299	■ Required: Yes or No & Quantity	**Yes**	**Yes**		
300	■ Service combined with	**Pump Switch Over**	**C.O. Transients**		
301	☐ Direct contact type	☐	☐	☐	☐
302	■ Bladder Type	**B.18**	**B.18**	☐	☐
303	■ Include Option No's.	**A**	**A**		
304	☐ Run-down minutes				
305	☐ Oil Temperature Control	☐	☐	☐	☐
306	☐ Constant Pressure Regulator	☐	☐	☐	☐
307	☐ Manufacturer				
308	☐ Model				
309	☐ Nominal | Usable Capacity Liters				
310	■ Material: Shell	**SS**	**SS**		
311	☐ Material: Bladder				
312	☐ Design | Test Pressure kg/cm²g				
313	■ Code: Construction | Stamp	■ ☐	■ ☐	☐ ☐	☐ ☐
314	■ Include: Charge Pressure Gauge plus	■	■	☐	☐
315	■ Manual Charge Valve or	■	■	☐	☐
316	■ Gas Supply Regulator	■	■	☐	☐
317	**OVERHEAD TANKS**				
318	Service Application	Rundown Lube	Low Press. Seal	Med. Press. Seal	High Press.
319	■ Figure No.	**B.15**			
320	■ Required: Yes or No	**Yes**			
321	☐ Service combined with				
322	☐ Direct Contact Tank	☐	☐	☐	☐
323	☐ Bladder Type	☐	☐	☐	☐
324	☐ Include Option No's.				
325	☐ Capacity minutes / Liters				
326	☐ Blowdown Connection				
327	**Rundown tanks (Fig. No.)**	**B.15**			
328	**Overhead tanks (Fig. No.)**				
329	☐ Corrosion Allowance				
330	■ Material	**SS**			
331	☐ Total Capacity Liters				
332	☐ Design | Test Pressure kg/cm²g				
333	■ Code: Construction | Stamp	■ ☐	☐ ☐	☐ ☐	☐ ☐
334					
335	**ACCUMULATOR UNITS (AS APPLICABLE)**	Rundown Lube	Low Press. Seal	Med. Press. Seal	High Press.
336	☐ Purchaser's Item No.				
337	☐ Corrosion Allowance				
338	☐ Manufacturer & Quantity				
339	☐ Model				
340	☐ Material: Shell				
341	☐ Material: Bladder				
342	☐ Nominal | Usable Capacity Litres				
343	☐ Design | Test Pressure kg/cm²g				
344	☐ Code: Construction | Stamp	☐ ☐	☐ ☐	☐ ☐	☐ ☐
345	**TRAPS FOR INNER SEAL OIL (Oil Seals) AS APPLICABLE**				
346	☐ Service Application	Low Pressure Seal Oil	Med. Pressure Seal Oil	High Press. Seal Oil	
347	☐ Purchaser's Item No.				
348	☐ Seal - Gas Vent Piping Arrangement				
349	☐ Float Controlled	☐	☐	☐	
350	☐ Transmitter Controlled	☐	☐	☐	
351	☐ Pots only, For Manual Drain	☐	☐	☐	
352	☐ With: Valving	☐	☐	☐	
353	☐ Flush Level Glass	☐	☐	☐	
354	☐ High Level Switch	☐	☐	☐	
355	☐ Include Option No's.				
356	☐ Retention: Hours				

357	**FLOAT TRAP (AS APPLICABLE)**	Low Pressure Seal Oil		Med. Pressure Seal Oil		High Press. Seal Oil	
358	☐ Manufacturer | Model						
359	☐ Pressure Rating						
360	☐ Material: Body						
361	☐ Material: Float | Trim						
362	☐ Drain Line piped to:						
363	**DRAIN POT (AS APPLICABLE)**						
364	☐ Corrosion Allowance						
365	☐ Material						
366	☐ Design | Test Pressure						
367	☐ Code: Construction | Stamp	☐	☐	☐	☐	☐	☐
368	☐ Drain Line piped to:						
369	**MIST ELIMINATOR (AS APPLICABLE)**						
370	☐ Corrosion Allowance						
371	☐ Material: Shell						
372	☐ Material: Demister Mesh						
373	☐ Design | Test Pressure						
374	☐ Code: Construction | Stamp	☐	☐	☐	☐	☐	☐

375	**INSPECTION & TESTING**			
376	**SHOP TESTS:**	Required	Witnessed	**SHOP INSPECTION:**
377	■ Cleanliness	■	■	☐ Compliance with Inspector's Checklist
378	■ Four Hour Run	■	■	■ Required for System Assemblies
379	■ Check Controls	■	■	■ Cleanliness prior to closure
380	■ Changeovers: Coolers / Filters	■	■	■ Required for Major Components
381	■ One & Two Pump Operations	■	■	■ Material Certifications to be furnished
382	■ Sound Level	■	■	☐ Special Examinations
383	■ Hydro test Assembled System	■	■	■ Code Construction / ~~Stamp~~ **ASME**
384	☐ Use for Complete Unit System Test	☐	☐	■ Supply Certified copies of all Test Logs and Data
385	■ Certf. copies of all test logs & data	■	☐	☐
386	■ functionality test of complete system	■	■	☐
387	☐	☐	☐	☐
388	☐	☐	☐	☐
389	☐	☐	☐	☐
390	☐	☐	☐	☐

391	**REMARKS:**
392	1) For instrumentation requirements also refer Instrumentation Data Sheet
393	2) The portable lube oil conditioner shall be suitable for conditioning of the complete quantity of lube oil reservoir in 12 hours.
394	3) Vendor shall fill separate Data Sheet for each compressor and submit the same during detailed engineering stage.
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Date	**Rev**	**Job Engineer**	**Rev. & Approved By**

इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम)
ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

Lube Oil Pump (Horizontal-Centrifugal)

Document No.
B269-454-80-42-DS-5155-010
Rev-A

1	**GENERAL**											
2	Project:	**P-25 Project, Panipat**			Job No.:	**B269**						
3	Owner:	**M/s IOCL**			Site:	**IOCL,Panipat,Haryana**						
4	Purchaser: .				Unit:	**PRU**	Unit No: 454					
5	Item No.:				Service:	**Main/ auxiliary/ Emergency oil pump**						
6	No. Reqd.:	Working:	Standby:		Parallel Operation Required:	☐ Yes	■ No					
7	Applicable to	■ Proposal	☐ Purchase		☐ As Built							
8	■ Scope option & Information specified by purchaser ☐ Information Reqd. from & option left to vendor. Vendor to cross ☒ the selected option.											
9	Driver: Working		Standby		Driver Supplied & Mounted By:	■ Pump Mfr.	☐ Other					
10	**OPERATING CONDITIONS**											
11	Liquid Handled	**Lube Oil**			Capacity (m^3/hr): Min/Nor/Rated:							
12	Pumping Temp. (˚C):	Normal		Max.		Discharge Pressure (kg/cm²,A):						
13	Specific Gravity at P.T./15°C:				Suction Pressure: Nor./ Max. (kg/cm²,A):							
14	Vapour Pressure at P.T. (kg/cm²,A):				Diff. Pressure (kg/cm²) @ Rated Capacity:							
15	Viscosity at P.T. (cP/~~cst~~):		Corr./Eros. By:		Diff. Head (m) @ Rated Capacity:							
16	Solids in suspension	☐ Yes	☐ No	Size:	%	NPSH Available (m):						
17	**MANUFACTURERS SPECIFICATIONS**											
18	Pump Manufacturer:				Model No.:							
19	**CONSTRUCTION**				**PERFORMANCE**							
20	Casing Mounting:	■ **Centerline**	☐ Foot	☐ Inline	Proposal Curve No.							
21	Casing Split:	☐ Axial	■ Radial		Visc. Corr. Factor:	C_0		C_Q		C_H		
22	Type:	☐ Single Volute	☐ Double Volute	☐ Diffuser	NPSH Reqd. (Water) (m):		F/L Speed (rpm):					
23	Casing Connection:	■ Vent	■ Drain	☐ Gauge	No. of stages:		Efficiency (%):					
24	Nozzles	Size	ANSI Rating	Facing	Position	Rated BKW(0% Tol.):	kW	Max.BKW rtd. Imp.:				
25	Suction		**300#**			BKW @ MCF(Δ=1.0):	kW	Rec. Driver Rating: (kW)				
26	Discharge		**300#**			Max.head rtd imp.(m):		Cap@ BEP(m³/hr):				
27	Imp. dia.(mm)	Max:		Rated:		Min:		Type:	**Closed**	MCF (m³/hr):Stable		Thermal	
28	Brg.: Type/No. Radial:	Thrust:	Lub: **Oil**		M.A.W.P @ °C /P.T./Design Temp.(kg/cm²,G):							
29	Cplg.:Make/Type:		**Fleximetl w spacer**	Nonspark Guard	■ Yes	☐ No	Hydrostatic Test pressure (kg/cm²,G):					
30	Driver Half cplg. mounted by:	■ Pump Mfr.	☐ Others		Rotation facing coupling end:	☐ CW	☐ CCW					
31	Packing Type:		Size:		No. of rings:		Seal flush/ Quench plan:	**11/61**	Material:			
32	Mech. Seal: Make		Model:		API Code:	C2A1A1161	Ext. seal flush fluid:		LPM:	@	Kg/cm²G/	EC
33	Base Plate Drain Rim Type :	■ Yes	☐ No	Fdn. Bolts:	■ Yes	☐ No	Seal Barrier fluid:		LPM:	@	Kg/cm²G/	EC
34	Throat Bush:	■ Yes	☐ No	Matl.:	Bal. Device:	☐	☐ No	Ext. quench fluid:		LPM:	@	Kg/cm²G/	EC
35	Materials (API-610 Matl. Class):	**S-8**	MOC	ASTM Grades	C.W. Plan :		LPM:	@	Kg/cm²G/	EC		
36	I - Cast Iron (Ductile)	Casing	**S**		Weight(kg): Pump+Base+Coupling:		Driver:					
37	B – Bronze	Impeller	**L**		**AUXILIARY PIPING INTERFACE CONNECTIONS**							
38	S - Carbon Steel	Inner Case parts			(All interface conn.shall be termntd.with a flng. block valves)							
39	C - 11-13% Chr. Stl.	Sleeve Packed	**---**			**Size**	**Rating(ANSI)**	**Facing**				
40	h – Hardened	Sleeve Seal	**L**		Lantern Ring Inlet/Outlet							
41	f – Faced	Casing ring	)H-BHN	**Lhf**		Ext. Seal flush fluid Inlet/Outlet						
42	K -SS 304	Impeller ring	50(min)	**Lhf**		Seal Quench fluid Inlet						
43	L -SS 316	Shaft	**X**		Seal pot vent/ drain							
44	X - AISI 410	Throttle Bush			Casing vent/ drain							
45	Y	Throat Bush	**L**		C.W Inlet/ Outlet							
46	Z	Balance Drum			Base plate drain (only flanged)							
47	■ Driver suitable for Pump starting with open Disc. Valve condition.				Casing steam jacket							
48	**INSPECTION & TESTS (EACH PUMP)**											
49		Witness	Observe		Witness	Observe						
50	■ Shop Test / Inspection	☐	☐	■ NPSH As Reqd. ☐ ■ Per Spec. ☐ Mandatory	☐	☐						
51	■ Material Certificates	☐	☐	■ Dismantle Insp. & Re-assembly after Test	☐	☐						
52	■ Hydrostatic	☐	☐	■ Unitisation/Dimensional Check	☐	☐						
53	■ Performance/Sound Level	☐	☐	■ Check for direction of rotation of pump & driver.	☐	☐						
54	**Applicable Specification: Job Spec & API Std. 610, 11 th Edition**											
55	**REMARKS:-** 1) Max. allowable casing working pressure shall not be less than ________ kg/cm²g @ ___˚C.											
56	2) Down Stream Design Pressure is ____kg/cm²g. Maximum shut-off, considering max suction pressure, including all tolerances shall not exceed this value.											
57	3) Both main & standby pump shall be identical in design, construction, speed,etc.											
58	4) Vendor shall fill in all the data for LOP & submit to EIL approval during detailed engg. stage											

DATE	**REV**	**JOB ENGINEER**	**REV. & APPROVED BY**

1	**GENERAL**																
2	Project:	**P-25 Project, Panipat**								Job No.:	**B269**						
3	Owner:	**IOCL**								Site:	**IOCL, Panipat, Hrayana**						
4	Purchaser:									Unit:	**PRU**				Unit No: 454		
5	Item No.:									Service:	**Lube Oil Cooler for Compressor**						
6	No. Regd:	**Two**	Working:	**One**	Standby:	**One**											
7	Applicable to:		■ Proposal		☐ Purchase					☐ As-Built							
8	■: Scope, Option & Info specified by Purchaser. ☐: Info required from and options left to vendor. Vendor to cross (☒) the selected option.																
9	Size			Type						Horiz / ~~Vert~~					Connected in parallel/in series		
10	Surface per unit		m²	Surface per shell		m²				Shell per Unit: **One**					No. of Units: **Two**		
11	**PERFORMANCE OF ONE UNIT –**																
12				**Shell side**						**Tube side**							
13	Fluid circulated		kg/hr	**LUBE OIL**						**COOLING WATER**							
14	Total fluid entering		kg/hr														
15	Vapour		kg/hr														
16	Liquid		kg/hr														
17	Steam		kg/hr														
18	Non Condensables		kg/hr														
19	Fluid Vapourised or Condensed		kg/hr														
20	Steam Condensed		kg/hr														
21	Gravity - Liquid			In			Out										
22	Viscosity - Liquid		cP	In			Out										
23	Mol. Weight - Vap. / Non cond.																
24	Enthalpy / Latent Heat		kcal/kg														
25	Specific Heat		kcal/kg ^{0}C	In			Out										
26	Thermal Conductivity		kcal/hr m	Out													
27	Operating Temperature		^{0}C	In			Out			In:			Out:				
28	Operating Pressure		kg/cm²,g	In			Out			In:			Out:				
29	No. of passes per shell																
30	Velocity		m/sec							Min / Max / Design:							
31	Pressure Drop		kg/cm²	All.			Calc.			All.			Calc.				
32	Fouling Resistance		hr m² ^{0}C/kcal	**0.0002**						**0.0004**							
33	Heat Exchanged		kcal/hr							Weighted M.T.D. (corrected)							
34	Transfer Rate Service (kcal/hr m²EC)		Clean:							Dirty:							
35	**CONSTRUCTION (Of One Shell)**																
36	Design Pressure		kg/cm²,g														
37	Test Pressure		kg/cm²,g	**As per Code**						**As per code**							
38	Design Temperature		^{0}C				T/Sht.										
39	No.of Tubes:		OD(in)(mm)		BWG min. thk.(mm):			Length(in)(mm):			Pitch (in)(mm)						
40	Shell		OD		ID			Long Baffle: ☐ Yes ☐ No			Sealing Strips: ☐ Yes ☐ No						
41	Baffles		Pitch(mm)		%Cut	Dia		Area		Vert./Horiz./45E	Impinging Plate: ☐ Yes ☐ No						
42	**MATERIALS (According to ASTM)**				**Gasket**			**Nozzle**	**Shell Side**					**Tube Side**			
43		XR	SR						No.	N	Series & Type			No.	N	Series & Type	
44	**Shell**	S	N	CS				**In**	**1**		**150#, WNRF**			**1**		**150#, WNRF**	
45	**Shell Cover**	S	N	CS				**Out**	**1**		**150#, WNRF**			**1**		**150#, WNRF**	
46	**Channel**	S	N					**Vent**									
47	**Channel Cover**	S	N					**Drain**									
48	**Flt. head cover**	S	N														
49	**Shell Cover**	Bolt-ing & nuts				Shell side (mm)	Tube side (mm)										
50	**Shell Channel**																
51	**Floating Head**							Test Ring: ■ Yes ☐ No						Test Flange: ☐ Yes ■ No			
52	**Channel Cover**				IT			Tube to Tube sheet joint:						☐ Welded ■ Expanded			
53	**Baffles/Tube Sprts**							**Weights**	**Bundle**		**Empty**			**Full of Water**			
54	**Tube Sheet**			Naval/Inhibited Adm. Brass				**(kgs)**									
55	**Tubes**			Naval/Inhibited Adm. Brass				**APPLICABLE SPECS.: TEMA- C; ASME Sec. VIII Div.1**									
56	Legend: **SR**: Stress relief; **XR**: Radiography; **IT**: Insulation Thickness; **CA**: Corrosion Allowance; **S**: Spot; **N**: Nil																
57	REMARKS: 1. Shell Side Pressure test shall be done with oil. 2) LOC shall have 20% spare heat transfer area.																
58	3. Acceptable tube sizes shall 20mm ODx 2 thk/ 25mm ODx 2.5thk. 4. Refer Site and Utility Data attached elsewhere in MR.																
59	5. The design pressure of low pressure side shall be as a minimum 10/13 times of the design pressure of the high pressure side.																
60	6. Further the low pressure piping upto the isolation valve shall also be designed for 10/13th of the design pressure of the high pressure side.																
61																	

Date	**Rev**	**Job Engineer**	**Rev. & Approved By**

LIST OF
MANDATORY SPARE PARTS

PROJECT	:	**EPCM SERVICES FOR CAPACITY EXPANSION OF PANIPAT REFINERY (P25 PROJECT)**
UNIT NO.	:	**454(PROPYLENE RECOVERY UNIT)**
CLIENT	:	**M/s IOCL, PANIPAT REFINERY**
EPCM	:	**M/s ENGINEERS INDIA LTD.**
JOB NO.	:	**B269**

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
A	25.10.2021	Issued with MR	MKY	MG	TK

GENERAL NOTES:

The vendor shall note the following and include the Mandatory Spares accordingly in his scope.

a) Mandatory spares shall consist of the Spares as listed below.
b) The word 'Set' means the quantity required for full replacement of that part in one machine.
c) The vendor shall quote for all the mandatory spares as defined below & as applicable to the proposed design of the equipment. In case, any spare which is listed in the table but not applicable due to specific construction/design of the equipment, the same shall be highlighted as 'Not Applicable' against that spare supported with proper technical explanation.
d) Spare part shall be identical in all respects to the parts fitted on the main equipment, including dimensions, material of construction, and heat treatment.
e) Spare rotors shall be boxed in a metal container for vertical storage with nitrogen purging. Storage container shall be property of the owner. Storage metal container shall be provided with Pressure Indicator & Nitrogen cylinder for ensuring recommended positive pressure so as to cater transit requirements.

1. MECHANICAL MANDATORY SPARES

ITEM	*SPARE PART*	*Quantity Required (BASED ON THE NUMBER OF INSTALLED ITEMS)*				
		1	**2**			**Notes**
A	**Compressor**					
1	Set of dynamically balanced rotor(Having container for vertical facility with nitrogen atmosphere)	1				
2	Complete dry gas seal cartridge **(DE + NDE)**	1				
3	Set of all Bearings **(DE + NDE)**	1				
4	Set of Labyrinths/carbon rings **(DE + NDE)**	1				
5	Lube oil Filter cartridge / element					400% of Installed Qty.
6	Dry gas Seal Filter cartridge / element					400% of Installed Qty.
B	**Lube Oil Pump Centrifugal (Main + Stand By)**					
1	Set of shaft & impeller	1	1			
2	Set of mechanical seals	1	1			
3	Set of Bearings	1	1			
4	Set of Casing Wear Rings	1	1			
5	Set of Impeller Wear Rings	1	1			
6	Set of throat bush	1	1			
7	Set of Gaskets	1	1			
8	Set of O'- rings	1	1			
	Emergency Oil Centrifugal Pump					
1	Set of shaft & impeller	1				
2	Set of mechanical seals	1				
3	Set of Bearings	1				
4	Set of Casing Wear Rings	1				
5	Set of Impeller Wear Rings	1				
6	Set of throat bush	1				
7	Set of Gaskets	1				
8	Set of O'- rings	1				

ITEM	*SPARE PART*	*Quantity Required (BASED ON THE NUMBER OF INSTALLED ITEMS)*				
		1	**2**			**Notes**
C	**Positive Displacement Pumps(Rotary), as applicable**					
1	Set of rotor assembly	1				
2	Set of mechanical seals	1				
3	Set of Bearings	1				
D	**Special Purpose Gearbox**					
1	Set of Bearings	1				
2	Complete set of High speed and Low speed gear assembly	1				
3	Bushes/Gaskets (as applicable)	1				
E	**Variable speed planetary gear mechanism**					
1	Set of Bearings	1				
2	Complete set of High speed planetary gear assembly	1				
3	Bushes/Gaskets (as applicable)	1				
4	Lube oil filters					400% of Installed Qty.
5	Special grade oil (if applicable)					
F	**Special Purpose Coupling**					
1	Set of Coupling Shim Membranes	1				

2. ELECTRICAL MANDATORY SPARES

Sl. No.	Item Description	Quantity
1.0	**66kV/*kV Power Transformer**	**one set of spare for each transformer**
1.1	Complete set of gaskets	1 set
1.2	Sealing / Gauge glass of Conservator	2 Nos of each rating & type
1.3	Control fuses / MCB for MB cubicles	20% for each rating OR 1 No. (min.) of each rating, whichever is more
1.4	Online Moisture Removal System	1 Nos. – Refer Electrical Job Specification (B269-454-16-50-SP-5155)
1.5	Primary side bushing	1 Nos.
1.6	Secondary side bushing	1 Nos.
1.7	Neutral side bushing	1 Nos.
2.0	**HV Switchboard (one set of spare for each rating & type)**	**one set of spare for each rating & type**
2.1	Closing Coil	1 No. of each rating and type
2.2	Shunt tripping coil	1 No. of each rating and type
2.3	Control fuses/MCB	10 Nos. each rating and type
2.4	Indicating lamp covers	5 nos. of each colour
2.5	Indicating lamps	20% or 3 Nos. (min) whichever is more
2.6	Ethernet switches	1 No. of each type
3.0	**Relays for Switchboard**	**One set of spare for each Switchboard**
3.1	Protection Relays	1 No. of each type
3.2	Auxiliary Relays	1 No. of each type
4.0	**Synchronous motors (one set of spare for each rating & type)**	
4.1	Power fuses	20% for each rating OR 1 no. (min.) of each rating, whichever is more
4.2	Control fuses / MCB	10 Nos. of each rating & type
4.3	Bearing (DE & NDE) (as applicable)	1 set
4.4	Control cards	1 No. of each type
5.0	**HV induction motors (one set of spare for each rating & type)**	**one set of spare for each rating & type**
5.1	Bearing (DE & NDE) (as applicable)	1 set
5.2	Terminal studs/bushing assembly	1 set each
6.0	**MV induction motors 37 kW & above**	**one set of spare for each rating & type**
6.1	Bearing (DE & NDE)	1 set
6.2	Terminal studs/bushing assembly	1 set each
7.0	**Variable Frequency Drive (one set of spare for each VFD)**	**Quantity is per VFD**
7.1	Transistors / IGBT / IGCT	1 No of each rating & type
7.2	Control cards	1 No of each type
7.3	Power supply cards	1 No of each rating & type

7.4	Power fuses	20% for each rating OR 1 no. (min.) of each rating, whichever is more
7.5	Control fuses / MCB	10 Nos. of each rating & type
7.6	Contactors	10% of each type OR 1 no. (min) of each type, whichever is more
7.7	Indicating lamps	20% OR 1 nos. (min.), whichever is more
7.8	Indicating lamps covers	2 nos of each colour
7.9	Blocker Diode	2 nos. of each rating & type
8.0	**V/F controlled soft starter (one set of spare for each soft starter)**	**Quantity is per Soft starter**
8.1	Transistors / IGBT / IGCT	1 No of each rating & type
8.2	Control cards	1 No of each type
8.3	Power supply cards	1 No of each rating & type
8.4	Power fuses	20% for each rating OR 1 no. (min.) of each rating, whichever is more
8.5	Control fuses / MCB	10 Nos. of each rating & type
8.6	Contactors	10% of each type OR 1 no. (min) of each type, whichever is more
8.7	Indicating lamps	20% OR 1 nos. (min.), whichever is more
8.8	Indicating lamps covers	2 nos of each colour
8.9	Blocker Diode	2 nos. of each rating & type

NOTES:

a) The word ‘TYPE’ means the Make, Model no., Type, Range, Size/ Length, Rating, Material as applicable.

b) The terminology used under 'Item Description' is the commonly used name of the part and may vary from manufacturer to manufacturer.

c) Mandatory spares as indicated above do not cover commissioning spares.

d) Mandatory spares as indicated above do not cover two year O&M spares.

e) Mandatory spares shall be applicable for electrical items of sub-packages as per mandatory spares philosophy specified elsewhere in the bid document.

