PLANNING, SCHEDULING, MONITORING & CONTROL SYSTEM FOR PACKAGE CONTRACT

PROJECT : ETHYLENE CRACKER UNIT AND UTILITIES & OFFSITES OF BINA PETCHEM & REFINERY EXPANSION PROJECT (BPREP)

OWNER : BHARAT PETROLEUM CORPORATION LIMITED (BPCL)

PMC : ENGINEERS INDIA LTD. (EIL)

JOB NO. : B957

Abbreviations:

ATR	Action taken report
FEED	Front End Engineering Design
HO	Home Office
KOM	Kick Off Meeting
LOA	Letter of acceptance (Award of Contract)
MOM	Minutes of Meeting
MR	Material Requisition
WBS	Work Breakdown Structure

CONTENTS

1.0 INTRODUCTION

It is the requirement for all "Bidders" for Package works covering entire scope starting from Basic/Residual engineering up to Construction / Installation & Commissioning to maintain a proper Planning, Scheduling and Monitoring system to ensure timely completion of the contract.

This Procedure is applicable for various Package MR / Tender wherein Residual basic/detailed engineering is done by the contractor based on design parameters given in the Tender.

Therefore, every bidder shall establish and maintain an effective Planning, Scheduling, Monitoring & Control System including deployment of professionally qualified and experienced Planning Engineer for entire duration of the contract. The system should be predictive type to diagnose and anticipate the problems well in advance and provide preventive measures. To achieve this objective, Bidder / Vendor or Contractor shall prepare & submit following Schedules / documents for review / approval by client / Consultant at various stages of the project.

2.0 ALONG WITH THE BID

2.1 Time Schedule

The bidder is required to submit a "Proposed Time Schedule" in bar chart form covering major milestones along with the bid. The schedule shall cover all phases of the contract i.e. Basic / Residual Engineering, Detailed Engineering, Ordering, Manufacturing & Delivery, Tendering, Construction and Commissioning within the time stipulated in the bid document covering Client's interfaces / activities.

2.2 Planning, Scheduling & Monitoring System

The Bidder shall describe the system of Planning, Scheduling & Monitoring, level of detailing / tracking methodology etc. along with the name of computer packages like Primavera, MS Excel Spread Sheet etc. and sample outputs in line with guideline of this procedure.

Client / Consultant reserves the right to disqualify the bidder if the above-mentioned documents are not furnished / not in line with the requirement as stated above.

3.0 AFTER AWARD OF THE CONTRACT

3.1 Documents to be submitted within 2 weeks from LOA.

Following documents to be submitted to Consultant/ Client within 2 weeks from award of contract. These documents will be discussed during KOM, comments if any shall be provided in line with provision of the contract.

- Planning, Scheduling and Monitoring Procedure
- L-1 Schedule as defined in Section – 2.1 above
- Proposed Progress Measurement system/ Progress WBS
- 90 Days Look ahead schedule – List of activities to be performed in the initial phase of the project.

3.2 Overall Schedule for the contract & WBS

The Vendor / Contractor shall submit within 4 weeks from award of contract / Effective Start date, a detailed "Overall Project Schedule" in the activity network form clearly indicating the major milestones, inter-relationship / inter-dependencies between various activities together with critical path and floats covering all functions, disciplines, work groups & activity level, preferably in Primavera or MS Project. While developing the Overall Project schedule time period indicated in L-1 schedule to be adhered to.

Grace period available if any shall not be considered while developing Overall Project schedule.

A Work Breakdown Structure (WBS) indicating the scope of work, execution philosophy and the magnitude of work in hierarchal fashion shall be submitted with the Overall Project Schedule. The network and WBS shall be reviewed and approved by Client / Consultant and after incorporating their comments (if any) shall be issued for implementation by Vendor / Contractor within one week from receipt of comments.

Milestone List: A list of milestones extracted from Overall Project schedule for the entire duration of the contract also to be submitted along with Overall Project Schedule. Milestones shall be chosen in such a way that minimum 1 milestone to maximum 5 milestones are scheduled every month (Average 2 to 3 milestones per month). These milestones should haveimportance with respect to key areas / activities of project execution covering all functions viz.,Engineering, Procurement, Construction and Commissioning.

The Overall Project Schedule once approved by the Client / Consultant shall be referred as "Baseline Schedule" and shall not be changed without prior approval of the Client / Consultant.

The Overall Schedule shall be updated on monthly basis and submitted along with Monthly Progress Report indicating base line schedule.

3.3 Progress Measurement Methodology

Level 1 weightages at functional level as per annexure attached with this procedure shall be followed for preparation of Progress WBS. Based on initial proposed progress WBS discussed during Kick off meeting, the Vendor / Contractor shall submit detailed progress measurement methodology within 4 weeks from award of contract/ Effective Start date for approval, to be adopted for measurement of progress for all phases of work i.e. Engineering, Ordering, Manufacturing & Delivery, Tendering, Construction and Commissioning along with breakup of weightages. Weightages for as built drawings shall be considered as separate function if applicable as per terms of the contract.

The progress basis shall be physical realization of work, such as in terms of deliverables and construction quantities accomplished.

3.4 Functional Schedules

Based on approved Overall Project Schedule and progress measurement system / methodology, the Vendor / Contractor shall prepare detailed functional schedule for each function viz. Residual Basic Engineering, Detailed Engineering, Ordering, Manufacturing & Delivery, Tendering, Construction and Commissioning. Based on functional schedules, the Vendor / Contractor shall