3. INSTRUMENTATION MANDATORY SPARES

The vendor shall note the following and include the Mandatory Spares accordingly in his scope.

a) Mandatory spares shall consist of the Spares as listed below.
b) The word 'Set' means the quantity required for full replacement of that part in one machine.
c) The bidder shall include all the specified mandatory spare parts in the base price. The mandatory spares shall be as defined below & as applicable to the proposed design of the equipment. In case, any spare which is listed but not applicable due to specific construction/design of the equipment, the same shall be informed during detailed engineering with proper technical explanation.
d) Spare part shall be identical in all respects to the parts fitted on the main equipment, including dimensions, material of construction, heat treatment etc.

	INSTRUMENTATION			
	Mandatory spares shall be quoted and included in base price as follows:			
1	**FIELD INSTRUMENTS**			
1.1	Pressure Gauges/Differential Pressure gauge (Normal/Diaphragm type/ Capillary type/Seal type)	20% (Subject to minimum 2) of each type, range, MOC and rating		
1.2	Transmitters for Pressure, Flow (DP), Level(DP),Differential pressure(DP) and Temperature	20% (subject to minimum of 2) of each type, range, make and material of construction.		
1.3	Level Gauge	a) For transparent gauges, 20% of illuminators with holder and reflector and 20% of bulbs		
		b) In case of magnetic type level gauges, 20% of bi-color rollers for each gauge to be provided in addition to above.		
		c) 20% subject to minimum two number of glass of each type, size along with pair of Gaskets (Cushion & Wet Gaskets),		
1.4	3 Way manifold , Hook ups	10% (subject to minimum of 1) of each type, size and material of construction.		
1.5	Displacer Type Level Transmitters	a) Displacer and chain for each transmitters-10% (subject to minimum of 1) b) 10% (subject to minimum of 1) of Head assembly (including electronics, torque tube, pull rod, gasket spindle for mechanical zero adjustment) for each type, range and make.		
1.6	Radar Level Transmitter	a) a) 10% or minimum one number probe / antenna for each level instrument b) 10 % or minimum one number of electronic card of each type c) 2 number fuses against each instrument		
1.7	Temperature Element: Thermocouple	20% (subject to minimum of 2) of each type, range, length of Thermocouple with Thermo well		
1.8	RTDs	20% (subject to minimum of 2) of each length of RTD with Thermo well.		
1.9	Variable Area Flow meter (Rota meters)	20% or minimum one no. (Complete set) for each type, size, rating and material.		
1.10	Copper tube	10% of installed quantity of each size.		
1.11	SS tube	10% of installed quantity of each size		
1.12	Instrument Signal Cable (single pair/ triad & multi pair/triad)	10% of installed quantity of each type and size		
1.13	FF cables (Spur & Trunk)	10% of installed quantity of each size		
1.14	Thermocouple extension cable	10% of installed quantity of each type and size		
1.15	Control cable and power cable	10% of installed quantity of each type and size		
1.16	Terminal blocks	10% of installed quantity of each size		
1.17	Steam Trap	10% of installed quantity of each size		
1.18	I/P Converter	10% of installed quantity		
1.19	Fittings/Lugs/Nipples/ Sockets/blinds/Unions	10% of installed quantity of each type and size		
1.20	½", 3/4", 1 " Valves used for instruments (Ball, Needle, Gate, Globe)	10% of installed quantity of each type		

1.21	Guided wave Radar Level Instrument	10% or minimum one number of full set of transmitter
2.0	**In-line Instruments**	
2.1	Control Valves	a) 20 % or minimum 2 nos of each type(for flashing, low noise and anti cavitation) , size, rating of Trim set consisting of seat, seat ring / seal ring, plug with stem, cage (wherever applicable) b) 20% (subject to minimum of 2) of Positioners (Smart) with links of each type and make. c) 20% (subject to minimum of 2) of Diaphragm of each type , d) 20% (subject to minimum of 2) of Air filter regulators of each make, e) 50% (subject to minimum of 2) of Bonnet Gaskets/gland packings, piston O-rings, seal rings, bearing & liner (of butter-fly valves) for all types of valves. f) 10% (subject to minimum of 1) of any special accessories provided along with the control valve like boosters, position transmitters (wherever applicable), proximity switches, I/P converters, O rings of Piston actuators etc.
2.2	On-Off Valves	a) 20% (subject to minimum of 2) of Air filter regulators, b) One number of Seal kit consisting of O rings, gaskets, etc. against each valve. c) 10% (subject to minimum of 1) of proximity switches, d) 20% (subject to minimum of 2) of solenoid valves of each type e) 10% (subject to minimum of 1) of accessories like quick exhaust valves and temperature dependent fuses, O rings of Actuators etc.
2.3	Pressure control Valve (Self actuating valve)	a) One number of Repair kit consisting of orifice, plug, spring, gasket, diaphragm, O-ring for each valve. b) 10 % or minimum 1 nos of each type/size,rating etc. of Trim set consisting of seat, seat ring / seal ring, plug with stem, cage (wherever applicable), packing material for each valve to be provided as spare.
2.4	Orifice Plates	10% or minimum 1 of blind plates of each size, thickness and material
3.0	**Machine Monitoring system, spare philosophy:**	
3.1	Machine Monitoring System/Condition monitoring system	a) 20 % or minimum 2 nos of each type of probes (vibration, speed, displacement etc.) and transducers/proximeter/extension cables/connector protective sleeves etc.
		b) Electronic modules / cards : 10% or minimum 1 no. of each type,
		c) portable, offline measurement kits : 1 set of each type used
		d) monitor units & LCD display unit for local control panel : 10% or minimum 1 no. of each type,
		e) TDxNet cards : 10% or minimum 1 set of each type used
		f) One Calibration kit and one portable/ offline measurement kits for vibration probes for each unit wherever vibration probes are installed.

4.0	**FF Junction Box**	For FF JBs, spares FF JBs along with its all component like terminator , barrier etc shall be limited to a maximum quantity of 10% or min 2 nos.
5.0	**Other Items**	
	Pulsating dampener, Snubber, Syphon, Gauge Saver, etc.	10% (subject to minimum of 1) of each item used,
	Loop powered indicators	20% (subject to minimum of 2) of Loop powered indicators used,
	Solenoid Valves	20% or minimum 2 nos. of solenoid valves of each type used.
	MCT Block	10% of each type of MCT Block used.
	Panel mounted instruments	10% or minimum one number of each instrument
	Annunciators	a) Power Supply Module 10% subject to minimum 1 No.of each type
		b) Tone Generator Card 10% subject minimum 1 No.of each type
		c) Flasher Module 10% subject to minimum 1 No.of each type
		d) I/O Module 10% subject to minimum 1 No.of each type
		e) Lamps 10%
		f) Fuses 1 dozen per Annunciator
		g) Hooter –10% or minimum one
6.0	**Gas detection system**	Sensors : 20% or minimum 2 sets of each type, Electronic cards / modules/display : 10% or minimum of 1 set of each type used,
6.1	Fire Detection and Alarm system	Sensors : 20% or minimum 2 sets of each type,
		Electronic cards / modules/display : 10% or minimum of 1 set of each type used,
7	**PLC**	These spares are in addition to 20% installed spares. Installed spares also includes 30% spare windows in Alarm annunciator. Mandatory spares shall be calculated by vendor as per philosophy outlined below .The philosophy shall be applied after taking into account the installed spares.
7.1	**A)** Modules	a) 5% or minimum one of each hardware/module (including Controller card, IO card, Power supply card, communication cards , Field termination assemblies and any other cards/modules etc) of each type which are being used in PLC .
		b) 10 % or minimum two of all components of cabinets like Bulk power supplies(of each rating/make), Diode Oring units(of each rating/make), Auto transfer switches, barriers, signal converters, Trip amplifiers, auxiliary modules, relays, converters, annunciator cards, fuses, fused terminals, lamps/LEDs, Push buttons, selector switches , IS mV/I Converters, IS RTD/I Converters, Alarm cards (receiver switches)etc. of each type.
		c) 20% or minimum two of Prefabricated cable Set with connecting plugs for each type and length.
		d) 10 % or minimum 2 nos. of RS232/485 converters ,cables.
		e) 10 % or minimum 2 nos. of Keyboard/Mouse/Track Balls
		f) System Cabinet Air Filter 100%
		g) 20 % or minimum 2 nos. of Cabinet Cooling Fans of each type.
		h) 20% or minimum two no. of each type of Fuses, MCBs, Auxiliary relays.

		10 % or minimum 2 nos. of communication system components such as hubs, switches, routers, etc.
	B) Operator PC/Engineering console PC /Sub system PC/Printers of each type/ make/ model.	20% or minimum 2 numbers of latest version to be supplied as spare for each control room
	C) Consumables	Consumable including a) 20% or minimum two no. of each type of Printer cartridges/ Ribbon for all type of printers, Blank CD (RW), Other storage device as applicable(like magnetic cartridge tape, Floppy disc, Hard disk etc) b)Printer paper for each type of printer : 25 Rims
8.0	**Package equipment-Compressors (Hydrogen/nitrogen/PSA/ Air/other)**	a)Control room spares in line with that of PLC above b) Field Instruments(Transmitters/Switches, condition monitoring, SOVs, Control valves ,analysers ,thermocouples etc . in line with field instrument philosophy
10.0	**Installed engineering spares**	a. I/O Level- 20% Marshalling Level-20% b. Additional Power Feeder with Switch Fuse Assembly - 20% c. Additional Spare Windows in Alarm Annunciators - 30% d. All types of marshalling hardware i.e. terminals etc. - Min. 20% e. Free Space for hardware with installed DIN Rail, Base plate, backplane - Min. 20% f. Spare MCB - Min. 20% g. FF Segment pre-wired spare capacity for device per segment - 25% h. Electronic System spare channels shall be 20% i. Serial links-20% for each type. j. FF segment-20% The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals. The system shall be fully engineered considering 20% installed engineering spares including processor loading. The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals. The system shall be fully engineered considering 20% installed engineering spares including processor loading
11.0	**Spare Space**	I/O Level- 10% Marshalling Rack- 10%
12.0	**Startup and Commissioning spares**	As required as per vendor recommendation.
13.0	**Consumable spares for one year operation**	Consumable spares shall be applicable for systems like PLC, analysers / Chromatographs, Machine Monitoring systems, Local / Main Control Panels.

NOTES:- Spares shall be supplied for Instruments as applicable for the units in bidder scope of supply and work

1. Above-mentioned mandatory spares list defines the minimum requirement. Additional items as recommended by manufacturer if any shall also be considered.

2. Mandatory spares as indicated above do not cover commissioning spares.

3. Next rounded figure to be considered wherever % is specified. Example: For total 11 Nos.

Instruments with 10%> spares basis, 2 Nos. spares shall be provided.

4. The word 'TYPE' means the Make, Model no., Type, Range, Size/ Length, Rating, Material as applicable.

5. The terminology used under 'Part Description' is the commonly used name of the part and may vary from manufacturer to manufacturer.

6. For all type of analysers and gas chromatographs, calibration cylinders, carrier gas cylinders, wherever applicable to be supplied for one year operation after SAT.

7. ***Wherever complete instrument/set is considered as spare, spare quantity shall never exceed ordered/purchased quantity (for example, if ordered quantity is 1 and mandatory spare philosophy is 20% or min 2, in such cases mandatory spares quantity shall be 1 and not 2***.).

8. Wherever x% or min 1 or 2 is indicated the same shall be whichever is higher.

9. For Fibre Optic Cable 100% spare cores shall be considered. LIU shall be provided for the cable as per supplied number of cores. All cores as supplied shall be spliced connected to LIU without leaving any loose cores.

अपकेंद्रीय क्षैतिज पम्प के लिए निरीक्षण और परीक्षण योजना (विशेष प्रयोजन प्रक्रिया)

INSPECTION AND TEST PLAN FOR PUMP CENTRIFUGAL HORIZONTAL (SPECIAL PURPOSE PROCESS)

Rev. No.	Date	Purpose	Prepared by	Checked by	Convener Standards Committee	Chairman Standards Bureau
					Approved by	
4	23.05.20	REVISED AND RE-ISSUED	TV	RMR	RKS	SKS
3	20.03.14	REVISED AND RE-ISSUED	TKK	RKS	SCG	SC
2	18.06.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
1	21.01.08	REVISED AND RE-ISSUED	SMG	SS	MVKK	VC
0	23.07.02	ISSUED FOR IMPLEMENTATION	VKJ	TVD	AKB	GRR

Abbreviations:

AS	:	Alloy Steel	NPSH	:	Net Positive Suction Head
COC	:	Certificate of Compliance	PESO	:	Petroleum and Explosives Safety Organization
DFT	:	Dry Film Thickness	PMI	:	Positive Material Identification
EIL	:	Engineers India Limited	PO	:	Purchase Order
EPC	:	Engineering Procurement Construction	PQR	:	Procedure Qualification Record
EN	:	European Norms	PR	:	Purchase Requisition
HT	:	Heat Treatment	QAP	:	Quality Assurance Plan
HV	:	High Voltage	RT	:	Radiography Testing
IC	:	Inspection Certificate	Specs.	:	Specifications
IRN	:	Inspection Release Note	SQT	:	Seal Qualification Test
ITP	:	Inspection and Test Plan	SS	:	Stainless Steel
LCP	:	Local Control Panel	Temp	:	Temperature
MOM	:	Minutes of Meeting	TPI or TPIA	:	Third Party Inspection Agency
KW	:	Kilo Watt	UCP	:	Unit Control Panel
MRT	:	Mechanical Run Test	UT	:	Ultrasonic Testing
MTC	:	Material Test Certificate	VDR	:	Vendor Data Requirement
MV	:	Medium Voltage	VFD	:	Variable Frequency Drive
NDT	:	Non Destructive Testing	WPS	:	Welding Procedure Specification
			WPQ	:	Welders Performance Qualification

Inspection Standards Committee

Convener: Mr. R.K. Singh

Members:

Mr. Rajesh Sinha	Mr. Himangshu Pal	Mr. Chandrashekhar	Mr. Avdhesh Agrawal
Mr. Mahendra Mittal	Mr. R Muthuramalingam (RPO Representative)	Mr. Tarun Kumar / Mr. Mahesh Gupta, Eqpt Div	

1.0 SCOPE:

This Inspection and Test Plan covers the minimum testing requirements of Pump Centrifugal Horizontal (Special Purpose Process)

2.0 REFERENCE DOCUMENTS:

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

SL. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures / Documents**						
1.1	Pressure test, MRT, Performance test, NPSH tests, NDT as applicable, Heat Treatment as applicable, Dynamic Balancing Test of Impeller, Nozzle load test, String Test as applicable and other procedure as applicable	Documented Procedures	100%	Procedures	-	H	R
1.2	WPS, PQR,WPQ - 1) Qualification for Overlay 2) Repair welding procedures	Welding procedure Qualification, Welder parameters	100%	WPS/PQR/ WPQ Records	-	H	W- New, R – Existing (Note-3)
1.3	Pre-Inspection meeting	Verification of technical requirements as per PR/contract	100%	MOM	-	H	W/R (For <160KW) H (For >160KW)

SL. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.0	**Material Inspection**						
2.1	Incoming Material Casing, Stuffing Box, Impeller, Shaft Material, Wear rings & Bearing Housing (As applicable)	Visual & Dimensions, Chemical Properties / Physical Properties, Heat Treatment as per Specs UT for Shaft & Other Forgings and (#)Wear ring differential hardness	100%	MTC , HT Chart, Inspection Report, COC for #	H	H	R (Note-4)
2.2	Accessories- Buffer Liquid Reservoir, Barrier/Buffer Liquid Cooler, Mechanical Seal, Seal Plan Cooling (As applicable)	Pressure Test & Seal Qualification test (As applicable) for Mechanical seal, Reservoir, coolers Dynamic balancing of seal and coupling.	100%	MTC/ Inspection & Test Record, Pressure test report and COC/ SQT (if applicable) for Mechanical Seal	H	H	R (Note-4)
2.3	Piping & Hardware Items- Valves, Flanges, Pipes, Fittings, Gaskets, Fasteners, Instruments etc (As applicable)	Visual & Other Requirement as per purchase specification / Approved Documents	100%	MTC & Inspection Report	H	H	R (Note-4)
2.4	Motor / VFD (As applicable) *(supplier/sub supplier to arrange TPIA certification)	1) Type test/ Routine test of Motor, VFD & Other test requirement as per purchase specification / Approved Documents 2) MTC review 3) PESO Certificate review (As applicable)	100%	MTC & Inspection Report	H	H*	W (Note-7)
2.4.1	Combined testing of motor & VFD (As applicable) *(supplier/sub supplier to arrange TPIA certification)	1) Routine Test & Type Test 2) PESO requirement (As applicable)	100%	MTC & Inspection / Test Records	H	H*	W (Note-7)

SL. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.5	Steam Turbine (As applicable)	MRT of Turbine & & Other checks as per approved QAP (Note-8)	100%	MTC & Inspection Report / Test Records	H	H	W (Note-6)
2.6	Gear box (As applicable)	MRT of gear box & Other checks as per approved QAP (Note-8)	100%	MTC & Inspection Report	H	H	W (Note-6)
2.7	Lube Oil system (As applicable)	Functional test & Other checks as per approved QAP (Note-8)	100%	MTC & Inspection Report	H	H	W (Note-6)
2.8	LCP/UCP (As applicable)	Functional Test & Other checks as per approved QAP (Note-8)	100%	MTC & Inspection Report	H	H	W (Note-6)
3.0	**In Process Inspection**						
3.1	NDT (As applicable) for Casing, Impeller, Stuffing Box, Shaft Casing to Nozzle butt weld	Surface and Internal imperfections	100%	Test Reports, RT films & NDT report	-	H	R
3.2	Pressure test before Assembly of Pump casing (In un-painted condition) & stuffing box	Leak Tightness Check	Each Set	Inspection and Test Records	-	H	R
3.3	Impeller / Rotor assembly	Dynamic Balancing	Each Impeller / Rotor assembly	Inspection and Test Records	-	H	W - 1 per Tag R - Spare

SL. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.4	Nozzle Load test (As applicable if specified in PR)	Stiffness of base-plate and Suction/Discharge Nozzles	100%	Inspection Report	-	H	R - For existing, reports as per quoted model W - 1 per model if reports are not available
4.0	**FINAL INSPECTION**						
4.1	Testing of Pumps	1) Performance test 2) NPSH (R) (As applicable) 3) MRT for 4 hours duration (To measure Vibration Limits, Noise level, Bearing Temp Rise)	Each Pump	Inspection and Test Records, Calibration records of driver	-	H	H
4.2	Dismantle inspection of pump after performance test / MRT (4 hours)	1) Visual insp. of casing inside surface 2) Wear ring area visual Check 3) Clearance measurement 4) Examination of Mechanical seal	Each Pump	Inspection and Test Records	-	H	W
4.3	Unitization of Pump with job driver on a common job base Frame	Alignment of pump with driver and Check Direction of Rotation	Each Set	Inspection and Test Records	-	H	W

SL. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.4	Complete Unit String Test along with all accessories (As applicable)	Mechanical Performance of the Train (Vibration Limits, bearing/oil temperature, Driver parameters and controls)	Each Set	Inspection and Test Records	-	H	H
4.5	Testing of auxiliary piping (If applicable)	Leak Tightness	Each Set	Inspection and Test Records	-	H	R
4.6	Job Instruments if applicable	Compliance to PR requirements	100%	MTC & Statutory certification (As applicable)	W	H	R
4.7	Testing and Measuring Instruments	Validity of calibration & accuracy	100%	Calibration Report	W	H	R
4.8	Final Pump skid Assembly & Spares verification	Visual, Nozzle dimensions including foundation dimensions of base frame, Battery Limits Check, Overall skid completeness check and PMI Check of all SS & AS components and welds on Skid	100%	Inspection Report	-	H	H
5.0	**Painting**						
5.1	Surface Preparation & Painting of all Carbon Steel Parts of Skid	Visual Inspection for workmanship, Panting Scheme, Paint Shade, Painting DFT Check	100%	Inspection Report	-	H	R
5.2	Pickling & Passivation for Stainless Steel Parts (As applicable)	Visual Inspection for workmanship	100%	Inspection Report	-	H	R

SL. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.3	Packing & Preservation	Visual Inspection for workmanship	100%	Inspection Report	-	H	-
6.0	**Documentation & IC/IRN**						
6.1	Stamping and review of inspection documents, issue of IC	Review of documents for compliance as per PR.	100%	Inspection Certificate (IC)	-	-	H
6.2	Review of final documentation of supplier	Compilation of documents as per VDR attached with PR	100%	Dossier / Completion certificate	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (minimum 1 number of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/Standards referred there in /Job Specification /Approved Documents.
3. WPS/PQR/WPQ Shall be qualified & certified by a reputed TPIA.
4. Certifications shall be as per EN 10204 Type 3.1 except for Mechanical seal & wear ring hardness.
5. Bought out items to be procured from EIL/Client approved suppliers.
6. Third Party Inspection Certifications shall be as per EN 10204 Type 3.2 and TPIA shall be arranged by supplier.
7. Inspection Test Requirements of Motors shall be as per EIL ITP 6-81-1064 (MV Motors), 6-81-1031 (HV Motors), 6-81-1038 (MV VFDs), 6-81-1050 (HV VFDs).
8. Separate QAPs for Steam Turbine, Gear Box, Lube Oil System & Local Control Panel (LCP/UCP) and all other bought out / sub-ordered items (As applicable) shall be submitted for EIL/ TPIA review / approval.
9. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.

STANDARD SPECIFICATION

FOR

POSITIVE MATERIAL IDENTIFICATION (PMI) AT SUPPLIER'S WORKS

PROJECT : PANIPAT REFINERY EXPANSION (P-25) PROJECT

OWNER : INDIAN OIL CORPORATION LIMITED

CONSULTANT :ENGINEERS INDIA LIMITED.

JOB NO. :B269

Rev. No.	Date	Purpose	Prepared By	Checked By	Approved By
0	27-04-2020	ISSUED FOR IMPLEMENTATION	SM	CS	CS

Abbreviations:

API	:	American Petroleum Institute
AS	:	Alloy Steel
HIC	:	Hydrogen Induced Cracking
LSTK	:	Lump Sum Turn Key
NACE	:	National Association of Corrosion Engineers
PMI	:	Positive Material Identification
RTJ	:	Ring Type Joint
Sch	:	Schedule
SS	:	Stainless Steel
TPI or TPIA	:	Third Party Inspection Agency

CONTENTS

1.0 SCOPE

1.1 This specification applies to the requirements for Positive Material Identification (PMI) to be performed at the Supplier's works on Metallic Materials procured either directly by the Owner/EIL/ LSTK contractor or indirectly through the sub-Suppliers.

1.2 This specification covers the procedures and methodology to be adopted to assure that the chemical composition of the material is consistent with the material specifications as specified in purchase documents using 'Alloy Analyzer' at the time of final inspection before dispatch.

1.3 The scope of this specification shall include but shall not be limited to Positive Material Identification (PMI) to be performed on Materials listed below:

1.3.1 For alloy Steel materials as below:

- Alloy Steel Pipes including Clad Pipes
- Alloy Steel Flanges & Forgings
- Alloy Steel Fittings including Clad Fittings
- Alloy Steel Fasteners
- Alloy Cast & Forged steel valves
- Alloy Steel Instrumentation Items (Control Valves, Safety Valves etc.)
- Longitudinal Pipe & Fittings Welds.
- Gaskets (for Ring Type Joints)

1.3.2 For Carbon Steel materials as below:

- All Carbon Steel Piping items under NACE or HIC or H2or Wet Hydrogen Sulfide (H_2S), Hydrofluoric acid (HF), Sulfuric acid (H_2SO_4) services etc.
- Carbon Steel flanges and valves (Rating 900# and above)

Following items shall be excluded from scope of PMI examination.

- Gaskets other than for Ring Type Joints
- Internal Components of Valves

1.4 All grades of material supplies including Stainless Steels shall be liable for PMI test at site. In case of any defective materials being found at site, the Supplier shall be responsible to effect replacement of such defective materials at project site without any delays to the satisfaction of EIL site RCM (Resident Construction Manager).

2.0 REFERENCE DOCUMENTS

2.1 API Recommended Practice 578 (First Edition, May 1999) - Material Verification Program for New and Existing Alloy Piping Systems.

3.0 DEFINITIONS

3.1 **Supplier:** Any Supplier or Manufacturer on whom an order is placed for the supply of referred items. This definition shall also include any sub-Supplier or manufacturer on whom a sub-order is placed by the Supplier.

3.2 **Inspection Lot:** A group of items offered for inspection covered under same size, Heat and Heat treatment lot.

3.3 **Alloy Material:** Any metallic material (including welding filler materials) that contains alloying elements such as Chromium, Nickel, Molybdenum or Vanadium, which are intentionally added to enhance mechanical or physical properties and/or corrosion resistance.

4.0 PMI EXAMINATION

4.1 The Supplier shall submit a procedure of PMI to comply with the requirements of this Specification. Approval of PMI Procedure shall be obtained from Owner/EIL/TPIA prior to commencing manufacture/ inspection of product.

4.2 PMI examination of materials is independent of any certification, markings or colour coding that may exist and is aimed at verifying that the alloy used are as per specified grades.

4.3 The Supplier shall identify all incoming alloy materials and maintain full traceability of all alloy materials, including all off-cuts. Transfer of identification marks shall be undertaken prior to cutting to ensure maintenance of identification on off-cuts.

4.4 The Supplier shall ensure that all alloy materials are segregated and stored in separately identified locations to prevent the mix up of materials of different alloy specifications or alloy material with carbon steel. Non ferro-magnetic materials shall be segregated at all times from ferro-magnetic materials.

4.5 PMI examination is subject to surveillance inspection by Owner/EIL/TPIA.

5.0 ACCEPTABLE METHODS FOR PMI

5.1 The method used for PMI examination shall provide a quantitative determination of the alloying elements like chromium, nickel, molybdenum or vanadium in Alloy Steel items.

5.2 Instruments or methods used for PMI examination shall be able to provide quantitative, recordable, elemental composition results for positive identification of alloying elements present.

5.3 The acceptable instruments for alloy analyzer shall be either “Portable X-Ray fluorescence” or “Optical Emission” type each capable of verifying the percentage of alloy elements within specified range.

5.4 Chemical spot testing, magnets, alloy sorters and other methods using eddy current or triboelectric testing methods are not acceptable for PMI examination.

5.5 The PMI instrument used shall have the sensitivity to detect the alloying elements in the specified range.

5.6 All PMI instruments shall have been serviced within a 6 month period of the time of use to verify the suitability of batteries, sources etc., and the data of the last service shall be stated on the PMI Report Form (Sample enclosed).

5.7 Each analyzer must be calibrated according to the manufacturer’s specification at the beginning and end of each shift. Instrument must be checked against known standard for each alloy type to be inspected during the shift.

5.8 Certified samples, with full traceability, of a known alloy materials shall be available for use as a random spot check on the instrument calibration.

5.9 The surfaces to be examined shall be prepared by light grinding or abrasive paper and solvent cleaner. Evidence of Arc burn resulting from examination shall be removed by light grinding or abrasive paper. No permanent marks, which are injurious to the usage of product in service, are acceptable.

5.10 Alloy Steel ring type joint Gaskets shall be inspected by using portable X-Ray fluorescence instrument.

5.11 Testing shall be done as per the procedures outlined by the manufactures of alloy analyzer being used. Modification of these procedures if any must be approved by Owner/EIL.

5.12 The persons performing PMI shall demonstrate their capabilities to the satisfaction of Owner/EIL/TPIA visiting engineer. If the Supplier has qualified operator on their rolls, he may perform the examination. Otherwise PMI examination shall be sub-contracted to an independent testing agency approved by EIL.

5.13 Whenever material is identified as not meeting requirements by the visiting engineer a rejection note shall be issued.

6.0 EXTENT OF PMI EXAMINATION

Following sampling plans shall be applicable for PMI examination of various items.

A.	Flanges, Fittings Valves, RTJ Gaskets	-	100%
B.	Pipes	-	100% (for pipes procured from traders). 2 random samples drawn from each Size/Heat/Lot (for pipes procured directly from mills)

C. Fasteners -

Lot Size	Sample Size
Upto 100	2% (Min 2)
101 to 500	1% (Min 3)
501 and above	0.5% (Min 5)

Note:

a. For Welded Pipes and Fittings, PMI shall be performed on Base Metal as well as weldments.

7.0 ACCEPTANCE CRITERIA

7.1 Base Metal

PMI test results showing presence of characteristic elements upto 10% less than the minimum specified value in the material specification and upto 10% more than the maximum specified value in the material specification shall be acceptable.

7.2 Deposited Weld Metal

For deposited weld metal using welding consumables matching with base metals, the recorded presence of characteristic elements upto 12.5% less than the minimum specified value in the welding consumable specification and upto 12.5% more than the maximum specified value in the welding consumable specification shall be acceptable.

8.0 REJECTION CRITERIA

8.1 If PMI test results fall outside the acceptable range as specified in 7.0 above, the supplier shall obtain a quantitative check analysis performed by a laboratory acceptable to Owner / EIL / TPIA for a complete chemical analysis. Alternatively, the item can be tested with a spark analyser for verification. Results of this analysis shall be submitted to Owner / EIL / TPIA for final decision.

Decision of Owner / EIL / TPIA shall be final in this regard.

8.2 If any sample drawn to PMI test on the basis of percentage selection as per 6.0 above, fails to meet specification requirements, 100% of items of lot shall be tested for PMI by supplier. Any failure thereafter during sample check shall mean rejection of whole lot.

9.0 RECORDING AND DOCUMENTATION

The results of PMI examination shall be recorded in a Report Format as enclosed with this specification.

10.0 MARKING

10.1 All alloy materials tested by PMI shall be identified using either of the following methods by indicating "PMI OK"

a) Bar Code/Hologram Sticker
b) A low stress stamp marking

POSITIVE MATERIAL IDENTIFICATION REPORT BULK MATERIALS							Page of
Project:	Client						Job No.
PMI Report No.	Supplier/Sub-Supplier						
Purchase Order No.	Testing Agency						
Purchase Requisition No:	PMI Location						
Bulk Item Type (as per Requisition)							
Material Specification/Grade Number of items in Lot							
Requisition Item No./ Description	Major content, Weight Percent						Remarks Accept/Reject
Element	Cr	Ni	Mo	V	Ti*	Cb / Nb **	
Specified Range							
Actual observations 1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
Instrument Type / ID Last Service Date	Inspection Agency						Witnessed By

* To be reported in case of SS321 Material
** To be reported in case of SS347 Material

TITLE OF THE DOCUMENT:_____

DOCUMENT NO.:_____

Sl. No.	Clause No.	Technical Requirements specified	Deviation	Technical Justification	Remarks

SITE & UTILITY DATA

PROJECT : **EPCM SERVICES FOR CAPACITY EXPANSION OF PANIPAT REFINERY (P25 PROJECT)**

CLIENT : **M/s IOCL, PANIPAT REFINERY**

EPCM : **M/s ENGINEERS INDIA LTD.**

JOB NO. : **B269**

Rev. No	Date	Purpose	Prepared by	Checked & Approved by
A	25.10.2021	Issued with MR	MKY	MG/TK

1.0 PLANT LOCATION

1	Site Location	Panipat
	State/Country	Haryana/ India
	Nearest Railway Station	Panipat
	Nearest Town/ City	Panipat
	Nearest Airport	New Delhi
	Nearest State Highway	NH-1
	Nearest Port	
2	Rainy season	June-September
3	Source of Water	Munak Headworks and Recycled treated effluent water

2.0 METEOROLOGICAL DESIGN DATA

2.1 METEOROLOGICAL DATA

This section presents relevant data towards preparing process engineering specifications.

S.No.	Parameter	Unit	Min.	Nor.	Max.	Design
1	Barometric pressure	mbar	967.3	978.675	988.4	
2	Ambient temperature□	C	tmin=(-) 0.7	tnor =	tmax=46.6	
3	Relative humidity at ambient temperature	%	@ tmin	88@ tnor	95@ tmax	
5	Rainfall data for 1-hour period	mm			72	
5.1	Rainfall data for 24-hours period	mm			218	
6	Wind data					
6.1	Wind velocity @30 m ht.	Km/h			168	
6.2	Wind velocity @10 m ht.	Km/h			152	
6.3	Wind direction Morning				SE to NW	
6.4	Wind directionEvening				NW to SE	
7	Elevation above mean sea level	m				238

2.2 DATA FOR EQUIPMENT DESIGN

S.No.	Parameter	UOM	Design Value
1	Dry bulb temp. (for air cooler design)	Deg C	43
2	Wet Bulb Temp.	Deg C	27.5
3	Ambient Temp. for MDMT	Deg C	(-) 0.7

4	Air temp. for air cooled exchangers where followed by water cooling	Deg C	43

S.No.	Parameter	UOM	Design Value
4	Air temp. for air cooled exchangers where followed by water cooling	Deg C	43
5	Air temp. for air cooled exchangers where not followed by water cooling	Deg C	45
6	Coincident temperature for corresponding relative humidity for Air Blower / Air Compressor	Deg C	94 % @ 42 Deg C
	Corresponding Relative humidity for Air Blower / Air Compressor	%	
7	Earthquake criteria		As per IS: 1893, latest revision the site falls under seismic zone IV.

3.0 UTILITY SPECIFICATIONS

3.1 UTILITY CONDITIONS AT UNIT BATTERY LIMITS

Utility pressure and temperature levels, as made available at battery limits of a process unit, as indicated below:

Utility conditions at unit B/L [All B/L pressures are as measured at grade] for PANIPAT REFINERY

S.No	Describe	Parameter	Min	Nor.	Max	Design	Remarks
1	HIGH PRESSURE STEAM (HP)						
		Pressure,KG/CM² G	38	40	42	47 /FV	
		Temp.,DEG C	380	390	400	425	
2	MEDIUM PRESSURE (MP) STEAM						
		Pressure,KG/CM² G	12	14	15	18 / FV	
		Temp.,DEG C	210	260	305	350	
3	LOW PRESSURE (LP) STEAM						

		Pressure,KG/CM² G	3	4	5	7 / FV	
		Temp.,DEG C	143	160	190	240	
S.No	**Describe**	**Parameter**	**Min**	**Nor.**	**Max**	**Design**	**Remarks**
4	CONDENSATE RETURN(PURE & SUSPECT/SURFACE) AT PROCESS UNIT B/L						
		Pressure,KG/CM² G		5		14	
		Temp.,DEG C	40	90	100	150	
5	SERVICE WATER (SW)						
		Pressure,KG/CM² G	3	5	6	10.55	
		Temp.,DEG C		Amb		65	
6	COOLING WATER						
		Supply Pressure,KG/CM² G	3.8	4	4.5	8	
		Return Pressure,KG/CM² G	2.2	2.4	2.8	8	
		Supply temp. DEG C	28	33		65	
		Return temp. DEG C			45	65	
7	DEMINERALISED WATER						
		Pressure,KG/CM² G	4	7.5	8	16	
		Temp.,DEG C	30	40	50	65	
8	BOILER FEED WATER (HP/MP)						
		Pressure (MP BFW),KG/CM²G	25	28	35	40	
		Pressure (HP BFW),KG/CM²G	47	50	58	76	
		Temp.(MP BFW),DEG C	100	100-105	110	150	
		Temp. (HP BFW),DEG C	100	100-105	110	150	
9	PLANT AIR						
		Pressure,KG/CM² G	4	6	8	10	
		Temp.,DEG C		AMB		65	
10	INSTRUMENT AIR						
		Pressure,KG/CM²	5	6	7	10	

		G					
		Temp.,DEG C		AM B		65	
S.No	**Describe**	**Parameter**	**Min**	**Nor.**	**Max**	**Design**	**Remarks**
11	NITROGEN						
		Pressure,KG/CM² G	4	5	7	10.5	
		Temp.,DEG C		AM B		65	
12	FUEL GAS (REFINERY)						
		Pressure,KG/CM² G	2	3.5	5.2	7	
		Temp.,DEG C	35	40	65	65	
13	REFINERY FUEL OIL (CPP)						
		Supply Pressure, kg/cm2G	8	10	12	16.5	
		Return Pressure, kg/cm2G		3		16.5	
		Temp, DEG C		120		160	
14	RLNG						
		Supply Pressure, Kg/cm2G	38	40	45		
		Temp, DEG C	10	30	45		

4. COMPRESSED AIR & NITROGEN SYSTEMS

The specifications of plant air and instrument air are indicated below:

S.No.	Parameter	Plant Air	Instrument Air
1	Dew Point at atmospheric pressure	Water free	(-) 40 deg C
2	Oil Content, ppm	nil	nil

INERT GAS SOURCE

Inert Gas shall be generated from: Other considerations, if any:

1	Cryogenic Nitrogen Plant	YES
2	PSA Plant	NO
3	Nitrogen Cylinder	NO
4	Others	NO

INERT GAS SPECIFICATION

S.No.	Parameter	Inert Gas

1	Dew Point at atmospheric pressure	(-) 100 deg C
2	Oil Content, ppm	nil
3	Nitrogen purity, vol%	99.99 min.
4	Oxygen content, vol ppm	3.0 max
5	Carbon dioxide content, vol ppm	3.0 max
6	Carbon monoxide content, vol ppm	traces

Unit and Offsite designers are required to indicate whether there is a requirement of prioritized continuous demand or intermittent large demand of Plant Air, Instrument Air or Inert Gas.

5. Flare System

5.1 Maximum flare backpressure shall be considered for sizing of pressure relief devices

S.No.	Flare syste m	Superimposed backpressure(kg/cm²g)	Built-up back pres. at unit battery limits(kg/cm²)	Built-up back pres. at PSV outlet(kg/cm²g)
1	HC FLARE (LP FLARE)	0.1	1.5	1.7
2	HC FLARE (HP FLARE)	0.1	5.2	5.5
3	ACID GAS FLARE	0.1	0.5	0.7

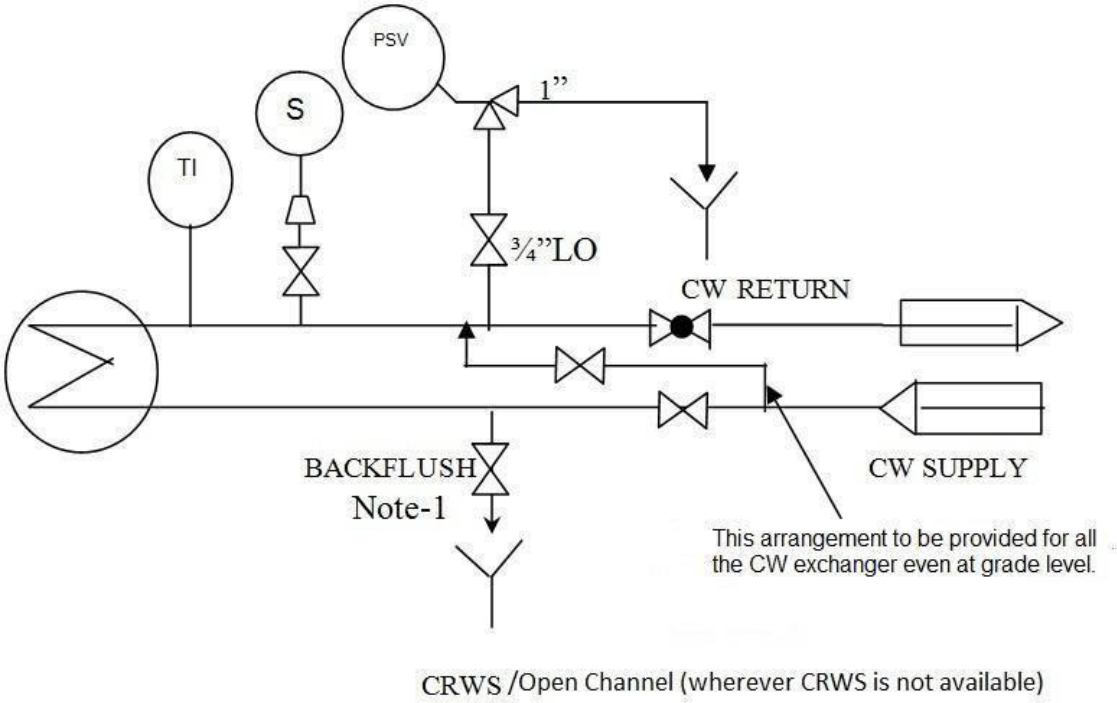
Note-
1. The back pressure for high pressure flare at unit battery limit shall be optimized to reduce flare header sizes.

2. Destination of PSV discharge to HP/LP flare shall be decided by Licensor/ Unit designer and indicated in the P&ID's accordingly.

5.2 Overpressure (as percentage of set pressure) for sizing of relief valves shall be

S.No.	Contingency	Condition-1	Condition-2
1	Steam generating equipment	5%	5%
2	Fire case	21%	as per designer
3	Thermal relief (piping / equipment)	25%/10%	as per designer
4	Operational failures	10%	as per designer

6. Typical cooling water piping and instrumentation at heat exchangers



Note:
1. Backflush line size shall be of same size as cooling water line upto 6". For cooling water line > 6", Back flush shall be 6" only.

7. WATER QUALITY

The quality of treated raw water/ circulating cooling water/ DM water/ Boiler Feed water as applicable are as per:

S.No	Parameter	Raw water quality	Treated Raw Water	DM/ Polished Water	BFW	Bearing Cooling Water	Recirculating/ Once through Cooling water
1	PH	8-8.4		6.7-8.9	8-9		7.5-8/8.0
2	Turbidity, NTU (5 min settled)/TSS, mg/l	20-40 (500 in monsoon)					10-15/ 30
3	Total suspended solids, mg/l	20-40(500 during monsoon)					
4	Total dissolved solids, ppmw	100-160		4-8	5 max		400-650/800 mg/l
5	Conductivity@20 DEGC, micro mho/cm			<0.2	20 max		
6	MO Alkalinity as CaCO3, mg/l	80-112					

S.No	Parameter	Raw water quality	Treated Raw Water	DM/ Polished Water	BFW	Bearing Cooling Water	Recirculating/ Once through Cooling water
7	Ca Hardness as CaCO3, mg/l	65-85					260-340/450
8	Total Hardness	90-125		NIL			360-500/650
9	Mg Hardness as CaCO3, mg/l						90-100/125
10	Total reactive Silica as SiO2, ppmw	8-10		<0.04	0.05 max		35-40/100 mg/l
11	Colloidal Silica as SiO2, ppmw						
12	Sodium as Na, mg/l						
13	Potassium as K, mg/l						
14	Chlorides as Cl, ppmw	8-10		NIL	1 max		55-65/75
15	Free chlorine, mg/l						
16	Free Bromine, mg/l						0.3-0.5/1.0
17	Sulphates as SO4, ppmw	15-75					300-450/600 mg/l
18	Organophosphates as PO4, mg/l						8-10
19	Inorgc phosphates as PO4, mg/l						4-6
20	Nitrates as NO3, mg/l						
21	Nitrates as N, mg/l						
22	Dissolved oxygen, mg/l						
23	Total Iron, ppmw	<0.2		<0.01	1 max		1.0
24	Dissolved Iron Fe), mg/l						
25	Total Copper, mg/l			<0.003			
26	Lead as Pb, microgram/l						
27	Manganese as mg/l						

S.No	Parameter	Raw water quality	Treated Raw Water	DM/ Polished Water	BFW	Bearing Cooling Water	Recirculating/ Once through Cooling water
28	Zinc as Zn, mg/l						
29	Chromium as Cr, mg/l						
30	Polymeric dispersant, mg/l						10/20-30
31	Zinc Sulphate as Zn, mg/l						1-2/3
32	Benzotriazole, mg/l						
33	Oil content, mg/l				Nil		-/10
34	KMnO4 value at 100 DEG C, ppm						30-40/50
35	ORP Value, mV	245					
36	Ammonia	Nil					
37	Sulfide as S, mg/l	Nil					
38	Azole (BZT) ppm						0.2-0.5

VENDOR DATA REQUIREMENTS
FOR
CENTRIFUGAL COMPRESSOR PACKAGE
(SPP)

Rev. No.	Date	Purpose	Prepared by	Checked by	Approved by
A	18-NOV-2021	ISSUED FOR BIDS	MKY	MG	TK

VENDOR DATA REQUIREMENTS

The following drawings/documents marked "✔" shall be furnished by the bidder.

S. NO.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
1.	General Arrangement showing compressor, drive transmission system (as applicable) & electric motor driver including all assosciated auxiliary systems [like sealing system, lube oil system, local control panel, injection panels (as applicable) and rundown tank etc.] along with interface connections/ terminal point details including their location cordinates, maintenance space, erection & maintenance weights, capacity & hook height of maintenance crane etc.	✔	✔		✔	*Preliminary GA with bid*
2.	Test Procedure(s) : Witness tests as specified in data sheets / other specs enclosed in the inquiry / MR or as required by approved ITP/QAP		✔		✔	
3.	Foundation drawing of auxiliaries such as lube oil console, local control panel, injection panels (as applicable), dry gas sealing system, rundown tank etc.		✔		✔	
4.	Drawing for underground points indicating the required undergroud drain points in the compressor house			✔	✔	
5.	Allowable forces and moments at compressor suction and discharge nozzles		✔		✔	
6.	Allowable thermal movements compressor suction and discharge nozzles		✔		✔	
7.	Utility consumption data including electric load data.	✔	✔		✔	
8.	Schedule of lubricants, chemicals & consumables with their specifications.			✔	✔	
9.	List of Purchaser's interface points with their connection details			✔	✔	
10.	Centrifugal Compressor datasheet alongwith performance curves.	✔	✔		✔	
11.	Data Sheets for Gear box/Variable Speed Planetary Gear mechanism (as applicable).		✔		✔	
12.	Data Sheets for Coupling for compressor train		✔		✔	
13.	Data Sheets for Lube oil system		✔		✔	
14.	Data Sheets for Dry Gas Seal (as applicable)		✔		✔	
15.	Data Sheets alongwith performance curves for Lube oil pump		✔		✔	
16.	P&ID for Process Gas System including Anti Surge Control & Process controls		✔		✔	
17.	P&ID for Compressor shaft Sealing System		✔		✔	

S. NO.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
18.	P&ID for Utility & Cooling Water Distribution System		✔		✔	
19.	P&ID for Bearing Temp. & Vibration monitoring System		✔		✔	
20.	P&ID for Compressor wash water/ wash oil injection system (as applicable)		✔		✔	
21.	General Arrangement Drawings for Centrifugal Compressor		✔		✔	
22.	General Arrangement Drawings for Coupling for compressor train		✔		✔	
23.	General Arrangement Drawings for Compressor Sealing System		✔		✔	
24.	General Arrangement Drawings for LO System.		✔		✔	
25.	General Arrangement Drawings for Loose supply piping items (like strainer, flow element, ASV, QCNRV, PSVs etc.) in vendor's scope, to be installed in purchaser's piping.		✔		✔	
26.	Cross Sectional Drawings for Centrifugal Compressor & its rotor assembly		✔		✔	
27.	Cross Sectional Drawings Gear box or Variable Speed Planetary Gear mechanism (as applicable).		✔		✔	
28.	Cross Sectional Drawings for Compressor end seals/ Dry Gas Seal (as applicable).		✔		✔	
29.	Cross Sectional Drawings for Journal and thrust bearing assembly for compressor, steam turbine and gear box (as applicable)		✔		✔	
30.	Cross Sectional Drawings for LOP along with their seal assembly & driver			✔	✔	
31.	Mechanical Run Test procedure for Centrifugal Compressor and Gear Box (as applicable)		✔		✔	@
32.	Performance Test procedure for Centrifugal Compressor		✔		✔	@
33.	Compressor shaft seal performance test procedure		✔		✔	@
34.	Lateral Analysis Reports of Compressor, Gear Box (as applicable) and Electric motor drive			✔	✔	
35.	Train Torsional & Lateral Analysis Report (as applicable)			✔	✔	
36.	Cause & effect diagram		✔		✔	
37.	Control Narrative			✔	✔	
38.	Installation, Operation & Maintenance manuals for complete compressor package			✔	✔	
39.	Precommissioning & commissioning procedure for complete compressor package			✔	✔	
40.	List of Mandatory Spares (indicating exact name of the part, part no. and material of construction)	✔	✔		✔	
41.	Quotation for recommended spare parts for two years of normal operation (indicating exact name of the part, part no. and material of construction)	✔				

S. N O.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
42.	List of recommended commissioning spares (indicating exact name of the part, part no. and material of construction)	✔		✔	✔	
43.	List of recommended Special Tools & Tackles (indicating exact name of the part and part no.)	✔		✔	✔	
44.	Filled in BQC PTR proforma along with supporting documents	✔				
45.	List of loose supply items in vendor's scope, to be installed in purchaser's piping	✔	✔		✔	
46.	P&ID for Lube Oil System & Variable Speed Planetary Gear mechanism (as applicable).		✔		✔	
47.	Foundation drawing of compressor train [i.e. for compressor, drive transmission system (as applicable) & electric motor driver] including details of load points loaction and their details, foundation load data (static & dynamic), foundation bolts, their location, foundation bolt pocket dimensions and recommended type of grout, grout thickness, make, grade and quantity.		✔		✔	
48.	Duly filled-in & signed / stamped Technical Compliance Statement (Doc. No. B269-454-80-42-TCL-5155)	✔				
49.	Data Sheets for LO Cooler		✔		✔	
50.	Document Control Index (DCI) or Supplier /Vendor Drawing & Documentation Schedule (This shall be the first document to be submitted by vendor immediately after FOI)		✔			
51.	General arrangement of Gear box or Variable Speed Planetary Gear mechanism (as applicable)		✔		✔	
52.	Dynamic simulation study report		✔		✔	

Notes :

1. "TICK" denotes applicability.
2. Post order, drawing / document review shall commence only after approval of Document Control Index (DCI).
3. All post order documents shall be submitted / approved through EIL eDMS portal.
4. Final documentation shall be submitted in hard copy (Six prints) and soft (two CDs/DVDs) in addition to submission through EIL eDMS.
5. Refer - 6-78-0001: Specification for quality management system from Bidders.
6. Refer - 6-78-0003: Specification for documentation requirement from Suppliers.
7. All drawings & documents shall be submitted in A4 or A3 paper sizes. Documents in higher paper size shall be submitted in exceptional circumstances or as indicated in the MR/Tender.
8. Post order- The schedule of drawing / data submission shall be mutually agreed between EIL & the bidder / contractor / supplier during finalization of Document Control Index (DCI).
9. Also refer other department's VDR :-
10. Electrical

11. Instrumentation
12. Piping
13. "@" indicates submission of documents to Inspection Agency.

SPECIFICATION FOR SURFACE PREPARATION AND PROTECTIVE COATING SYSTEM - NEW CONSTRUCTION

PROJECT : P-25

OWNER : IOCL

JOB NO. : B269

Rev. No.	Date	Purpose	Prepared by	Reviewed by	Approved by
2	06.05.2020	Issued for Tender	S S Pandey	P Chowdhary	A Roy
1	28.04.2020	Issued for Tender	S S Pandey	P Chowdhary	A Roy
0	17.04.2020	Issued for Tender	S S Pandey	P Chowdhary	A Roy

Contents

1.0 GENERAL

1.1 This technical specifications shall be applicable for the work covered by the contract, and without prejudice to the provisions of various international codes of practice, standard specifications etc. It is understood that contractor shall carry out the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-In-Charge.

1.2 Wherever it is stated in the specification that a specific material is to be supplied or a specific work is to be done, it shall be deemed that the same shall be supplied or carried out by the contractor. Any deviation from this standard without written deviation permit from appropriate authority will result in rejection of job.

1.3 This specification covers the requirement for protective coating for new construction.

2.0 SCOPE

2.1 Scope of work covered in the specification shall include, without being limited to the following.

2.1.1 This specification defines the requirements for surface preparation, selection and application of primers and paints on external surfaces of equipment, vessels, machinery, piping, ducts, steel structures, external & internal protection of storage tanks for all services and chimneys if any. The items listed in the heading of tables of Coating Systems, is indicative only. However, the contractor is fully responsible for carrying out all the necessary painting, coating and lining on external and internal surfaces as per the tender requirement.

2.2 Extent of Work

2.2.1 The following surfaces and materials shall require shop, pre-erection and field painting:

- All uninsulated Carbon Steel & Alloy Steel equipments like Vessels, Columns, Storage Tanks, Exchangers if any, parts of boilers etc.
- All uninsulated carbon steel and low alloy plant and related piping, fittings and valves (including painting of identification marks), furnace ducts and stacks.
- All insulated parts of vessels, boilers, chimneys, stacks, piping and steam piping and if any other insulated items present.
- All items contained in a package unit as necessary.
- All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.
- Flare lines, external surfaces of MS chimney with or without refractory lining and internal surfaces of MS chimney without refractory lining, (If present).
- Identification colour bands on all piping as required including insulated aluminium clad, galvanized, SS and nonferrous piping.
- Identification lettering/ numbering on all painted surfaces of equipment/piping insulated aluminium clad, galvanized, SS and non-ferrous piping.

- Marking / identification signs on painted surfaces of equipment/piping including hazardous service.
- Supply of all primers, paints and all other materials required for painting (other than Owner supplied materials)
- Over insulation surface of equipments and pipes wherever required.
- Painting under insulation for carbon steel, alloy steel and stainless steel as specified.
- Painting of pre-erection/fabrication and Shop primer.
- Repair work of damaged pre-erection/ fabrication and shop primer and weld joints in the field/site before and after erection as required.
- All CS Piping, equipments, storage tanks and internal surfaces of RCC tanks in ETP plant.
- Quality control, testing and inspection during all stages of work (surface preparation, application of coating and testing of furnished coating).

2.2.2 The following surfaces and materials shall not require painting in general. However, if there is any specific requirement by the Owner, the same shall be painted as per the relevant specifications:

a. Uninsulated austenitic stainless steel.

b. Plastic and/or plastic coated materials

c. Non-ferrous materials like aluminum, Cu-Ni alloy.

2.3 Documents

2.3.1 The contractor shall perform the work in accordance with the following documents issued to him for execution of work.

a. Bill of quantities for piping, equipment, machinery and structures etc.

b. Piping Line List.

c. Painting specifications including special civil defence requirements.

2.4 Complete coating (i.e., primer, intermediate and top coats) of shop fabricated equipment and piping, may be carried out at shop. Any coating damage during transportation/erection of the equipment/piping shall be repaired by the fabricator/manufacturer in accordance with this specification.

2.5 In case of conflict between coating systems given in this document and any other system specified elsewhere in the applicable contractual documents like SOR, MR, and PR etc, Contractor shall approach the Client/Client's authorized representative for confirming the suitable coating systems.

2.6 Changes and deviations required for any specific job due to clients requirement or otherwise shall be referred to EIL for deviation permit.

3.0 REFERENCE CODES & STANDARDS

3.1 Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, latest editions of the following codes and standards are applicable for the work covered under this specification.

International Organization for Standardization (ISO):

ISO 12944: Corrosion Protection of steel Structures by Protective Paint System

ISO 14713-2: Zinc Coatings - Guidelines and Recommendations for the Protections against Corrosion of Iron and Steel in Structures, Part-2: Hot Dip Galvanizing

ISO 8502-3: Preparation of steel substrates before application of paints and related products -Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)

ISO 8502-9: Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 9: Field method for the conductometric determination of water-soluble salts.

ISO 2808: Paints and varnishes - Determination of film thickness

National Association for Corrosion Engineer (NACE):

NACE SP 0198: Control of Corrosion under Thermal Insulation and Fireproofing Materials

NACE SP 0188: Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

Steel Structures Painting Council (SSPC)

SSPC VIS 1: Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

SSPC PA 2: Measurement of Dry Paint Thickness with Magnetic Gauges

American Society for Testing and Materials (ASTM):

ASTM D6677-18: Standard Test Method for Evaluating Adhesion by Knife

ASTM D1475-13: Standard Test Method for Density of Liquid Coatings, Inks, and Related Products

ASTM D5894–16: Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)

ASTM D823–18: Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panels

ASTM D2369-10 (2015): Standard Test Method for Volatile Content of Coatings

ASTM D1640/D1640M-14(2018): Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings

ASTM D522/D522M–17: Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

ASTM D3363 - 05(2011): Standard Test Method for Film Hardness by Pencil Test

ASTM D2197–16: Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion

ASTM D968–17: Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

ASTM D1044–13: Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion

ASTM D1849-95 (2019): Standard Test Method for Package Stability of Paint

ASTM D2247–15: Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity

ASTM D543–14: Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

ASTM D870–15: Standard Practice for Testing Water Resistance of Coatings Using Water Immersion

ASTM D5146-10(2019): Standard Guide to Testing Solvent-Borne Architectural Coatings

ASTM D2485–18: Standard Test Methods for Evaluating Coatings for High Temperature Service

Other Applicable Standards:

RAL DUTCH: International Standard for colour shade (Dutch Standard)

ANSI A 13.1: Scheme for identification of piping systems: American National Standards Institution

ISO 8501-1 / SIS-05 59 00: ISO standard for Preparation of steel substrates before application of paints and related products. This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-In-Charge.

3.2 The contractor shall arrange, at his own cost, to keep a set of latest edition of above standards and codes at site.

3.3 The paint manufacturer's instructions shall be followed as far as practicable at all times for best results. Particular attention shall be paid to the following:

a. Instructions for storage to avoid exposure as well as extremes of temperature.

b. Surface preparation prior to painting shall carried out as per this standard

c. Mixing and thinning.

d. Application of paints and recommended limit on time intervals in between coats.

4.0 EQUIPMENT

4.1 All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipments, scaffolding materials, shot & grit blasting equipments & air compressors etc. required to be used shall be suitable for the work and all in good order and shall be arranged by the contractor at site and in sufficient quantity. The manufacturer's test certificates / data sheets for all the above items shall be reviewed by Engineer-in-charge at site before start of work.

4.2 Mechanical mixer shall be used for paint mixing operations in case of two pack systems except that the Engineer-In-Charge may allow the hand mixing of small quantities at his discretion in case of specific requirement for touch up work only.

5.0 SURFACE PREPARATION, SHOP PRIMER COATING APPLICATION & REPAIR

5.1 General

5.1.1 In order to achieve the maximum durability, one or more of following methods of surface preparation shall be followed, depending on condition of surface to be painted and as instructed by Engineer-In-Charge. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system.

a. Abrasive blast cleaning

b. Mechanical or power tool cleaning

5.1.2 Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. Unless otherwise specified, surface preparation shall be done as per provisions of relevant tables given elsewhere in this specification. The minimum acceptable standard, in case of thermally sprayed metal coatings, in case of mechanical or power tool cleaning it shall be St. 3 or equivalent. In case of blast cleaning it shall be Sa 2-1/2 as per Swedish Standard SIS-055900 (latest edition) or SSPC-SP or ISO 8501-01.Blast cleaning shall be Sa 3 as per Swedish Standard in case thermally sprayed metal coatings.

Before surface preparation by blast cleaning, the surface shall be degreased by aromatic solvent to remove all grease, oil etc.

5.1.3 Irrespective of whether external or internal surface to be coated, blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceed 85%. In case of internal coating of storage tanks, dehumidifier shall be used, to control humidity level below 60%. Dehumidifier should depress the dew point of air in the enclosed space, sufficient enough so as to maintain it 3^0C below the metal substrate temperature during centre period of blasting and coating application. During the interval time between application of primer coat and subsequent intermediate and top coats or between blast cleaning completion and start of application of primer coat, dehumidifier unit should be in continuous operation to ensure that no condensation occurs on substrate.

Dehumidifier should be able to maintain grain drop (moisture removal) at the rate of 25 grains per pound of air per hour. Dehumidifier should have capacity of at least 2 air changes per hour of the enclosed space. All necessary psychometric data should be collected by contractor for the given site conditions before starting operation of dehumidifier to ensure that desired values of dew point, moisture content in enclosed scope is achieved.

Dehumidification to be maintained round the clock for surface preparation and painting till the total coating application is over.
Dehumidifier shall not be stopped under any condition till the entire blasted surface is primed to the satisfaction of the technical representative of the paint manufacturer interested with quality assurance for the work. In case the dehumidifier breaks down

in middle of the job, the same shall be replaced at the risk and the cost of the contractor and the entire unfinished work shall be repeated.

5.1.4 The Engineer in-charge shall have the right to disallow usage of dehumidifier if the performance is not meeting the specified requirements. Under such circumstances the contractor shall remove the equipment and replace the same with another equipment to provide satisfactory results without any additional cost to the owner.

5.1.5 Irrespective of the method of surface preparation, the first coat of primer must be applied by airless spray/ air assisted conventional spray if recommended by the paint manufacturer on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavorable weather conditions, the Engineer-In-Charge shall have the liberty to control the time period, at his sole discretion and/or to insist on re-cleaning, as may be required, before primer application is taken up. In general, during unfavorable weather conditions, blasting and painting shall be avoided as far as practicable.

5.1.6 The external surface of R.C.C. chimney to be painted shall be dry and clean. Any loose particle of sand, cement, aggregate etc. shall be removed by scrubbing with soft wire brush. Acid etching with 10-15% HCL solution for about 15 minutes shall be carried and surface must be thoroughly washed with water to remove acid & loose particles and then dried completely before application of paint.

5.2 Procedure for Surface Preparation

5.2.1 Air Blast Cleaning with abrasives

The surfaces shall be blast cleaned using one of the abrasives like angular chilled cast iron or steel grit, copper slag or Nickel slag, $A1_2O_3$ particles at pressure of 7kg/cm^2 at an appropriate distance and angle depending of nozzle size maintaining constant velocity and pressure. Chilled cast iron or steel shall be in the form of shot or grit of size in the range of G16 – G42 conforming to SSPC AB1 and S250 grade size of steel shots (maximum) to obtain a desired surface profile of 35-50 microns trough to peak. For all other abrasives, size shall be in the range of G16 – G24. The combination of steel grits and shots shall be normally in the ratio of 3:1. The quality of abrasives shall be free from contaminants and impurities and shall meet the requirements of SSPC AB1. Compressed air shall be free from moisture and oil. The blasting nozzles should be venturi style with tungsten carbide or boron carbide as the materials for liners. Nozzles orifice may vary from 3/16" to ¾". On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey white metallic luster. Primer/first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall not be done outdoors in bad weather without adequate protection or when there is dew on the metal, which is to be cleaned. Surface profile shall be uniform to provide good key to the paint adhesion (i.e. 35 to 50 microns). If possible vacuum collector shall be installed for collecting the abrasives and recycling.

5.2.2 Mechanical or Power Tool Cleaning

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire- brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust mill scale etc. shall be removed by clean rags and /or washed by water or steam and thoroughly dried with compressed air jet before application of paint.

5.3 Non-Compatible Shop Coat Primer

For equipments on which application of total protective coating (Primer + Intermediate + top coat) is carried out at shop, compatibility of finish coat with primer should be checked with paint manufacturer. If the shop coat is in satisfactory condition showing no major defect upon arrival at site, the shop coat shall not be removed.

5.4 Shop coated equipments (coated with Primer & finishing coat) should not be repainted unless paint is damaged. Repair shall be carried out as per this specification depending upon compatibility of paint.

5.5 Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer should be completely removed before application of selected paint system for particular environment.

5.6 For Package units/equipment, shop primer should be as per the paint system given in this specification. However, manufacturer's standard can be followed after review.

Field coating application (field primer, intermediate and top coat) on shop primed equipments, structures, piping, etc., shall be carried out only after its erection and all welding, testing, steam purging (wherever carried out) have been completed. Refer clause 2.4.

5.7 Coating Procedure and Application

All paint coatings shall be applied by airless spray excepting at the following special cases where application can be carried out by brush subject to suitability of the application of the paint product by brush.

- Spot repair
- Stripe coating on edges
- Small bore parts not suitable for spray application.

Irregular surfaces such as sharp edges, welds, small brackets, and interstices may stripe coated to ensure specified DFT is achieved. Paint manufacturer recommendation should be followed before deciding for brush application.

5.7.1 Surface shall not be coated in rain, wind or in environment where injurious airborne elements exists, when the steel surface temperature is less than 5°F above dew point when the relative humidity is greater than 85% or when the temperature is below 40°F and when the ambient/substrate temp is below the paint manufacturer's recommended temperature of application and curing. De-humidifier equipment shall be used to control RH and Dew point. The paint application shall not be done when the wind speed exceeds 20 km per hour.

5.7.2 Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hrs. of the same day.

5.7.3 To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.

5.7.4 Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional

coat can be applied without the development of any detrimental film irregularities, such as lifting or loss of adhesion of the under coat. Manufacturer instruction shall be followed for inter-coat interval.

5.7.5 When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life and shall be recommended by the original paint manufacturer.

5.7.6 Airless spray application shall be in accordance with the following procedure: as per steel structure paint Manual Vol.1 & Vol.2 by SSPC, USA, Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is sued to operate a pump to produce pressures of 1000 to 6000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less over spray. Airless spray usually is faster, cleaner, more economical and easier to use than conventional air spray.

Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from any container, including drums. The unit shall have in built agitator that keep the paint uniformly mixed during the spraying. The unit shall consist of in built strainer. Usually very small quantity of thinning is required before spray. In case of high build epoxy coating (two pack). 30:1 pump ratio and 0.020-0.023” tip size will provide a good spray pattern. Ideally fluid hoses should not be less than 3/8” ID and not longer than 50 feet to obtain optimum results.

In case of gun choking, de-choking steps shall be followed immediately.

5.7.7 Brush application of paint shall be in accordance with the following:

a. Brushes shall be of a style and quality that will enable proper application of paint.

b. Round or oval brushes are most suitable for rivets, bolts, irregular surface, and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.

c. Paint shall be applied into all corners.

d. Any runs or sags shall be brushed out.

e. There shall be a minimum of brush marks left in the applied paint.

f. Surfaces not accessible to brushes shall be painted by spray, doubers, or sheepkin.

5.7.8 For each coat the painter should know the WFT corresponding to the specified DFT and standardize the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

5.8 Drying of Coated Surfaces

5.8.1 No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exceed maximum specified for it as a first coat; if it exceeds the paint material has possibly deteriorated or maxing is faulty.

5.8.2 No paint shall be force dried under conditions which will cause chalking, wrinkling, blistering formation of pores, or detrimentally affect the conditions of the paint.

5.8.3 No drier shall be added to paint on the job unless specifically called for in the manufacturer's specification for the paint.

5.8.4 Paint shall be protected from rain, condensation, contamination, snow and freezing until dry to the fullest extent practicable.

5.9 Spot Repair of Damaged Primer

5.9.1 Where pre erection shop primer has been damaged at isolated localized spots during handling and transportation, or after erection / welding, the repair of damaged coating of pre-erection / pre-fabrication or shop primer shall be done as given below and as per the Table given at Clause no. 9.1 of this specification.

5.9.2 Repair of damaged inorganic zinc silicate pre-erection / pre-fabrication or shop primer (F9) after erection / welding in the design temperature of -90°C to 400°C and damaged silicone aluminium (F-12) pre-erection / pre-fabrication or shop primer after erection / welding for design temperature range of 401 – 550 °C.

Surface Preparation: Quickly remove the primer from damaged area by mechanical scraping and emery paper conforming to SSPC-SP-3 to expose the white metal. Blast clean the surface, if possible. Feather the primed surface over the intact adjacent surface surrounding the damaged area by emery paper.

Primer coating: One coat of F-9 shall be applied wherever damage was observed on pre-erection / pre fabrication or shop primer of inorganic zinc silicate coating (F-9). Similarly one coat of F-12 shall be applied wherever damage observed on pre-erection **/** pre-fabrication shop primer of silicone aluminium (F-12).

5.9.3 Wherever if damaged areas are found extensive and spread over large areas, then entire pre-erection / pre-fabrication or shop primer shall be removed by blasting to achieve SSPC-SP-10 then entire blasted surface shall be primed again with F-9 or F-12 as applicable for the intended design temp.

5.10 Paint Application

5.10.1 Shop priming/pre-erection priming with F9 or F12 shall be done only on blasted surface (SSPC-SP-10)

5.10.2 Shop priming / pre-erection priming with F9 or F12 shall be done only with airless spray.

5.10.3 Assessment of Painting Requirement:

The paint system to be applied for a specific job shall be arrived at sequentially as given below:

- Identify the environment from area classification details and chose the appropriate table.

- Identify the design temperature from the technical documents

- Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.

- Identify the shop priming requirement from clause 9.1 based on compatibility of the above paint system.

- Identify the need of repair of shop primer and execute as per clause 9.1.

6.0 DOCUMENTATION/ RECORDS

6.1 A written quality plan with procedure for qualification trials and for the actual work including test and inspection plan & procedure for approval before start of work.

6.2 Daily progress report with details of weather conditions, particular of applications, no of coats and type of materials applied, anomalies, progress of work versus program.

6.3 Results of measurement of temperatures relative humidity, surface profile, film thickness, holiday detection, adhesion tests with signature of appropriate authority.

6.4 Particulars of surface preparation and paint application during trials and during the work.

6.5 Details of non-compliance, rejects and repairs.

6.6 Type of testing equipments and calibration.

6.7 Code and batch numbers of paint materials used.

The coating applicator must maintain a job record consisting of all the information as per 6.2 - 6.7 above as well as the approved procedure of work (6.1 above). The job record consisting of information as required in accordance to 6.2 - 6.7 shall be entered on daily basis and should be daily signed by Engineer-in-charge.

7.0 SURFACE PREPARATION STANDARDS

Sr. No.	Description	Various International Standards (Equivalent)			Remarks
		ISO 8501-1/ SIS-05 59 00	SSPC-SP, USA	NACE, USA	
1	Manual or hand tool cleaning Removal of loose rust, loose mill scale and loose paint, chipping, scrapping, standing and wire brushing. Surface should have a faint metallic sheen	St 2	SSPC-SP-2	-	This method is applied when the surface is exposed to normal atmospheric conditions when other methods cannot be adopted and also for spot cleaning during maintenance painting.
2	Mechanical or power tool cleaning Removal of loose rust loose mill scale and loose paint to degree specified by power tool chipping, de-scaling, sanding, wire brushing and grinding, after removal of dust, surface should have a pronounced metallic sheen.	St 3	SSPC-SP-3	-	
3	Dry abrasive blast cleaning There are four common grades of blast cleaning				
3.1	White metal Blast cleaning to white metal cleanliness. Removal of all visible rust. Mill scale, paint & foreign matter 100% cleanliness with desired surface profile.	Sa 3	SSPC-SP-5	NACE No. 1	Where extremely clean surface can be expected for prolong life of paint system.
3.2	Near white metal Blast cleaning to near white metal cleanliness, until at least 95% of each element of surface area is free of all visible residues with desired surface profile.	Sa 2½	SSPC-SP-10	NACE No. 2	The minimum requirement for chemically resistant paint systems such as epoxy, vinyl, polyurethane based and inorganic zinc silicate paints, also for conventional paint systems used under fairly corrosive conditions to obtain desired life of paint system.
3.3	Commercial Blast Blast cleaning until at least two-third of each element of surface area is free of all visible residues with desired surface profile.	Sa 2	SSPC-SP-6	NACE No. 3	For steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint systems.

Sr. No.	Description	Various International Standards (Equivalent)			Remarks
		ISO 8501-1/ SIS-05 59 00	SSPC-SP, USA	NACE, USA	
3.4	Brush-off Blast Blast cleaning to white metal cleanliness, removal of all visible rust, mill scale, paint & foreign matter. Surface profile is not so important	Sa 1	SSPC-SP-7	NACE No. 4	

8.0 PAINT MATERIALS

Typical characteristics and codes of various paint materials used in this specification are as follows:

Table: Paint Materials Characteristics

Description	P-2	P-4	P-6	P-7
Technical name	Chlorinated rubber Zinc Phosphate primer.	Etch primer/wash primer	Epoxy zinc phosphate primer	Cold Galvanizing
Type and composition	Single pack, air drying chlorinated rubber based medium plasticized with unsaponifiable plasticizer, pigmented with zinc phosphate.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.	Two component polyamine cured epoxy resin medium, pigmented with zinc phosphate.	One pack Synthetic Resin based zinc galvanizing containing min 92% of electrolytic zinc dust of 99.95% purity.
Volume Solids %, Minimum	37	9	49	37
DFT per coat, µ	40-45	8-10	40-50	40-50
Theoritical covering capacity in m^2/coat/ litre	8-10	8-10	8-10	4m²/kg
Weight per litre in Kg/litre	1.3±0.05	1.2±0.05	1.4±0.05	2.67 kg at 15°C
Touch dry at 30°C (max.)	30 min.	2 hrs.	30 min.	10 min.
Hard dry at 30 °C (max.)	8 hrs.	24 hrs.	8 hrs.	24 hrs.
Over-coating interval	Min.: 8 hrs	Min: 4-6 hrs.	Min.:8hrs.	Min.:4 hrs
Pot life at 30 °C for two component paints	NA	NA	6 - 8 hrs.	NA
Adhesion (ASTM D4541)	NA	NA	>7 MPa	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	60 (Method A)	NA	80 (Method A)	50 (Method A)

Table: Paint Materials Characteristics (Contd.)

Description	F-2	F-3	F-6A/B	F-6C	F-7
Technical name	Acrylic Polyurethane finish paint	Chlorinated rubber based finish paint	Epoxy-High Build coating	Solvent less epoxy coating	High build coal tar epoxy coating.
Type and composition	Two-pack aliphatic isocynate cured acrylic finish paint.	Single pack plasticized chlorinated rubber based medium with chemical and weather resistant pigments.	F-6A Two-pack Aromatic amine cured epoxy resin medium suitably pigmented. F-6B: polyamide cured epoxy resin medium suitably pigmented	Two pack, cured with Amine Adduct; catalyzed epoxy resin suitably pigmented	Two pack polyamide cured epoxy resin blended with coaltar medium, suitably pigmented
Volume Solids %, (Min.)	40	36	57	98	62
DFT per coat, µ	30-4	30-40	100-125	250-500	100-125
Theoritical covering capacity in M^2/coat/litre	10-15	11-15	5-6	2-3	5.2-6.5
Weight per liter in kgs/litre	1.15±0.03	1.15±0.03	1.42±0.03	1.40±0.03	1.40±0.03
Touch dry at 30 °C, (Max.)	30 min.	30 min.	3 hrs.	3 hrs.	4 hrs.
Hard dry at 30 °C, (Max.)	8 hrs.	8 hrs.	16 hrs.	16 hrs.	48 hrs.
Full cure at 30 °C (for immersion/ high temperature service)	NA	NA	5 days	5 days	5 days
Over-coating interval	Min.12 hrs.	Min. Overnight	Min. Overnight, Max. 5 days	Min. 8 hrs., Max. 48 hrs.	Min. 24 hrs., Max. 5 days
Pot life (approx.) at 30 °C for two component paints	5-8 hrs.	NA	3-6 hrs.	30 min.	4-6 hrs.
Adhesion (ASTM D4541)	>5 MPa	>4 MPa	>7 MPa	>8 MPa	>5 MPa
Abrasion Resistance (ASTM D4060) For 1000 g load	<300 mg /1000 cycles/CS17 or <100 mg /1000 cycles/CS10	NA	NA	NA	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	80 (Method A)	60 (Method A)	80 (Method A)	120 (Method A)	125 (Method A)

Table: Paint Materials Characteristics (Contd.)

Description	F-8	F-9	F-11	F-12
Technical name	Self-priming type surface tolerant high build epoxy coating (complete rust control coating)	Inorganic zinc silicate coating	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C dry temp.	Heat resistant silicone Aluminium paint suitable upto 540°C dry temp.
Type & composition	Two pack epoxy resin based suitable pigmented and capable of adhering to manually prepared surface and old coating.	A two pack air drying self-curing solvent based inorganic zinc silicate coating with minimum 80% zinc content on dry film. The final cure of the dry film shall pass the MEK rub test ASTM D4752.	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C.	Ambient Temperature Curing, Single pack silicone resin based medium with Aluminium flakes.
Volume Solids %, Min.	75	57	35	18
DFT per coat, µ	100-125	65-75	15-20 (Note-13)	15-20 (Note-13)
Theoretical covering capacity in m^2/coat/litre	6.0-7.2	8-9	10-12	8-10
Weight per liter in kgs/litre	1.41±0.03	2.3±0.03	0.95±0.03	1.00±0.03
Touch dry at 30 °C (max.)	3 hrs.	30 min.	3 hrs.	30 min.
Hard dry at 30 °C (max.)	24 hrs.	12 hrs.	12 hrs.	24 hrs.
Full cure 30°C (for immersion /high temperature service)	5days	NA	NA	NA
Over-coating interval	Min. 10 hrs.	Min. 12 hrs. at 20 °C & 50% Relative Humidity	Min. 24 hrs.	Min. 24 hrs.
Pot life at 30 °C for two component paints	90 min.	4-6 hrs.	NA	NA
Adhesion (ASTM D4541)	>5 MPa	>5 MPa	NA	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	80 (Method A)	400 (Method B)	250 (Method A)	540 (Method B)

Table: Paint Materials Characteristics (Contd.)

Description	F-14	F-15	F-16	F-17	F-20
Technical name	Polyamine cured coal tar epoxy	Two-component Epoxy phenolic coating cured with Polyamine adduct hardener	Ambient temperature curing Poly Siloxane coating/ High build cold applied inorganic copolymer based aluminium coating suitable for under insulation of CS and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Glass flake reinforced vinyl ester coating
Type & composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Two pack ambient temperature curing epoxy phenolic coating system suitable for application under insulation	Suitable for high temperature service and under insulation coating for CS, alloy steel and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Two component glass flake filled vinyl ester lining for under immersion services upto 90 °C.
Volume Solids %, Min.	67	67	58	98	98
DFT per coat, µ	100-125	75-100	75-100	300-450	500-600
Theoritical covering capacity in m^2/coat/ litre	5-8	4-5	7- 9	6.5- 8	1.6 minimum
Weight per liter in kgs/litre (mix paint)	1.45±0.03	1.65±0.03	1.3	1.7	>1.2
Touch dry at 30 °C (max.)	4 hrs.	3 hrs.	1 hr.	2 hrs.	2 hrs.
Hard dry at 30 °C (max.)	24 hrs	24 hrs	16 hrs	24 hrs	4 hrs.
Full cure 30 °C (for immersion /high temp. service)	7 days	7 days	NA	7 days	4 days
Over-coating interval	Min. 6 hrs., Max.5 days	Min. 36 hrs., Max. 21 days	Min.16 hrs., Max. NA	Min. 16 hrs., Max. 21 days	Min. 4 hrs., Max.3 days
Pot life at 30 °C (for two component paints)	4 hrs.	4-6 hrs.	1 hr.	1 hr.	50 min-1 hr.
Adhesion (ASTM D4541)	>6 MPa	>7 MPa	>8 MPa for Polysiloxane	>8 MPa	>7, Tensile strength >20N/mm2 (ASTM D 638)
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	125 (Method A)	150 (Method A)	550 (Method B)	150 (Method A)	90 (Method A)

Notes applicable for "Table: Paint Materials Characteristics"

1. Covering capacity and DFT achieved per coat depends on method of application. Covering capacity specified above is theoretical. For estimation of actual quantity of paints required, include the losses during application. Minimum specified DFT should be maintained in any case.
2. All primers and finish coats should be ambient temperature curing and air drying unless otherwise specified.
3. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship should be ensured. Wherever a deviation is noticed from the specification in manufacturer data sheet, more stringent one between the data sheet and the specification shall prevail e.g. if this specification recommends Sa2½ and the manufacturer data sheet requires Sa3, the surface preparation shall be done as per Sa 3. However in another case if this specification requires the surface preparation of Sa 2½ and the manufacturer data sheet recommends only Sa 2 as minimum, the surface preparation shall be done as per Sa 2½.
4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.
5. Higher specific gravity of F-9 is also acceptable.
6. Internationally recognized & acceptable testing method shall be used for lab testing wherever testing standards are not mentioned.
7. Theoretical covering capacity, hard dry, pot life, full cure period, & over coating interval shall be as per manufacturer's data sheets and no testing is required. Slight variation in the values of these parameters along with weight per liter may be permissible with the discretion of engineer-in-charge only.
8. Temperature resistance tests (ASTM D2485) shall be carried out for minimum required temperature resistance indicated.
9. Wherever ASTM D 2485 method B is applicable, test results of the panels subjected to salt spray (ASTM B 117) after muffle furnace exposure shall be submitted for pre-qualification purpose.
10. F-6A shall be suitable for immersion services.
11. F-6C shall be suitable for immersion services of hydrocarbons and DM water.
12. F-7 shall be suitable up to 80 °C minimum for buried service & immersion in hydrocarbons.
13. Where F-11/ F-12 is used as primer, anchor profile height shall be as per F-11/ F-12 paint manufacturer recommendation.
14. F-14 shall be suitable for under insulation service up to 125 deg C.
15. F-15 shall be suitable for high temperature immersion & under insulation services.
16. F-17 shall be suitable for high temperature immersion service and underground services

9.0 COATING SYSTEMS

Corrosivity category C5-I (very high – industrial) in accordance with ISO 12944-2 and other International Standards/Practices are considered for selecting the Coating Systems for bare steel surfaces exposed to atmosphere. Atmospheric zone coating systems are selected for a high durability (beyond 15 years) period.

For insulated surfaces, coating selection is based on NACE 0198 guidelines and other successful international practices.

9.1 Repair of pre-erection/pre-fabrication or shop primer after erection/welding for all un-insulated CS, LTCS & low alloy steel items

Sr. No.	Design Temp. in °C	Surface Preparation	Coating System	Total DFT in Microns (min.)	Remarks
1	-90 to 400	SSPC-SP-3	1 coat of F-9	65-75	See Note below and Clause 5.9.1
2	401 to 550	SSPC-SP-3	2 coat of F-12	2X20=40	

Note: The application and repair of pre-erection/pre-fabrication or Shop Primer given in above tables shall be done for all the items to be painted. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with F-9 or F-12 as applicable.

9.2 Coating system for Gratings (Note 5), Rolling & Stationery Ladders, Spiral Stairways, Hand Rails

Sr. No.	Design Temp., °C	Coating System	Total DFT in Microns (min.)
1	Up to 60	Hot Dip Galvanizing to 80-85 microns as per ISO 14713-2/ ISO 1461 + 1 coat of P-6 @ 40µ DFT/coat + 1 coat of F-2 @ 40 microns DFT/coat	80 microns of Painting (excluding the thickness of galvanizing)

Notes:

1. No galvanized specimen shall have thickness less than 80 microns.

2. Repair of the damaged areas of galvanized coatings due to welding during erection shall be carried out as per recommended practice ASTM A 780, using cold galvanizing spray process. Organic paint systems are not acceptable for the repair.

3. After repair of damaged galvanized coating by cold galvanization (P-7), the repaired area shall be top coated with paint system as given in table above (i.e. 1 coat of P-6 @ 40µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).

4. Suggested cold galvanizing manufacturers are Zinga, Loctite, ZRC or equivalent make.

5. Galvanized gratings don't require painting in general except for safety reason such as escape routes, walkways. Hence, Galvanized gratings shall be painted for indication of escape routes or walkways only as per table above (i.e. 1 coat of P-6 @ 40µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).

9.3 Coating System for uninsulated and above ground (atmospheric zone) CS, LTCS & low alloy steel surfaces

(Structural steel, pipings, vessels, columns, reactors, pumps, compressors, exchangers, valves & other equipment etc.)

Sr. No.	Design Temp., °C	Surface Preparation & Pre-erection/ Shop Primer	Coating System		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
1	-90 to -15	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	None	None	65-75	**a)** No over-coating to be done on F-9 as it will lead to mud cracking.
2	-14 to 80	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	1 coat of P-6 @ 40 µ DFT/coat (Tie/ Mist Coat)	2 coats of F-6A/ F-6B @ 100 µ DFT/Coat + 1 coat of F-2 @ 40µ DFT/Coat	345-355	
3	81 to 400	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	None	2 coats of F-12 @ 20µ DFT/Coat	105-115	
4	401 to 540	SSPC-SP-10; 2 coat of F-12 @ 20µ DFT/Coat	None	1 coats of F-12 @ 20µ DFT/Coat	60	

Notes:

1. The list of items given in the heading of the above table is not exhaustive. There may be more items for a particular contract where these specifications are used. The Contractor is fully responsible for completing painting including prefabrication primer for all the items supplied and fabricated through his scope of work as per tender document.

2. If the Pre-erection/Pre-fabrication & Shop Primer has already been completed, the same shall not be repeated again in the field. In case the damages of primer are severe and spread over large areas, the engineer-in-charge may decide & advise re-blasting and priming again. Repair of pre-fabrication/pre-erection primer, if required, shall be done as per this specification.

3. Flare line within unit or offsite areas shall be coated as per Sr. No. 3 of above table

4. For external surface of MS chimney with or without refractory lining and for internal surface without refractory lining, paint system as per Sr. No. 3 of above table shall be followed.

5. For external surface of RCC Chimney, 2 coats of F-6B @ 100µ DFT/coat to obtain total DFT of 200 µ shall be applied after proper surface preparation as per clause no. 5.1.6.

6. In case of paint systems where finish (top) coat is F-12, the colour bands shall be applied over the Aluminum paint as per the Color coding requirement for specific service of piping.

9.4 Coating system for effluent treatment plant (ETP)

Sr. No.	Design Temp., °C	Surface Preparation	Coating System		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
1	For External Surfaces of C.S./M.S. items: Screens, Walk way bridges, Baffles, Dual media filters, Vertical pumps, piping in treated effluent sump, bio sludge pump, Screw pump and pump house, CS tanks, sumps and vessels.					
	-45 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat + 1 Coat of P-6 @ 40 µ	2 coats of F-6A/ F-6B @100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat; (2x100+40=240)	345-355	-
2	For Internal Surfaces of CS/MS Items: Bio-sludge sump, Filter feed sump, Process sump, Sanitary sump, Transfer sump, Sludge, Slop oil tank, scrapping mechanism in Clarifier					
	-45 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat + 1 coat of epoxy based mist coat	3 coats of F-6A @100µ DFT/coat (3x100=300)	365-375	Note:1
3	All R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc. in Process sump, TPI separator (Process and Oil), Aeration Tank and Transfer sump etc.					
	-45 to 80	Blast cleaning to SSPC-SP guide lines and Acid etching with 10-15% HCl acid followed by thorough water washing.	Epoxy Screed lining		3mm	Epoxy screed lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions
4	C.S/M.S Dual media filters (Internal), Chemical dosing tanks (internal) such as Di-Ammonium Phosphate (DAP) and Urea					
	Up to 60	SSPC-SP-10	Natural Rubber Lining (As per IS 4682, Part 1 or equivalent International standards)		4.5mm	Natural Rubber lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions

Notes:

1. Coating manufacturers shall provide their Quality control test certificate of coating materials (F-6A) for immersion service of the exposed effluent.

9.5 External coating systems for uninsulated carbon steel and low alloy steel Storage Tanks

Sr. No.	Design Temp., °C	Surface Preparation (Field)	Coating system		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
a	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external floating roof, outside surfaces (other than oil side surface) of external floating roof pontoons and associated external structural works.					
1	-45 to 80	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat + 1coat of P-6 @ 40µ DFT/ coat	2 coats of F-6A/ F-6B @ 100µ DFT /coat + 1 coat of F-2 @ 40µ DFT/ coat	345-355	F-6 should be suitable for occasional water immersion
2	81 to 120	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat + 1 coat of F-15 intermediate coat @ 80µ DFT/coat	1 coat of F-15 finish coat @80µ DFT/ coat + 1 coat of F-2 @ 40µ DFT/ coat	280	-
3	121 to 400	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat	2 coats of F-12 @20 µ DFT/ coat Or 1 coat of F-16 @ 125 µ DFT / coat	105-115 Or 190-200	For higher design temperatures, system as per Sr. No. c (1) of this table is applicable
b	External surfaces of bottom plate (soil side) for all storage tanks					
1	-45 to 80	SSPC-SP-10	1 coat of F-7 @ 125µ DFT/ coat	2 coats of F-7@ 125µ DFT/coat	375	F-7 should be suitable for immersion service of the products given
2	81 to 150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat + 1 coat of F-15 intermediate coat @ 80µ DFT/coat	1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-

3	151 to 400	SSPC-SP-10	1 coat of F-16 @ 125 µ DFT /coat	1 coat of F-16 @ 125 µ DFT /coat	250	-
c	For underside of the bottom plate (in case tank is not lifted during PWHT)					
1	-180 to 650	For CS, SSPC SP 10	1 coat of inert polymeric matrix coating @ 125 µ	1 coats of inert polymeric matrix coating @ 125 µ	250	Note 2(c)
		For SS, SSPC-SP-7 (15-25µ surface profile)				

Notes

1. All paint coating application including primer for tankage shall be carried out at field after erection and completion of all welding.

2. For underside of bottom plate :

   a) Painting shall be carried out before laying of bottom plate for tanks with Non-Post Weld Heat Treatment (PWHT).

   b) For tanks with PWHT, painting shall be carried out after PWHT.

   c) In case tank is not lifted during PWHT then painting shall be applied before laying of bottom plate.

Caution: PWHT temperature shall not exceed 650 °C.

9.6 Internal coating systems for carbon steel and low alloy Storage Tanks

Sr. No.	Design Temp., °C	Surface Preparation	Coating system		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
a	**Crude Oil, ATF, Turpentine Oil, Lubricating Oil & Vegetable Oil** Underside of external floating roof, top side & underside of internal floating roof, internal surface of cone roof, inside of bottom plate, Internal surfaces of Shell - including wetted and free board height, oil side surfaces of deck plates, oil side surface of pontoon of external floating roof, all outside surfaces of pontoon of internal floating roof, roof structures, structural steel, ladders and other CS internals					
1	-45 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat;	240	Note-4
b	**Petroleum Products & Intermediates like LDO, HSD , Gas Oil, Feeds of FCC-PC, FCC-LCO, VGO-HDT, ISOM, DHDT, Reformate, DCU, NHT & Gasoline, Naphtha, Isomerate & Kerosene** Underside of external floating roof, top side & underside of internal floating roof, internal surface of cone roof, inside of bottom plate, internal surfaces of bare shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surface of pontoon of external floating roof, all outside surfaces of pontoon of internal floating roof , support structures, ladders and other CS internals					
1	-45 to 45	SSPC-SP-10	1 coat of F-9 @ 75 µ DFT/coat	-	65-75	Note-4
2	46 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat;	240	Note-4
c	**Potable Water, Raw Water & Fire Water** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 60	SSPC-SP-10	1 Coats of F-6A @ 100 µ DFT/coat;	2 Coats of F-6A @ 100µ DFT/ Coat	300	Note-1
d	**De-Mineralized (DM) Water** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 60	SSPC-SP-10	1 Coats of F-6B @ 100µ DFT/coat;	2 coats of F-6C @ 200µ DFT/ coat;	500	-
2	61 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat; (80+80=160)	240	Note-2
e	**Hydrochloric Acid (HCl) 10 %** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					

1	-45 to 60	SSPC-SP-10	1 Coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat	2 Coats of F-20 @ 500µ DFT/ Coat	1100	-
f	**Aggressive Solvents like Hexane, Hexene, Benzene, Xylene & Toluene** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 65	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	---	65-75	-
g	**Ethylene Glycol (EG) Tanks** Internal shell-full height, bottom plate, underside of roof and all accessories					
1	All	SSPC-SP-10	None	3 coats of vinyl chloride co-polymer @ 75µ /Coat; (3x75=225)	225	-
h	**Inside Pontoon and Inside of Double Deck of all Floating Roofs**					
1	-45 to 80	SSPC-SP-3	1 coat of F-8 @ 100µ DFT/coat	1 coat of F-8 @ 100µ DFT/coat	200	-
i	**Wet Slops, Amine Solutions, Sour Water , Water Draw Off** All internal surfaces, accessories and roof structures of Cone and Dome roof Tanks					
1	-45 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat;	240	-
j	**Vacuum Residue, Fuel Oil , Dry Slop, Bitumen & Other High Temperature Hydrocarbon Liquids** Underside of external floating roof, top side & underside of internal floating roof, internal surface of cone roof, bottom plate, inside of bare shell – including wetted and non-wetted surfaces, oil side surfaces of deck plates, oil side surface of pontoon of external floating roof, all outside surfaces of pontoon of internal floating roof, roof structures, structural steel, ladders and other CS internals					
1	Up to 150°C	SSPC-SP-10	-	1 coat of F-17 @ 375µ DFT/ coat;	375-475	Note-3, 4
k	**Alkalis upto 50 % Concentration** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	Up to 60°C	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	2 Coats of F-6 A @ 100µ DFT/coat;	280-300	-

Notes:

1. For Potable water tank lining, F-6 A shall be suitable for drinking water service and should have certification from competent authority like NSF International Standard NSF/ANSI-61 2004 or Water Regulations Advisory Scheme (WRAS), UK or Central food research Institute Mysore, India.
2. F-15 shall be suitable for immersion in DM water upto 150 °C.
3. F-17 shall be suitable for immersion in high temperature hydrocarbons (vacuum oil, dry slop, bitumen etc.) upto 150 °C.
4. External surface of CS heating coils shall not be painted.

9.7 Coating systems for external side of underground carbon steel plant piping and underground Vessels

Sr. No.	Design Temp., °C	Surface Preparation & Shop Primer	Coating system		Total Final DFT, µ (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
a	**Underground carbon steel plant piping**					
1	25 to 65		a) For CW, CRWS & FW: Three Layer Polyethylene (3 LPE) as per EIL Job Specification no. B269-000-02-42-PCS-0002		-	-
			b) For OWS:			
			SSPC-SP-10; 1 coat of synthetic fast drying primer 25 @µ DFT/ coat	1 layer of coal tar tape coating @ 2mm +1 coat of synthetic fast drying primer 25 @µ DFT/ coat + 1 layer of coal tar tape coating @ 2mm /layer as per EIL Std. Spec. 6-79-0011		
2	65 to 150	---	SSPC-SP-10; 1 coat of F-17 primer @ 400µ DFT/ coat	1 coat of F-17 intermediate coat @ 400µ DFT/coat	800	-
3	151 to 450	---	SSPC-SP-10; 1 coat of F-16 primer @ 125µ DFT/ coat	1 coat of F-16 finish coat @125µ DFT/ coat	250	This system is suitable up to 550 °C
b	**External side of uninsulated underground storage vessels**					
1	-45 to 80	SSPC-SP-10; 1 coat of F-7 @ 125µ DFT/ coat	---	2 coats of F-7 @ 125µ DFT/coat	375	-
2	81 to 150	SSPC-SP-10; 1 coat of F-17 primer @ 400µ DFT/ coat	---	1 coat of F-17 @ 400µ DFT/coat	800	-
3	151 to 400	SSPC-SP-10; 1 coat of F-16 primer @ 125µ DFT/ coat	---	1 coat of F-16 finish coat @125µ DFT/ coat	250	This system is suitable up to 550 °C

9.8 Coating System for Insulated CS, LTCS, Low Alloy Steel & Stainless Steels Surfaces

(Insulated Structures, Piping, Equipments, Storage vessels, tanks, Columns etc.)

Sr. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT, µ (min.)	Remarks
			Primer/ Intermediate	Finish Coat		
a	**Carbon steel, LTCS and Low Alloy Steel Piping, Storage tanks, Vessels, Equipments etc. (Note-1)**					
1	-45 to 125	SSPC-SP-10; 1 coat of F-15 @ 75µ DFT/coat	-	2 coats of F-15 @ 75µ DFT/coat;	225	-
2	126 to 540	SSPC-SP-10; 2 coat of F-12 @ 20µ DFT/coat	-	2 coat of F-12 @ 20µ DFT/coat;	80	Note-2
b	**Stainless Steel and Alloy-20 Piping, Vessels & Equipments (Note-1, 3)**					
1	-45 to 125	SSPC-SP-7 (15-25µ surface profile); 1 coat of F-15@ 75 µ DFT/coat	-	2 coat of F-15 @ 75 µ DFT/coat;	225	
2	126 to 550	SSPC-SP-7 (15-25µ surface profile); 1 coat of F-16/ Inert Polymeric Matrix @ 125 µ DFT/coat	-	1 coat of F-16/ Inert Polymeric @ 125 µ DFT/coat	250	
c	**Cyclic Service of Carbon Steel, LTCS, Alloy Steels & Stainless Steel (Note 4)**					
1	- 45 to 125	SSPC-SP-10 For CS, LTCS & Low Alloy Steel, SSPC-SP-7 for SS (15-25µ surface profile); 1 coat of F-15 @ 75 µ DFT/coat	-	2 coat of F-15 @ 75 µ DFT/coat;	225	Note-5

2	-180 to -45 and 126 to 650	SSPC-SP-10 For CS, LTCS & low Alloy Steel; SSPC-SP-7 for SS (15-25µ surface profile) ; 1 coats of inert polymeric matrix coating @ 125 µ	-	1 coats of inert polymeric matrix coating @ 125 µ	250	

Notes

1. Coating system for design temperature range not covered in Sr. No. a & Sr. No. b, shall be as per the Sr.No.c2.
2. Alternatively, for Tanks, Vessels & Equipments, thermally sprayed aluminium coating (TSAC) @ 300µ as per ANNEXURE-I is also acceptable.
3. The blast cleaning abrasives for SS and Alloy steel surfaces shall be Aluminium oxide grits/shots or garnet.
4. "Cyclic Service" is characterized by rapid temperature fluctuation.
5. Alternatively, for this temperature range, 1 coat of F-17 @ 300 µ is also acceptable.
6. No painting is required for insulated Monel, Incoloy and Nickel lines.

9.9 Internal Coating System for carbon steel components of coolers/ condensers for fresh water service

(Water boxes, channels, partition plates, end covers and tube sheets etc.)

Sr. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT, µ (min.)	Remarks
			Primer	Finish paint		
1	-45 to 80	SSPC-SP-10	1 coat of F-15 @ 80 microns	2 coats of F-15 @ 80µ DFT/coat;	240	-
2	80 to 140	SSPC-SP-10	---	1 coat of Glass Fibre Reinforced Novolac Epoxy	1500	-

Note: Above table is applicable in line with the data sheets of the respective exchangers.

9.10 Internal Coating System for galvanized or non-ferrous or stainless steel/ duplex stainless steel components of coolers/ condensers for fresh water service

Sl. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT (min.), µ	Remarks
			Primer	Finish paint		
1	-45 to 80	Sweep Blasting	1 coat of F-15 @ 80µ DFT/coat;	1 coat of F-15 @ 80µ DFT/coat;	160	-
2	80 to 140	Sweep Blasting	-	1 coat of Glass Fibre Reinforced Novolac Epoxy	1500	-

Note: Above table is applicable in line with the data sheets of the respective exchangers.

10.0 STORAGE

All paints and painting materials shall be stored only in rooms to be arranged by contractor and approved by Engineer-in-charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word "PAINT STORAGE – NO NAKED LIGHT – HIGHLY INFLAMABLE" shall be clearly displayed outside. Manufacturer's recommendation shall be followed for storage of paint materials.

11.0 COLOUR CODE

The colour coding of OWNER is applicable. It is in the applicators/contractors scope to obtain confirmation for applicable colour coding from the OWNER.

In absence of any existing color coding scheme of the OWNER, Color Code scheme given in ANNEXURE-II shall be followed.

12.0 IDENTIFICATION OF COLUMNS, TANKS, VESSELS & PIPINGS etc.

12.1 Equipment number shall be stencilled in black or white on each vessel, column, equipment & machinery (insulated or uninsulated) after painting. Line number in black or white shall be stencilled on all the pipe lines of more than one location as directed by Engineer-In-Charge; Size of letter printed shall be as below:

Column & Vessels	-	150mm (high)
Pump, compressor & other machinery	-	50mm (high)
Piping	-	40-150 mm

12.2 Identification of Storage Tanks

The storage tanks shall be marked as detailed in the drawing.

13.0 PAINTING FOR CIVIL DEFENCE REQUIREMENTS

13.1 Following items shall be painted for camouflaging if required by the Client:

a. All Columns
b. All Tanks in Offsites
c. Large Vessels
d. Spheres

13.2 Two coats of selected finishing paint as per defense requirement shall be applied in a particular pattern as per 13.3 and as per the instructions of Engineer-In-Charge.

13.3 Method of Camouflaging

13.3.1 Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matte finish).

Dark Green		Light Green		Dark Medium Brown
5	:	3	:	2

13.3.2 The patches should be asymmetrical and irregular.

13.3.3 The patches should be inclined at 30º to 60º to the horizontal.

13.3.4 The patches should be continuous where two surfaces meet at an angle.

13.3.5 The patches should not coincide with corners.

13.3.6 Slits and holes shall be painted in dark shades.

13.3.7 Width of patches should be 1 to 2 meters.

14.0 QUALITY CONTROL, INSPECTION AND TESTING

14.1 All painting materials including primers and thinners brought to site by contractor for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable (see section 16.0).

14.2 The contractor must produce Test Certificate from Pre-Qualified Paint Manufacturer for various tests as detailed out in section 17.0 of this document. The Engineer-in-Charge shall have the right to test wet samples of paint from each batch at random for verifying quality of paint supplied. Contractor shall arrange to have such tests, when called for by Engineer-in-Charge, performed at his cost at any one of the NABL accredited laboratories under witness of NACE CIP Level-2 (min.) / Owner/ Owner's representative.

Samples for the test will be drawn at random in presence Engineer-in-Charge or his representations. Following tests to be carried out if called for by Engineer-in-Charge:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)
- Drying time (touch dry & full curing)
- Adhesion
- Flexibility
- Hardness
- Storage stability (pot life)

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

14.3 The painting work shall be subject to inspection by Engineer-In-Charge at all times. In particular, following stage-wise inspection will be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

(a) Surface preparation
(b) Primer application
(c) Each coat of paint

14.4 **Surface preparation:** Following tests are to be carried out during surface preparation**.**

i) Test for presence of oil/ grease and contamination

The steel substrate after degreasing as per SSPC-SP 1 shall be tested as per following procedure to validate absence of oil and grease contamination:

- Visual inspection: Continue degreasing until all visible signs of contamination are removed.
- Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice

corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination.
- Continue degreasing and inspection till test is passed.

ii) Tests for surface finish of blasted surface shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component atleast once per 200 m^2 of blasted surface and minimum of 3 checks per shift.

iii) Test for presence of soluble salt as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg/m^2. Checks shall be done on each component atleast once per 200 m^2 of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of IS 12944-4 (water cleaning). After cleaning surface shall be retested for salt after drying.

iv) Blast Profile Measurement

The angular profile depth measurement shall be done by profile tape as per method NACE Standard RP 0287 or ASTM D 4417 method B (Profile depth gauge micrometer). Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported. If desired profile (35-50 µ or as recommended by paint manufacturer) is not achieved, blasting shall continue to get the required profile.

v) Test for Blasting Media (for every fresh batch of media and one random test during blasting):

- Blasting Media shall be visually inspected for absence of contamination and debris using 10X magnification.
- Inspection for the absence of oil contamination shall be conducted using following procedure:
  - Fill a small clean 200 ml bottle half full of abrasive.
  - Fill the bottle with potable water, cap and shake the bottle.
  - Inspect water for oil film/slick. If present, the blasting media is not to be used.
- Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.
- Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

vi) Test for Blasting Air (once daily before start of blasting and once at random during blasting):

The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate, zinc rich epoxy or zinc phosphate etc. Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer-In-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, contractor shall be responsible for making good any defects found during final inspection/guarantee period/ defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and

extra coat of paint should be applied to make-up the DFT specified without any extra cost to owner, the extra coat should have prior approval of Engineer-in-charge.

14.5 Primer Application

After surface preparation, the primer should be applied to cover the crevices, corners, sharp edges etc. in the presence of inspector nominated by Engineer-In-Charge. The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by Engineer-In-Charge before application of successive coats.

The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring dry film thickness of each coat, surface profile gauge for checking of surface profile, holiday detectors and pinhole detector and protector whenever required for checking in case of immersion conditions.

Prior to application of paints on surfaces of chimneys, the thickness of the individual coat shall be checked by application of each coat of same paint on MS test panel. The thickness of paint on test panels shall be determined by using gauge such as 'Elkometer'. The thickness of each coat shall be checked as per provision of this specification. This shall be approved by Engineer-In-Charge before application of paints on surface of chimney.

At the discretion of Engineer-In-Charge, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations. The contractor is responsible to arrange the same.

14.6 Inspection of finished coating: Inspection of applied coatings shall consist of measurement of the following:

i) Coating Dry Film Thickness Check: DFT measurement shall be as per ISO 2808. Type II electromagnetic gauges should be used for ferrous substrates. DFT gauge calibration, number of measurement shall be as per SSPC-DA 2. Measured DFT shall be within + 10% of the dry film thickness, specified in the specifications.

ii) Adhesion Testing: Adhesion of the primer to the steel substrate and inter-coat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife test in accordance with ASTM D 6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is destructive and tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform the adhesion test on a steel coupon coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m^2 of coated surface.

iii) Holiday Testing: Holiday testing shall be conducted in accordance with NACE SP 0188. For immersion services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP 0188. Any holiday is unacceptable and should be marked and repaired immediately.

14.7 The contractor shall arrange for spot checking of paint materials for Specific gravity, glow time (ford cup) and spreading rate.

14.8 Final Inspection of coating system

A final inspection shall be conducted prior to the acceptance of the work. The coating contractor and the facility owner shall both be present and they shall sign an agreed inspection report. Such reports shall include:

General

- Names of the coating contractor and the responsible personnel
- Dates when work was performed

Coating Materials

- Information on coating materials being applied
- Condition of coating materials received

Environmental Conditions

- Weather and ambient conditions
- Coating periods

Surface Preparation

- Condition of surface before preparation
- Tools and methods used to prepare surface
- Condition of surface after preparation

Coating Application

- Equipment used
- Mixing procedure prior to application
- Coating application techniques used

Testing

- Type and calibration of inspection instruments used
- Type of quality control tests performed, and results

15.0 GUARANTEE

The contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work.

16.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR/ SUB-CONTRACTOR

Painting contractor who is awarded any job for EIL, Projects under this standard must have necessary equipments, machinery, tools and tackles for surface preparation, paint application and inspection. The contractor mush have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The contractor supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

17.0 QUALIFICATION/ ACCEPTANCE CRITERIA FOR COATING SYSTEM

17.1 Pre-Qualification of Paint Coating Manufacturer and Products

Paint Coating manufacture meeting the following requirements shall be considered for supply of their products:

- Manufacturer should have been in continuous business of paint coating formulation and manufacturer for at least past 5 years.
- Manufacturer should posses past experience of supplying his products to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms in the past 5 years.
- Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon, petrochemical, fertilizer, chemical processing industry or offshore platforms.
- The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 requirements and preferably should posses ISO 14000 certificate.
- The Quality control set up should be manned by qualified paint technologists whose bio data should be sent along with quality control organization chart.

CONTRACTOR shall procure the paint materials from the qualified manufacturer meeting above requirements and after obtaining prequalification testing approval as per requirements mentioned in clause 17.2 below.

17.2 Pre-Qualification Testing Procedure:

The paint manufacturer engaged by the mechanical contractor shall carry out the tests in reputed Government Laboratories (like National Test House Mumbai, National Test House Kolkata, Institute of Chemical Technology Mumbai, HBTI Kanpur, IICT Hyderabad) as a part of qualification. Paint manufacturer shall provide the paint samples to laboratory for testing of the parameters for each category of paint as mentioned in Clause 8.0 (Paint Materials Characteristics) and testing of Coating System properties as per Table given below. The testing laboratory will confirm the compliance of the paint material with respect to the acceptance criteria mentioned in this specification. Contractor shall furnish these test certificates along with all necessary supporting documents/information to Site-in-charge for approval/ acceptance. The paint manufacturer will be qualified and approved by Site-in-charge for supply of paints after review/assessment of the submissions made by the contractor. Test certificates which are more than 3 years old will not be considered. Paint manufacturers are advised to carryout pre-qualification testing prior to paints supply at site.

TABLE: PRE-QUALIFICATION TESTING

System No.	Coating System	Reference Clause	Total DFT, µ (Min.)
1.	F-9+P6+F6A/B+F2	Clause 9.3, Sr. No. 2 of table	345
2.	F12+F12+F12	Clause 9.3, Sr. No. 3 of table	60
3.	F15+F15+F15	Clause 9.5,	240

		Sr. No. b (2) of table	
4.	F16+F16	Clause 9.5, Sr. No. b (3) of table	250
5.	F17	Clause 9.6, Sr. No. j (1) of table	375
6.	F8+F8	Clause 9.6, Sr. No. h (1) of table	200
7.	F7+F7+F7	Clause 9.5, Sr. No. b (1) of table	375
8.	F-20	Clause 9.6, Sr. No. e (1) of table	1100
9.	F6B+F6C+F6C	Clause 9.6, Sr. No. d (1) of table	500
10.	Inert Polymeric Matrix	Clause 9.5, Sr. No. c (1) of table	250
11.	F6A+F6A+F6A	Clause 9.6, Sr. No. c (1) of table	300

Sr. No.	Test	For System Number	Duration	Acceptance Criteria
1.	Cyclic Test Salt Spray: 72 hrs. Drying in air: 16 hrs. UV-A340 nm weather meter: 80 hrs. One cycle: 168 hrs. (25 cycles at 168 hrs. each cycle) (ASTM D5894)	1	4200 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling shall be observed.
2.	Chemical Resistance Test (ASTM D543)			
2a.	10% & 40% NaOH	3,5,8 & 11* *H_2SO_4 solution pH = 5.0 to 5.5 for system 11	1000 hrs.	Shall pass.
2b.	5% H_2SO_4		168 hrs.	No cracking, discoloration, blistering, peeling or softening of film shall be observed.
2c.	Xylene		4 weeks	
2d.	Acetone		4 weeks	
2e.	Ethanol		4 weeks	
2f.	Kerosene		4 weeks	

2g.	Sea water		2000 hrs.	
3.	Immersion in DM/DI water @ 90° (ASTM C868)	3,5 & 8	30 days	No softening, blistering or film damage.
4.	Resistance to DM water using water immersion. (ASTM D870)	9	2000 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling.
5.	100% Humidity Test (ASTM D2247)	1 to 11 (except system-2)	1440 hrs.	Shall pass
6.	Dry Heat Resistance Test (ASTM D2485 method B at 540^0 C for system 2 and 550^0 C for system 4)	2 & 4	-	Shall pass the test. No peeling, cracking, blistering, abnormal discoloration or loss of adhesion.
7.	Thermal Shock Resistance Test; 5 cycles @ 30 minutes in furnace at 120 ^{0} C and 15 minutes in water after quenching in water for each cycle. (ASTM D2485 method A)	2,3,4 & 10 (For system-2, testing to be done after heating the panels at 175°C for 2 hrs.)	-	Shall pass
8.	Cathodic Disbondment Test (ASTM G8 @ 60°C)	3 & 5	-	Shall pass

Each coating product to be qualified shall be identified by the following:

1) Specific gravity of Base and curing agent (Ref. ISO 2811)
2) Ash content (ASTM D1650), volatile and non-volatile matters (ISO 3251) of each component

These identification tests of coating materials shall be carried out on the batch, which is used for the Pre-qualification testing and in the same reputed government laboratory.

17.3 Information to be furnished during delivery of paint materials:

CONTRACTOR along with delivery of paint material has to furnish following information from paint manufacturer to EIL for acceptance/approval of products:

a) Batch test certificates

Along with paint products delivery to site from the pre-qualified coating manufacturer, CONTRACTOR has to produce test certificate (from paint manufacturer) for each category of product for the following test items. All test results must mention clearly the batch no. and category of product tested. Tests shall be witnessed by NACE CIP Leve-2 (minimum) inspector. Tests to be conducted for following properties:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)

b) Product information sheet/ technical data sheet for each category of product

The contractor shall be fully responsible for the quality of the paints products as per prequalification testing. After the paint materials are supplied to site, the supplier shall organize random sampling and testing in a laboratory as per discretion of the Engineer-in-charge (refer clause 14.2). Failing to meet the specified quality requirements may cause rejection of the paint products.

18.0 METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING

(Pre-Qualification tests (sec. 17.2), Batch testing (sec. 17.3) and Inspection testing (sec. 14.0))

18.1 Samples of coating materials should be submitted to the laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory.

18.2 All test panels should be prepared by testing laboratory. Surface preparation for a system shall be done in accordance with this specification. For individual products testing, minimum surface preparation shall be Sa 2.5. Colour photographs of test panels should be taken before and after the test and should be enclosed along with test report.

Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

18.3 Manufacturers should intimate EIL, details of sample submitted for testing, name of testing agency, date, and contact personnel of the testing agency.

ANNEXURE-I

SPECIFICATION FOR THERMALLY SPRAYED ALUMINIUM COATING (TSAC)

1.0 SCOPE

The following sections outlines the requirement of supply, application and testing of thermally sprayed aluminum coatings (TSAC) for corrosion protection of carbon steel piping and equipments with design temperature not exceeding 540 ^{0} C.

2.0 ITEMS TO BE THERMALLY SPRAYED

Steel Structures/equipments to be protected by TSAC shall be as specified in this specification. Structures, components thermally sprayed shall not have any uncoated area or shall not be in mechanically connected by flanges etc to any uncoated bare steel work. Such adjacent areas to TSA coated areas, if not coated by TSA shall have suitable paint coating system as per the standard specification.

3.0 TSAC REQUIREMENTS

3.1 Surface Preparation

All the parts to be sprayed shall be degreased according to SSPC-SP-1. The absence of oil and grease after degreasing shall be tested by method given elsewhere in the specification (Refer Sec. 6.7). Thereafter the surface to be abrasive blasted to white metal finish as per NACE 1/SSPC-SP-5 for marine and immersion service. Using SSPC VIS 1, it is to be visually assessed that the blast cleaned surface meets requirement of SSPC-SP-5. Thereafter clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on the blasted surface. Finally blasted surface shall be tested for presence of soluble salts as per method ISO 8502-9. Maximum allowable salt content shall be considered 50mg/m^2. (5 micrograms/cm^2) .In case salt content exceeds specified limit. The contaminated surface shall be cleaned by method as per Annex C of IS 12944-4 (Water Cleaning). After cleaning the surface shall be retested for salt content after drying. Testing shall be carried out at least on each component, once per 200 m^2 and a min of 3 times per shift during progress of work.

The blasting media shall be either chilled iron or angular steel grit as per SSPC-AB-3 of mesh size G-16 to G-40. Copper, Nickel slag, Garnet or Aluminum Oxide as abrasives will also be suitable having mesh size in the range of G16 to G24 (10-30 mesh), conforming to SSPC-AB-1. Mesh size shall be required as appropriate to the anchor tooth depth profile requirement and blasting equipment used. The blasted surface should be having angular profile depth not less than 65 microns with sharp angular shape but shall not exceed 85 microns. The profile depth shall be measured according to NACE standard RP 0287 (Replica Tape) or ASTM D 4417 method B (Profile depth gauge).

For manual blasting one profile depth measurement shall be taken every 10-20 m^2 of blasted surface. Surface preparation shall be completed in one abrasive blast cleaning operation wherever possible. If rust bloom (visual appearance of rust) appears on the blast cleaned surface before thermal spraying, the affected area shall be re-blasted to achieve specified degree of cleanliness after which only thermal spraying shall commence.

Air blasting pressure at nozzle shall be normally maintained at 100 psi. Air pressure and media size should be reduced and adjusted to preclude damage/distortion to thin gauge materials. Blasting time on work piece should be adjusted to only clean the surface and cut required anchor tooth with minimum loss of metal. Blast angle should be as close to perpendicular as possible but in no case greater than $\pm 30^{0}$ from perpendicular to work surface. Blasting media must be free of debris, excessive fines, and contaminants such as NaCl and sulfur salts (Ref. SEC 6.0 of this Spec). Blast cleaning shall not be performed when the surfaces to be blasted are wet or less than 5°C above dew point temperature or when the relative humidity in the vicinity of the work is greater than 90%.

3.1.1 Blasting Equipment

The TSAC applicator shall use mechanical (centrifugal wheel) or pressure pot blast cleaning equipment and procedures. Suction blasting equipment shall not be used. Sec 6.6.2 shall be used to validate clean and dry air.

3.1.2 Feed Stock

The feed stock shall be in the form of wire. The feed stock shall be 99.5% aluminum of commercial purity grade, its composition shall be in accordance with requirement of BS 1475 or ASTM B833 or ISO 209-1 type A1 (wrought aluminum and aluminum alloys, wire). Wire shall be supplied in protective wrapping indicating batch number and other details.

3.1.3 Thickness Requirement

The nominal thickness of finished TSAC shall be 300 microns having minimum value of 275 microns at low thickness areas (valleys) and not more than 325 microns at peak areas.

The finished thickness shall be measured using SSPC-PA 2 type 2 fixed probe gauge (Magnetic Gauge).

3.1.4 Coating Bond Strength Requirement

The TSAC coating shall have a minimum individual tensile-bond strength value of 1000 psi for flame sprayed and 1500 psi for arc sprayed coating with an average of 2000 psi for arc sprayed coatings. Minimum tensile bond strength should be achieved by proper anchor tooth profile of blasted surface, laying down the TSA thickness in multiple passes and carrying out TSA application under controlled environment

3.1.5 Porosity

All thermally sprayed metallic coatings will have porosity. For thermally sprayed aluminum coatings porosity shall not exceed 15% of total surface area for flame sprayed coating and 8% for arc spray coating.

4.0 THERMAL SPRAY APPLICATION PROCEDURE

Items in the atmospheric zone to be coated by TSA shall be applied by either Flame spray or Arc spray method only. For coating under insulation, application shall be by arc wire method.

4.1 Equipment Set Up

4.1.1 Thermal spray equipment shall be set up calibrated, operated (1) according to manufacturer instructions/technical manuals and also TSAC applicators refinement thereto and (2) as validated by Procedure Qualification (Sec 7.0 of this specification).

4.1.2 **Spray Parameters**

Spray parameters (see 4.1.3 below) and thickness of each crossing pass shall be set and shall be validated with bend test (See 6.5 of this Spec).

4.1.3 Spray Parameters

Spray Parameters	Method of Application	
	Arc wire Spray	Flame Wire Spray
Arc voltage	27 V	-
Air pressure	80 psi	80 psi
Steel surface cleanliness	NACE-1 white metal	NACE-1 white metal / or Near white metal
Steel surface profile	75 microns (minimum)	75 microns (min.)
Arc current	250-280A	-
Coating thickness	225 microns (nominal)	225 microns(Nominal)
Coating adhesion	> 1500 psi (Total coating),see 3.1.4	>1000 psi
Coating porosity	Less than 8%	Less than 15%.
Spray distance (spray Gun work piece)	6-8”	5-7”
Spray Pass width	40mm	20 mm

The above parameters to be validated with a bend test by the contractor before start of work (for details of bend test see Sec 6.5 of this Spec).

4.2 Post Blasting Substrate Condition and Thermal Spraying Period.

4.2.1 The steel surface temperature shall be at least 5°C above dew point of ambient air temperature.

Steel substrate surface temperature shall be recorded by with a contact pyrometer. Thermal spraying should commence within 15 minutes from the time of completion of blasting

4.2.2 **Holding Period**

Time between the completion of final anchor tooth blasting and completion of thermal spraying of blasted surface should be no more than four hours. If within this period rust bloom appears Sec 4.4.1 of this specification will apply.

4.3 Pre-Heating

For flame spraying, the initial starting area of 1-2 square feet to be preheated to approx.120^{0}C to prevent condensation of moisture in the flame on the substrate. For arc spraying the preheating is not required.

4.4 Thermal Spraying

Spraying should commence only after validation of equipment set up by procedure qualification test and spray parameter validation tests described in Sec 7.0 and 6.5 respectively. Thermal spraying must commence within 15 minutes from the time of completion of blast cleaning

The specified coating thickness shall be applied in several crossing passes. The coating bond strength is greater when the spray passes are kept thin. Laying down an excessively thick spray pass increases the internal stresses in TSAC and decreases the bond strength of total TSAC. The suitable thickness for crossing passes shall be determined by procedure qualification test described in Sec 7.0 of this specification.

For manual spraying, spraying to be done in perpendicular crossing passes to minimize thin spots in coating. Approx. 75-100 microns of TSAC shall be laid down in each pass.

The surface geometry of the item or area to be sprayed should be inspected before application. The spraying pass and sequence shall be planned according to following.

- Maintain Gun as close to perpendicular as possible and within ± 30° from perpendicular to the substrate.
- Maintain nominal standoff distance and spray pass width as given below:

Spray method	Standoff (Inches)	Spray pass width (Inches)
Arc Wire	6-8	1 ½(40mm)
Flame wire	5-7	¾(20mm)

4.4.1 **Rust Bloom** (Visual appearance of rust or Discoloration):

If Rust bloom appears on the blasted surface before thermal spraying, the affected area shall be re-blasted to achieve the specified level of cleanliness.

If Rust bloom in form of discoloration, or any blistering or a degraded coating appears at any time during application of TSAC, then spraying shall be stopped and acceptable sprayed area shall be marked off. The unsatisfactory areas shall be repaired to the required degree of surface cleanliness and profile.

Blast the edges of the TSAC to provide for 2-3” feathered area overlap of the new work into existing TSAC.

Then apply TSAC to the newly prepared surfaces and overlap the existing TSAC to the extent of feathered edge so that overlap is a consistent thickness.

4.4.2 **Masking**

Masking all those parts and surfaces which are not required to be thermally sprayed as instructed by purchaser should be inspected by applicator to ensure that they are properly marked and covered by purchaser.

Complex geometries (flanges, valve manifolds, intersections) shall be masked by applicator to minimize overspray i.e. TSAC applied outside spray parameters (primarily gun to substrate distance and spray angle).

4.4.3 **TSAC Finish**

The deposited TSAC shall be uniform without blisters, cracks, loose particles, or exposed steel as examined with 10 X magnification.

5.0 SEALER

Sealant shall be applied after satisfactory application of TSAC and completion of all testing and measurements of the finished TSAC as per Sec 6.0 of this specification.

For shop work Sealer shall be applied immediately after thermal spraying and for field work sealer shall be applied within 8 hours. The sealcoat shall be thin enough to penetrate into the body of TSAC.

The sealant shall be Silicone Alkyd Aluminium paint having DFT not more than 35-40 micron. Typically seal coat shall be applied at a spreading rate resulting in theoretical 38 microns DFT. The seal coat shall be applied in accordance with SSPC-PA 1 and the paint manufacturer instruction for sealing.

6.0 TESTING AND MEASUREMENT SCHEDULE

6.1 Surface Finish

That the blasted cleaned surface meets the required criteria (NACE 1/SSPC-SP 5) shall be visually inspected using SSPC-VIS 1. The clear cellophane-tape test as per ISO 8502-3 shall be used to confirm absence of dust or foreign debris on the cleaned surface. Checks shall be done on each component at least once per 200 m^2 of blasted surface and minimum of 3 checks per shift.

6.2 Blast Profile Measurement: (In-Process testing during actual production before application of TSA coating)

The angular profile depth measurement shall be done by profile tape as per method NACE Standard RP 0287 or ASTM D 4417 method B (Profile depth gauge micrometer). Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported.

If profile is <65 microns blasting shall continue till greater than 65 microns depth profile is achieved.

6.3 TSAC Thickness (In-Process Testing For finished coating during regular production)

6.3.1 TSAC finished thickness shall be measured using SSPC-PA 2 type 2 fixed probe gauge.

6.3.2 For flat surfaces, measurements shall be taken along a straight measurement line, one measurement line for every 15 m^2 of applied TSAC shall be selected along which 5 measurements to be taken at 25 mm internal and average to be reported.

6.3.3 For curved surface or complex geometry, 5 measurements shall be taken at a spot measuring 10 cm^2 in area. One spot to be taken for every 15 m^2 of applied TSAC area.

6.3.4 The TSAC thickness in surface changes or contour changes, welds and attachments shall be also measured and reported.

6.3.5 If TSAC is less than specified minimum thickness, apply additional TSAC until specified thickness range is achieved.

6.3.6 All locations and values of TSAC thickness measurements shall be recorded in Job Record (JR).

6.4 Tensile Bond Testing (In-Process testing for finished coating during regular production)

- Tensile Bond strength of the TSAC finish coat shall be determined according to ASTM D 4541 using a self-aligning adhesion tester.

- One measurement shall be made every 50 m^2. If tensile bond at any individual spot is less than 1000 psi for flame sprayed coating and 1500 psi for arc sprayed coating the degraded TSAC shall be completely removed and reapplied.

- The tensile bond portable test instrument to be calibrated according to ASTM C 633

6.5 Bend Tests

Bend test shall be carried out at beginning of each work shift. Bend tests shall also be conducted on sample coupons before start of thermal spraying work to qualify the following as mentioned earlier in this specification.

- To qualify spray parameters and thickness of each crossing pass.

6.5.1 **Test Procedure**

a) Five corrosion control steel coupons each of dimension 50 mm x 150 mm x 1.3 mm thick to be prepared.

b) Surface shall be prepared by dry abrasive blast cleaning as per this specification.

c) TSAC shall be applied as per specified thickness range. TSAC should be sprayed in crossing passes laying down approx. 75-100 microns in each pass.

d) TSAC applied coupons shall be bent 180° around a 13 mm diameter mandrel.

e) Bend test shall be considered passed if on bend radius there is

- No cracking or spalling or lifting by a knife blade from the substrate
- Only minor cracking that cannot be lifted from substrate with a knife blade.

f) Bend test fails if coating cracks with lifting from substrate.

6.6 Tests for blasting media, blasting air

6.6.1 Blasting Media (For every fresh batch of media and one random test during blasting)

Blasting Media shall be visually inspected for absence of contamination and debris using 10 X magnification.

a) Inspection for the absence of oil contamination shall be conducted using following procedure :

- Fill a small clean 200 ml bottle half full of abrasive.
- Fill the bottle with potable water, cap and shake the bottle.
- Inspect water for oil film/slick. If present, the blasting media is not to be used.

b) Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.

c) Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

6.6.2 Test for Blasting Air (Once Daily before start of blasting and once at random during blasting)

The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

6.7 Test for presence of oil/grease and contamination

The steel substrate after degreasing as per SSPC-SP 1 shall be tested as per following procedure to validate absence of oil and grease contamination.

a) Visual inspection - Continue degreasing until all visible signs of contamination are removed.

b) Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination.

Continue degreasing and inspection till test is passed.

7.0 TSAC APPLICATOR QUALIFICATION

Following tests to be carried out as part of procedure qualification test for the applicator.

- Thickness measurement
- Coating bond strength
- Porosity test
- Bend strength

TSAC applicator's surface finishing and application process and equipment set up, calibration and operation shall be qualified by application of TSA on a reference sample which shall be used as a comparator to evaluate the suitability of application process. Only that applicator will be permitted to carry out the work when test specimens coated by the applicator meets the desired requirements as cited below.

The sample shall be made of a steel plate measuring approx. 18"x 18" x ¼" thick. If the actual work is less than ¼" thick then the sample to be made from material of representative thickness.

The surface preparation, TSAC application shall be made with actual field equipments and process/spray parameters and procedures as per the specification. The depth profile of blasted surface, TSAC coating thickness for each cross pass and total thickness range shall be as per specification.

The surface preparation and thermal spraying shall be carried out in representative environmental conditions spraying with makeshift enclosure.

7.1 After application of coating, thickness and tensile bond measurements shall be made in following manner.

- Divide the sample piece into four quadrants.
- Measure thickness along the diagonal line of each quadrant.
- Four each quadrant five in-line thickness measurements at 1" interval shall be done using SSPC-PA 2 type 2 fixed probe gauge. Thus a total of four "five in line" thickness measurements to be done for the whole sample.
- One tensile bond measurement using ASTM D 4541 type III or IV portable self-aligning test instrument to be done at centre of each quadrant. Total of 4 measurements for the sample.
- One porosity evaluation test by Metallographic examination shall be conducted to demonstrate the achievement of porosity within the limits specified. Sample shall be prepared for Metallographic examination as per ASTM E-3.
- The procedure shall be considered qualified if thickness and tensile-bond strength and porosity values meet the specification requirement.

7.2 Bend test: Bend test shall be carried out as detailed at sec. 6.5 of this specification.

Applicators thermal spray equipment set-up, operation and procedure of application including in-process QC checkpoints adopted during procedure qualification as described above should be always subsequently followed during entire duration of work.

8.0 DOCUMENTATION

The following information shall be provided by TSAC applicator before award of work.

- TSAC application process consisting of equipment capabilities and their technical parameters, feed stock material and source of procurement.
- Detailed application procedure and in-process quality control check points for (a) surface preparation (b) thermal spraying (c) seal coats.
- Type and specification of instruments to be deployed for measurement of blast profile depth, TSAC thickness and tensile bond.
- Paint manufacturer data sheet for the selected sealing coat to be applied.

9.0 RECORDS

- The TSAC applicator shall maintain job record to record production and QC information. All the results of the tests and quality control checks shall be entered in the record for each component/part thermally sprayed. All the result of tests (thickness, tensile bond, bend tests) and other validation tests (e.g. procedure qualification test, test for surface cleanliness after abrasive blasting, test for cleanliness of abrasives and air) shall also be recorded and duly signed by the Owner/ Owner's Representative.

- All the information mentioned in Sec 8.0 above should also form part of the Job record.

- Any modification affected after procedure qualification in the procedure, QC, spray parameter, equipment spec to the original information (submitted before award of the work) must also form part of Job record.

10.0 WARRANTY

The TSAC applicator shall warrant the quality of material used by providing the purchaser with a certificate of materials used to include

- Spray feed stock: Alloy type/designation, Lot Number, wire diameter, chemical analysis, name of supplier, manufacturer.

- Sealant: Name of manufacturer, application data sheet.

11.0 SAFETY

The TSAC applicator shall follow all safety procedures required by the purchaser/owner. Owner shall also give compliance requirement to be followed by applicator. The applicator shall follow all appropriate regulatory requirements.

12.0 CODES AND STANDARDS

This specification shall apply in case of conflict between specification and following applicable standards:

AWS C. 2.17	Recommended Practice for Electric arc Spray.
ASTM C 633	Test Method for Adhesive/Cohesive Strength of Flame Sprayed Coatings.
ASTM D 4285	Method for indicating Oil or Water in Compressed Air.
ASTM D 4417	Test Method for Field Measurement of Surface Profile of Blasted Steel.
BS 2569	Specification for Sprayed Metal Coating.
NACE Standard RP 0287	Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape.
ASTM D 4541	Test method for Pull-Off Strength of Coating Using Portable Adhesion Testers.
ANSI/AWS C2.18	Guide for the Protection of Steel with Thermal Spray Coatings of Aluminum, Zinc and Their Alloys and Composites.
NACE No. 12/AWS C2.23M/SSPC-CS	Specification for the application of thermal spray coatings (Metallizing) of aluminum, zinc, and their alloys and composites for the corrosion protection of steel.

23.00	
SSPC Publication	The inspection of coatings and linings: A Handbook of Basic practice for Inspectors, Owners, and Specifiers.
SSPC-AB 1	Mineral and Slag Abrasives.
SSPC-AB 3	Ferrous Metallic Abrasives.
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel.
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages.
NACE No. 1/SSPC-SP 5	White Metal Blast Cleaning.
NACE No. 2/SSPC-SP 10	Near –White Metal Blast Cleaning.
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.

ANNEXURE-II

COLOR CODE

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on these specified length to identify the particular service. Colour code is applicable for both unit and offsite pipes.

SR. No.	SERVICE	RECOMMNDED COLOUR FOR PAINT SYSTEM	RAL COLOUR CODE	
			BASE COLOUR	BAND COLOUR
	HYDROCARBON LINES (UNINSULATED)			
1	CRUDE SOUR	Dark Admiralty grey with 1 orange band	7012	2011
2	CRUDE SWEET	Dark Admiralty grey with 1 red band	7012	3001
3	LUBE OILS	Dark Admiralty grey with 1 green band	7012	6010
4	FLARE LINES	Heat Resistant Aluminium	9006	
5	LPG	Orange with 1 oxide red band	2011	3009
6	PROPYLENE	Orange with 2 blue bands	2011	5013
7	NAPTHA	Orange with 1 green band	2011	6010
8	M.S.	Orange with 1 dark admiralty grey band	2011	7012
9	AV.GASOLINE (96 RON)	Orange with 1 band each of green, white and red bands	2011 / 6010	9010 / 3001
10	GASOLINE (regular, leaded)	Orange with 1 black band	2011	9005
11	GASOLINE (premium, leaded)	Orange with 1 blue band	2011	5013
12	GASOLINE (white)	Orange with 1 white band	2011	9010
13	GASOLINE (Aviation 100/130)	Orange with 1 red band	2011	3001
14	GASOLINE (Aviation 115/145)	Orange with 1 purple band	2011	4006
15	N-PENTANE	Orange with 2 blue bands	2011	5013
16	DIESEL OIL (White)	Oxide red with 1 white band	3009	9010
17	DIESEL OIL (Black)	Oxide red with 1 yellow band	3009	1023
18	KEROSENE	Oxide red with 1 green band	3009	6010
19	HY.KEROSENE	Oxide red with 2 green bands	3009	6010
20	DISUFIDE OIL (EX-MEROX)	Oxide red with 1 black band	3009	9005
21	M.T.O	Oxide red with 3 green bands	3009	6010
22	DHPPA	Oxide red with 2 white bands	3009	9010
23	FLUSHING OIL	Oxide red with 2 black bands	3009	9005
24	LAB FS	Oxide red with 2 dark admiralty grey bands	3009	7012
25	LAB RS	Oxide red with 3 dark admiralty grey bands	3009	7012
26	LAB (Off. Spec)	Oxide red with 1 light grey band	3009	7035
27	N-PARAFFIN	Oxide red with 1-blue band	3009	5013
28	HEAVY ALKYLATE	Oxide red with red band	3009	3001
29	BLOW DOWN, VAPOR LINE	Off white / Aluminum with 1-Brown band	9006	8004
30	BLOWDOWN	Off white / Aluminum with 2 brown bands	9006	8004
31	A.T.F.	Leaf brown with 1 white band	8003	9010
32	TOULENE	Leaf brown with 1 yellow band	8003	1023

33	BENZENE	Leaf brown with 1 green band	8003	6010
34	LAB PRODUCT	Leaf brown with 1 blue band	8003	5013
35	FUEL OIL	Black with 1 yellow band	9005	1023
36	FULE OIL (Aromatic rich)	Black with 2 yellow bands	9005	1023
37	ASPHALT	Black with 1 white band	9005	9010
38	SLOP AND WASTE OILS	Black with 1 orange band	9005	2011
39	SLOP AROMATICS	Black with 2 orange bands	9005	2011
	CHEMICAL LINES			
40	TRI-SODIUM PHOSPHATE	Canary yellow with 1 violet band	1012	5000
41	CAUSTIC SODA	Canary yellow with 1 black band	1012	9005
42	SODIUM CHLORIDE	Canary yellow with 1 white band	1012	9010
43	AMMONIA	Canary yellow with 1 blue band	1012	5013
44	CORROSION INHIBITOR	Canary yellow with 1 Aluminum band	1012	9006
45	HEXAMETA PHOSPHATE	Canary yellow with 2 black bands	1012	9005
46	ACID LINES	Golden Yellow with 1 red band	1004	3001
47	RICH AMINE	Canary yellow with 2 blue bands	1012	5013
48	LEAN AMINE	Canary yellow with 3 blue bands	1012	5013
49	SOLVENT	Canary yellow with 1 green band	1012	6010
50	LCS	Canary yellow with 1 smoke grey	1012	7031
	WATER LINES			
51	RAW WATER	Sky blue with 1 black band	5015	9005
52	INDUSTRIAL WATER	Sky blue with 2 signal red band	5015	3001
53	TREATED WATER	Sky blue with 1 oxide red band	5015	3009
54	DRINKING WATER	Sky blue with 1 green band	5015	6010
55	COOLING WATER	Sky blue with 1 light brown band	5015	1011
56	SERVICE WATER	Sky blue with 1 signal red brown	5015	3001
57	TEMPERED WATER	Sky blue with 2 green bands	5015	6010
58	DM WATER	Sky blue with 1 aluminum band	5015	9006
59	DM WATER ABOVE 150°F	Sky blue with 2 black bands	5015	9005
60	SOUR WATER	Sky blue with 2 yellow bands	5015	1013
61	STRIPPED WATER	Sky blue with 2 blue bands	5015	5013
62	ETP TREATED WATER	Sky blue with 2 oxide red bands	5015	3009
	FIRE PROTECTION SYSTEM (ABOVE GROUND)			
63	FIRE WATER FOAM & EXTINGUISHERS	Post office red	3002	
	AIR & OTHER GAS LINES (UNINSULATED)			
64	SERVICE AIR	Sea green with 1 signal red band	6018	3001
65	INSTRUMENT AIR	Sea green with 1 black band	6018	9005
66	NITROGEN	Sea green with 1 orange band	6018	2011
67	FREON	Sea green with 1 yellow band	6018	1023
68	CHLORINE	Canary yellow with 1 oxide band	1012	3009
69	SO_2	Canary yellow with 2 white bands	1012	9010
70	H_2S	Orange with 2 red oxide bands	2011	3009
71	GAS (Fuel)	Orange with 1 aluminum band	2011	9006
72	GAS (Sour)	Orange with 2 aluminum bands	2011	9006
73	GAS (Sweet)	Orange with 2 signal red band	2011	3001

74	HYDROGEN	Orange with 1 light green band	2011	6021
STEAM AND CONDENSATE LINES (UNINSULATED)				
75	HP STEAM	Off white / Aluminum with 1 yellow band	9006	1023
76	MP STEAM	Off white / Aluminum with 1 red band	9006	3001
77	MLP STEAM	Off white / Aluminum with 1 orange band	9006	2011
78	LP STEAM	Off white / Aluminum with 1 light green band	9006	6021
79	CONDENSATE	Sky blue with 1 white band	5015	9010
80	CONDENSATE ABOVE 150°F	Sky blue with 3 oxide red band	5015	3009
81	BFW	Sky blue with 2 red bands	5015	3001
Note: For all insulated steam lines, the colour coding shall be follow as given for un-insulated lines with the specified length of color bands.				
INSULATED HYDROCARBON PIPING				
82	IFO SUPPLY	1Black ground colour with 1 yellow band in centre	9005	1023
83	IFO RETURN	Black ground colour with 1 green band in centre	9005	6010
84	HPS	Black ground colour with 1 red band in centre	9005	3001
85	BITUMEN	Black ground colour with 2 red bands in centre	9005	3001
86	CLO	Black ground colour with 1 brown band in centre	9005	8004
87	VB TAR	Black ground colour with 2 brown bands in centre	9005	8004
88	VR AM (BITUMEN / VBU FEED)	1 Black ground colour with 1 blue band in centre	9005	5013
89	VR BH	1 Black ground colour with 2 blue bands in centre	9005	5013
90	VAC. SLOP	1 Black ground colour with 1 white band in centre	9005	9010
91	SLOP	1 Black ground colour with 1 orange band in centre	9005	2011
92	CRUDE SWEET	1 Dark admiralty grey ground colour with 1 red band in centre	7012	3001
93	CRUDE OUR	1 Dark admiralty grey ground colour with 1 orange band in centre	7012	2011
94	VGO / HCU	1 Oxide red ground colour with 2 steel grey bands in centre	3009	7011
95	OHCU BOTOM / FCCU FEED	1 Oxide red ground colour with 2 steel grey bands in centre	3009	7011
UNINSULATED EQUIPMENTS, TANKS AND STRUCTURES				
96	HEATER STRUCTURE	Steel grey	7011	
97	HEATER CASING	Heat resistant aluminium	9006	
98	VESSELS & COLUMNS	Aluminium	9006	
99	HYDROGEN BULLETS	Pink	3014	
100	LPG VESSELS	Oxide red	3009	
101	SO_2 VESSEL	Canary yellow	1012	
102	HEAT EXCHANGER	Heat resistant aluminium	9006	
103	FO TANK AND HOT TANKS	Black	9005	

104	ALL OTHER TANKS	Aluminum / Off white	9006
105	CAUSTIC / AMINE / ACID TANKS	Golden yellow	1004
106	SOUR WATER	Sky Blue	5015
107	OUTER SURFACE IN BOILER HOUSE	Heat resistant aluminum	9006
108	COMPRESSORS AND BLOWERS	Dark admiralty grey	7012
109	PUMPS	Navy blue	5014
110	MOTORS & SWITCH GEAR	Bluish green	5024
111	HAND RAILING, MIDDLE RAIL, TOE PLATE, LADDER VERITAL POSTS, OVER HEAD MONORAIL, MONORAIL STOPPER PLATES, COKE CUTTING SYSTEM	Signal red	3001
112	STAIRCASE, LADDER, WALKWAYS, LADDER RUNGS, RAILING VERTICAL POSTS, CHEQUERED PLATE (BOTH FACES), GRATINGS	Black	9005
113	LOAD LIFTING EQUIPMENT	Leaf brown	8003
114	GANTRY GIRDER & MONORAIL	Dark Green	6009
115	EOT / HOT CRANES	Canary Yellow	1012
116	PIPE RACK STRUCTURALS, BUILDING STRUCTURALS, STEEL COLUMNS, BRACKETS, BEAMS, BRACINGS, ROOF TRUSSES, PURLINGS, SIDE GIRTS, LOUVERS, STRINGERS	Dark admiralty grey	7012
117	TRANSFORMERS & BATTERY ROOM STRUCTURALS	Dark admiralty grey	7012
118	ELECTRICAL MOTORS	Dark Blue	5013
119	GENERAL STRUCTURE	Black	9005
	PIPES AND FITTINGS OF ALLOY STEEL AND SS MATERIAL IN STORE		
120	IBR	Signal red	3001
121	9Cr-1Mo	Verdigris green	6021
122	5Cr-0.5Mo	Satin blue	5012
123	$2_{1/4}$Cr-1 Mo	Aircraft yellow	1026
124	$1_{1/4}$Cr-½ Mo	Traffic Yellow	1023
125	SS-304	Dark blue grey	5008
126	SS-316	Dark violet	4005
127	SS-321	Navy blue	5014

SAFETY COLOUR SCHEMES				
128	DANGEROUS OBSTRUCTION	Black and alert orange band	9005	2008
129	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Alert orange	2008	

Notes:

- All LPG service PSVs shall be painted in Deep Blue (RAL 5014).
- All drains & Vents shall be painted in Main line colour.
- The colour code scheme is for identification of piping service group. It consists of a ground colour and 1 or more colour bands.
- For electrical items, color code requirements as per electrical specifications shall be applicable. In absence of any specific color code requirements in electrical specification, color code mentioned in above table shall be followed.

Ground Colour

On uninsulated pipes, the entire pipe has to be painted in ground colour, and on metal cladded insulated lines, minimum 2M long portion should be painted.

Colour Bands

Location of colour bands:

- At Battery Limits
- Intersection points & change of direction points in piping
- Midway of piping section, near valves, across culverts
- At 50 M interval on long stretch pipes
- At starting and termination points.

Minimum width:

NB	Width
3” and below	75 mm
Above 3” to 6”	NB X 25 MM
Above 6” to 12”	NB X 18 MM
Above 12”	NB X 15 MM

For insulated pipes, NB indicates OD of the insulation.

Sequence:

Colour bands shall be arranged in sequence showing Table above and the sequence follows the direction of flow. The width of the 1st Band to 2nd band is 4:1,

Wherever deemed required by Process Department or Safety, pipes handling hazardous substances will be given hazard marking of 30 mm wide diagonal stripes of Black and Golden Yellow as per IS : 2379 or any other equivalent international standard.

Special Camouflage Painting for Uninsulated Crude and Product Storage Tanks.

Coating System shall be as per this specification.

Camouflage painting scheme for Defense requirement in irregular patches will be applied with 3-colours:

Dark Green	:	Light green	:	Medium Brown
5	:	3	:	2

- The patches shall be irregular and asymmetrical and inclined at 30 to 60 Degrees.
- Patches should be continuous at surface meeting lines / points.
- Slits / holes shall be painted in dark green shade.
- Width of patches shall be 1 to 2 meters.

Identification Markings on Equipment / Piping

Equipment tag Numbers shall be Stenciled / neatly painted using normal 'Arial' Lettering Style on all equipment and piping (Both insulated & uninsulated) after completion of all paint works. Lettering colour shall be either BLACK or WHITE, depending upon the background, so as to obtain good contrast.

Operations Group shall specify location.

Sizes shall be:

Columns, Vessels, Heaters:	150 mm
Pumps and other M/c	50 mm
Piping	OD/2 with Maximum 100 mm
Storage Tanks	(As per Drawings)

Colour Coding for Control Valve

a) Carbon steel body - Light grey

Alloy steel body - Canary yellow

Stainless steel body - Natural

b) The actuator of the Control valve shall be painted as:

Direct action (open on air failure) valves - Green

Reverse acting (close on air failure) valves - Red

The painting Status shall be comprehensively updated every 6 months for compliance

JOB SPECIFICATION FOR NON DESTRUCTIVE EXAMINATION REQUIREMENTS OF PIPING UNIT- PRU

PROJECT : P-25 PROJECT

OWNER : INDIAN OIL CORPORATION LIMITED

PMC : EIL

JOB NO. : B269

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
A	05.08.2020	ISSUED AS JOB SPECIFICATION	BSC	KB	UC

Abbreviations:

DP/LP	:	Dye/Liquid Penetrant
MP	:	Magnetic Particle
CS	:	Carbon Steel
AS	:	Alloy Steel
SS	:	Stainless Steel
ASTM	:	American Society for Testing & Materials
ASME	:	American Society of Mechanical Engineers
IBR	:	Indian Boiler Regulations
PMS:		Piping Material Specification

CONTENTS

1.0 GENERAL

1.1 Scope

This specification covers the general requirements for non destructive examination of shop & field fabricated piping.

1.2 Related Codes & Engineering Standards

Referred codes / standards are as follows. Latest editions of the Codes/Standards referred to shall be followed.

a) ASME Boiler & Pressure Vessel Codes, Section V & VIII (Div.1) including addenda.

b) ASME B31.3

c) ASME B16.5

d) ASME B16.34

e) Job Piping Material Specification,B269- 6-44-0005

f) Welding Specification Charts for Piping Classes, B269-000-79-41-WSC-XXXX

g) Standard Specification for Fabrication & Erection of Piping 6-44-0012

h) ASTM E10

i) Welding Specification for Fabrication of Piping, 6-77-0001

j) Design Guide for Radiography Requirements, 8-77-0010

k) Indian Boiler Regulations (IBR)

2.0 VISUAL EXAMINATION

2.1 Weld shall be visually inspected wherever accessible in accordance with the following requirements:

a)	Internal misalignment	1.5 mm or less
b)	Cracks or lack of fusion	not permitted
c)	Incomplete penetration	Depth shall not exceed the lesser of 0.8mm or 0.2 times thickness of thinner component joined by butt-weld. The total length of such imperfections shall not exceed 38 mm in any 150 mm of weld length.
d)	Surface porosity and exposed slag inclusions (For nom. wall thickness 4.7 mm and less)	not permitted

e)	Concave root surface (Suck up)	For single sided welded joints, concavity of the root surface shall not reduce the total thickness of joint, including reinforcement, to less than the thickness of the thinner of the components being joined.
f)	Weld ripples irregularities	2.5 mm or less.
g)	Lack of uniformity in bead width	2.5 mm or less.
h)	Lack of uniformity of leg length	2.5 mm or less.
i)	Unevenness of bead	2.0 mm or less.
j)	Weld undercutting	0.8 mm or 1/4 thickness of thinner components joined by butt weld, whichever is less. (shall be smooth finished)
k)	Overlap	1.5 mm or less
l)	Bead deflection	2.5 mm or less

m) External weld reinforcement and internal weld protrusion (when backing rings are not used) shall be fused with and shall merge smoothly into the component surfaces. The height of the lesser projection of external weld reinforcement or internal weld protrusion from the adjacent base material surface shall not exceed the following limits:

Wall thickness of thinner component joined by butt weld (mm)	Weld reinforcement or internal weld protrusion (mm) max
6.4 and under	1.6
Over 6.4 -12.7	3.2
Over 12.7 -25.4	4.0
Over 25.4	4.8

n) Throat thickness of fillet welds:

Nominal thickness of the thinner component x 0.7 or more.

o) Flattening

Flattening of a bend, as measured by difference between the nominal outside diameter and minimum or maximum diameter at any cross section shall not exceed 5 % of the nominal outside diameter of pipe.

p) Reduction of wall thickness

Reduction of wall thickness of a bend, as measured by difference between the nominal thickness and minimum thickness shall not exceed 10 % of the nominal wall thickness of pipe.

2.2 Welds having any of imperfections which exceed the limitations specified in various clauses of 2.1 shall be repaired by welding, grinding or overlaying etc. Number of times of repair welding for the same weld, however shall conform to applicable notes to Table 1- Note 6(b)b.5.

3.0 NON DESTRUCTIVE EXAMINATION

3.1 The type and extent of weld examination shall be in accordance with Table-1. All visual and supplementary methods of girth weld examination shall be in accordance with ASME B31.3 & the requirements of this standard specification.

3.2 Welds between dissimilar materials shall be examined by method & to the extent required for the material having the more stringent examination.

4. TABLE-1 (with applicable notes)

TABLE 1 : CLASS, TYPE & EXTENT OF WELD EXAMINATION

INSPECTION CLASS: I

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P.NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH-MENT WELD	FAB. BRANCH WELD (NOTE 1)	FAB. WELDS OF MITRES / REDUC.
1	2	3	4	5	6	7	8	9	10	11	12	13
I	CATEGORY 'D' FLUID SERVICE	CARBON STEEL	1	0 TO 186	150# UPTO 10.55 KG/CM^2	A3A, J2A, **A93A, A94A, A95A, A96A,**	a) VISUAL	100%	100%	100%	100%	100%
		AUSTENIC S.S.	8	- 29 TO 186		**A3K, A93M**						
		HDPE	---	- 20 TO 50			b) LP (NOTE 4, 6,9,)	---	---	---	5%	10%
		CURPO NICKEL	34	- 29 TO 60								

REMARKS FOR ABOVE TABLE:

1. LP TEST NOT APPLICABLE TO NON-METALLIC CLASSES.
2. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: II

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG. C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELD (NOTE 1)	FAB. WELDS OF MITRES/ REDUC.
1	2	3	4	5	6	7	8	9	10	11	12	13
II	a) ALL SERVICES COVERED UNDER INSPECTION CLASS-I, BUT, EXCEEDING CATEGORY 'D' PR /TEMP LIMITATIONS. b) ALL SERVICES OTHER THAN THOSE COVERED UNDER INSPECTION CLASS-I BUT NON-TOXIC, NOT SUBJECTED TO SEVERE CYCLIC CONDITIONS. c) TOXIC, NON-LETHAL & FLAMMABLE. d) FLAMMABLE / NON FLAMMABLE & TOXIC / NON-TOXIC; NOT SUBJECT TO SEVERE CYCLIC CONDITIONS	CARBON STEEL	1	- 29 TO 427	150# TO 600#	A1A, B1A,A32A , B9A, , A11A,	a) VISUAL	100%	100%	100%	100%	100%
							b) RADIOGRAPHY (NOTE 5,6)	5%	---	---	---	20%
		LTCS		-45 TO 204		A4A, B4A	c) MP / LP (NOTE 4,6,10,11)	---	5%	---	5%	20%
							d) HARDNESS	NOTE 7	NOTE 7	NOTE-7	NOTE-7	NOTE-7
		AUSTENITIC STAINLESS STEEL	8	-29 TO 500								

REMARKS FOR ABOVE TABLE :

1. EXTENT OF HARDNESS TEST FOR A11A IS 100%.
2. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.
3. NOTE- 7 FOR HARDNESS IS NOT VALID FOR P. NO. 8.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: III

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
III	FIRE WATER AND IBR SERVICES.	CARBON STEEL (FIRE WATER)	1	- 29 TO 427	150# TO 600#	**A91A, A92A**	a) VISUAL	100%	100%	100%	100%	100%
		CARBON STEEL (IBR)				A2A, B2A,	b) RADIOGRAPHY (NOTE 5,6)	10%	---	---	---	50%
							c) LP / MP (NOTE 4,6,11)	---	10%	---	10%	---
							d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7
		STAINLESS STEEL (IBR)	**8**									

REMARKS FOR ABOVE TABLE :

1. FOR IBR SERVICE A2A & B2A NOTE- 8 IS ALSO APPLICABLE.
2. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.
3. FOR **A91A & A92A** FIRE WATER SERVICE, NOTE-12 IS ALSO APPLICABLE.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: III (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
III (CONTD)	ALL GENERAL SERVICES EXCEPT THOSE SUBJECT TO SEVERE CYCLIC CONDITIONS.	C - 0.5 Mo STEEL.	3	ABOVE -29	150# TO 600#		a) VISUAL	100%	100%	100%	100%	100%
		0.5 Cr - 0.5 Mo STEEL					b) RADIOGRAPHY (NOTE 5,6)	20%	---	---	---	50%
		1 TO 3 Cr Mo. STEEL.	4,5A									
		C - 0.5 Mo STEEL (IBR).	3				c) LP / MP (NOTE 4,6,11)	---	20%	---	20%	---
		1 - 3 Cr Mo STEEL (IBR)	4,5A				d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7

REMARKS FOR ABOVE TABLE :

1. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: III (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH-MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
III (CONTD)	ALL GENERAL SERVICES EXCEPT THOSE SUBJECT TO SEVERE CYCLIC CONDITIONS.	3.5 Ni STEEL	9B	- 80 TO 120	150# TO 600#	NOTE-3	a) VISUAL	100%	100%	100%	100%	100%
							b) RADIOGRAPHY (NOTE 5,6)	10%	---	---	---	50%
							c) LP / MP (NOTE 4,6,10,11)	---	10%	---	10%	---
							d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7

REMARKS FOR ABOVE TABLE:

1. NOTE- 7 FOR HARDNESS IS NOT VALID FOR P. NO. 9B.
2. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.
3. NO PIPING CLASS IS APPLICABLE UNDER THIS INSPECTION CLASS, MATERIAL COMBINATION & RATING.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: III (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
III (CONTD)	ALL GENERAL SERVICES EXCEPT THOSE SUBJECT TO SEVERE CYCLIC CONDITIONS.	ALUMINIUM & ALUMINIUM BASE ALLOY	21 TO 25	ALL	150#	NOTE-1	a) VISUAL	100%	100%	100%	100%	100%
		COPPER & COPPER BASE ALLOY	31				b) RADIOGRAPHY (NOTE 5,6)	20%	---	---	---	50%
		ALUMINIUM BRONZE	35				c) LP / MP (NOTE 4,6,10,11)	---	20%	---	20%	---
		OTHER NON FERROUS ALLOYS	---									

REMARKS FOR ABOVE TABLE:

1. NO PIPING CLASS IS APPLICABLE UNDER THIS INSPECTION CLASS, MATERIAL COMBINATION & RATING.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: III (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
III (CONTD)	SPECIAL SERVICES (NACE, CAUSTIC, **H2S, HIC, NACE + HIC)**	CARBON STEEL	1	ALL	150# TO 600#		a) VISUAL	100%	100%	100%	100%	100%
							b) RADIOGRAPHY (NOTE 5,6)	20%	---	---	---	50%
	SPECIAL SERVICES (CAUSTIC, NACE)	**LTCS**		-45 TO 204	**150# TO 600#**		c) LP / MP (NOTE 4,6,10,11,13)	---	20%	10%	20%	---
	SPECIAL SERVICES (O, H, **H2S + H, HIC+ H , NACE +H, NACE + HIC +H**)	CARBON STEEL		ALL	150# TO 300#	**B67A**	d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7
	SPECIAL SERVICES (NACE, CAUSTIC)	AUSTENITIC STAINLESS STEEL	8		150# TO 600#							
	SPECIAL SERVICES (O, H)				**150# TO 300#**							

REMARKS FOR ABOVE TABLE:

1. EXTENT OF HARDNESS TEST FOR CLASSE **B67A** IS 100%.
2. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: IV

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
IV	ALL SERVICES OTHER THAN SPECIAL SERVICES (O,H)	CARBON STEEL	1	ALL	ABOVE 600#		a) VISUAL	100%	100%	100%	100%	100%
		CARBON STEEL (IBR)					b) RADIOGRAPHY (NOTE 5,6)	100%	---	---	---	100%
							c) LP / MP (NOTE 4,6,10,11)	---	100%	10%	100%	---
							d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7

REMARKS FOR ABOVE TABLE:

1. FOR IBR SERVICE E2A & F2A NOTE- 8 IS ALSO APPLICABLE.

2. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: IV (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
IV (CONTD)	ALL GENERAL SERVICES.	C - 0.5 Mo STEEL	3	ALL	ABOVE 600#	--	a) VISUAL	100%	100%	100%	100%	100%
		1 TO 3 Cr Mo. STEEL.	4, 5A				b) RADIOGRAPHY (NOTE 5,6)	100%	---	---	---	100%
		5 Cr - 9 Cr Mo STEEL	5B		ALL		c) LP / MP (NOTE 4,6,10,11)	100%	100%	10%	100%	100%
		CLADDED PIPE			ALL		d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7
		13 Cr (TYPE-410 SS)	6		ALL	--						
		KILLED CARBON STEEL	1	UPTO - 45	ABOVE 600#	--						
		1 TO 3 Cr 9Cr-1Mo-V STEEL (IBR)	4,5A	ALL								

REMARKS FOR ABOVE TABLE:

1. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)
INSPECTION CLASS: IV (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
IV (CONTD)	SPECIAL SERVICES (O, H, **HIC+ H, NACE, NACE+H, NACE + HIC + H)**	CARBON STEEL	1	ALL	ABOVE 300#		a) VISUAL	100%	100%	100%	100%	100%
	SERVICES SUBJECT TO SEVERE CYCLIC CONDITIONS, ETC.	**CARBON STEEL**	**1**	**ALL**	**ALL**		b) RADIOGRAPHY (NOTE 5,6)	100%	---	---	---	100%
	SERVICES SUBJECT TO SEVERE CYCLIC CONDITIONS	0.5 TO 9 CR Mo STEEL	3, 4, 5A, 5B	ALL	ALL	--	c) LP / MP (NOTE 4,6,10,11, 13)	---	100%	10%	100%	---
	SPECIAL SERVICES (NACE, O, H, **CAUSTIC, NACE + H, NACE + HIC + H)**						d) HARDNESS	NOTE 7	NOTE 7	NOTE 7	NOTE 7	NOTE 7
	SERVICES SUBJECT TO SEVERE CYCLIC CONDITIONS	13 CR STEEL (TYPE 410SS)	6			--						
	SERVICES SUBJECT TO SEVERE CYCLIC CONDITIONS.	3.5 NI STEEL	9B			--						
	SPECIAL SERVICES (NACE, O, H, CAUSTIC)					--						
	ALL GENERAL SERVICES.	NI ALLOYS	41, 42, 43									
	SPECIAL SERVICES (NACE, O, H, CAUSTIC)		41, 42, 43									
	ALL SERVICES		45									

REMARKS FOR ABOVE TABLE:

1. NOTE-7 FOR HARDNESS IS NOT VALID FOR P.NO.9B.

TABLE 1: CLASS, TYPE & EXTENT OF WELD EXAMINATION (CONTD.)

INSPECTION CLASS: IV (CONTD.)

INSPN. CLASS	SERVICE	MATERIAL (NOTE 3)	P. NO.	TEMP. DEG.C	PRESS. CLASS B16.5/ B16.34	APPLICABLE PIPING CLASS	TYPE OF EXAMINATION	TYPE OF WELD EXAMINED				
								GIRTH BUTT WELD	SOCKET WELD (NOTE 2)	ATTACH -MENT WELD	FAB. BRANCH WELDS (NOTE 1)	FAB. WELDS OF MITRES / REDUC.)
1	2	3	4	5	6	7	8	9	10	11	12	13
IV (CONTD)	SERVICES SUBJECT TO SEVERE CYCLIC CONDITIONS.	AUSTENITIC STAINLESS STEEL	8	ALL	ALL	--	a) VISUAL	100%	100%	100%	100%	100%
							b) RADIOGRAPHY (NOTE 5,6)	100%	--	--	--	100%
	LOW TEMP. SERVICE			BELOW - 45	**ALL**							

	GENERAL SERVICES			ALL	ABOVE 600#		c) LP / MP (NOTE 4,6,10,11)	--	100%	10%	100%	--
	HIGH TEMP. SERVICES			> 500	ALL		d) HARDNESS	-	-	-	-	-
	HIGH TEMP. SERVICES (O, H)											
	SPECIAL SERVICES (O,H, **NACE, NACE + H**)			**ALL**	**ABOVE 300#**							
	GENERAL SERVICES	**AUSTENITIC STAINLESS STEEL (IBR)**		**ALL**	**ABOVE 600#**							
	DUPLEX SS		**10H**	**ALL**	**ALL**							

REMARKS FOR ABOVE TABLE:

1. MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS.

Applicable Notes to Table-1

1. Branch welds shall consist of the welds between the pipe & reinforcing element (if any), nozzles & reinforcing element and the pipe & nozzle under the reinforcing element. Reinforcing element to be interpreted as pads, saddles, weldolets, sockolets etc.

2. Seal welds of threaded joints shall be given the same examination as socket welds.

3. Unless specifically stated, all materials shall be for "Non-IBR" service.

4. Magnetic Particle & the Liquid Penetrant method of examination shall be in accordance with Section V of the ASME Boiler and Pressure Vessel Code, Article VII and VI respectively. The entire area of the accessible finished weld surface shall be examined. Selected root runs, subject to a maximum of 10%, before finished weld, may also be examined, at the discretion of the engineer-in-charge.

   a) Wherever MP / LP testing is specified, either MP or LP test may be used. But wherever only MP test is specified, LP method of examination may be used only if MP examination is impracticable in the field as concurred by EIL site-in charge.

   b) "Random 5%" of Liquid Penetrant / Magnetic Particle test shall mean testing, by applicable test, one weld for each twenty welds or less made by the same welding procedure. "Random 10%" shall mean testing, by applicable test, one weld for each ten welds or less made by the same welding procedure. Similarly "Random 20%" shall mean testing, by applicable test, one weld for each five welds or less made by the same welding procedure. The welds to be examined in each designated lot shall include the work product of each welder or welding operator whose welds are part of the lot.

   c) When Liquid Penetrant examination is specified, the surface shall be free of peened discontinuities.

   d) Inspection shall be performed in the welds excluding those for which radiography has been done.

   e) Girth weld, branch weld, attachment weld & socket weld of 3-1/2% Ni steel shall be Liquid Penetrant tested only when welded with austenitic material where MP test has been specified.

5. Radiography:

   a) "Random 5%, 10% or 20% radiography" shall mean examining not less than one from each 20 welds or less in case of "Random 5% radiography", not less than one from each 10 welds or less in case of "Random 10% radiography", not less than one from each five welds or less in case of "Random 20% radiography" made by the same welding procedure. The welds to be examined in each designated lot shall include the work product of each welder or welding operator whose welds are part of the lot. Irrespective of percentage, no. of welds to be radiographed shall be minimum 1. However first two welds made by each welder shall also be radiographed in case of "Random radiography". Welds selected for examination shall not include flange welds and shall be radiographed for their entire length. However, where it is impossible or impracticable to examine the entire weld length of field welds for either random or 100% radiography, and if the same impossibility is agreeable to EIL site-in- charge, then a single 120 deg. exposure of the weld length may be given a Magnetic Particle test or Liquid Penetrant test. However in such cases for ferro-magnetic materials, only MP test shall be acceptable for classes higher than 600#.

b) In-process examination shall not be substituted for any required radiographic examination.

c) Number of radiographs per one circumferential weld shall be as per ASME Sec.V Articles 2 and 22.

6. When radiography or other non destructive inspection is specified, acceptance criteria for repairs or defects shall be as follows:

a) In case of 100% examination, any unacceptable weld shall be repaired and reinspected.

b) If required random examination reveals a defect requiring repair, then:

b.1 Two additional examinations of same type shall be made of the same kind of item (if welded joint, then by the same welding procedure and same welder or welding operator).

b.2 If the group of items examined as required by b.1 above is acceptable, the items requiring repair shall be repaired or replaced and reexamined as required and all items represented by this additional examination shall be accepted.

b.3 If any of the items examined as required by b.1 above reveals a defect requiring repair, two further comparable items shall be examined for each defective item found by examination.

b.4 If all the items examined as required by b.3 are acceptable, the items requiring repair shall be repaired or replaced and reexamined as required, and all items represented by this further examination shall be accepted.

b.5 Number of times repair welding could be done for the same weld before acceptance shall be as follows:

Material	**No. of times repair welding is allowed**
C.S. upto 300 #	3 or less
C.S. above 300 #	2 or less
Killed steel	2 or less
Low alloy steel	2 or less
Austenitic S.S.	2 or less
3.5 Ni steel	2 or less
Al & Al base alloy	2 or less
Cu & Cu base alloy	2 or less
Others	2 or less

b.6 Welds not found acceptable for allowed number of times of repair as per b.5 above shall be replaced and reexamined.

b.7 If any of the items examined as required by b.4 above reveals a defect requiring repair, all items represented by these examinations shall be either :

- repaired or replaced and reexamined as required.
- fully examined and repaired or replaced as necessary, and reexamined as necessary.

7. Hardness Test:

a) Hardness test shall be in accordance with ASTM specification E10. Hardness tests of the heat affected zone shall be made at a point as near as practicable to the edge of the weld. One test per weld shall be performed.

b) Hardness test where specifically called out in Table-1 of this specification or in PMS, shall be carried out irrespective of thickness and to the extent (%age) as mentioned therein.

c) All welds which are given heat treatment shall be hardness tested. Hardness test shall be performed after final heat treatment.

d) A minimum of 10% of welds, hot bends, and hot formed components in each furnace heat treated batch and 100% of those which are locally heat treated shall be hardness tested.

e) Hardness test requirement not covered in this specification shall be as per Engineering specifications.

f) The hardness limit applies to the weld and heat affected zone. Following hardness values shall be maintained:

Base Metal Group	**Maximum Hardness (BHN/RC)**
CS	238BHN/RC22
CS (NACE) , Caustic, Amine, H2	200BHN
Cr Upto 2%	225BHN
Cr 2.25%-10%	241BHN
18/8 SS (NACE)	RC22

g) In case hardness values are mentioned in both Welding Specification Charts for Piping Classes, (6-77-0005) & table given in Note-7(f), the lower of the two values shall be applicable.

8. For IBR service lines, following IBR requirements shall apply in addition to the notes 4, 5, 6, 7, 12 and Table 1. In case of conflict between above notes and these requirements, the more stringent ones shall apply. IBR piping shall be erected of IBR inspector approved material and construction procedure. Erected piping shall be hydrotested, inspected and approved by IBR inspector.

   a) Piping over 102 mm (4") bore:

      10% of welds made by each welder on a pipeline with a minimum of two welds per welder, selected at random, shall be subjected to radiography.

   b) Piping 102 mm (4") bore and under, but not less than 38 mm (1-1/2") bore:

      Two percent of welds made by each welder on a pipeline with a minimum of one weld per welder, selected at random, shall be subjected to radiography or may be cut for visual examination and tests.

   c) Piping less than 38 mm (1.5") bore:

      Special tests are not normally required but 2% of welds by each welder on a pipe line may be cut out from the pipeline for the visual examination and bend tests.

   d) Retests:

      If any test specimen is unsatisfactory, two further weld specimens for retests shall be selected from the production welds and subjected to tests. In the event of failure of any retest specimens, the production welds carried out by this welder subsequent to the previous test shall be given special consideration.

9. For fabricated fittings LP test shall be done on the final pass of welding only, in addition to visual examination.

10. For mitres and fabricated reducers, LP / MP test shall be done on root pass in addition to radiography applicable to circumferential joint of respective piping class.

11. For branch connections, LP/MP test shall be done on root pass and final pass.

12. 10% of the butt weld joints shall be radiographed, however, 50% of these butt weld joints shall be field weld joints.

13. All joints including butt weld joints for A16A, B16A and D16A and any other NACE classes shall be wet fluorescent magnetic particle tested. Percentage of wet fluorescent magnetic particle testing of butt weld joints shall be 100% and this testing shall be in addition to radiography.

14. For lined specs, testing (MP/LP/Radiography etc.) shall be performed before lining.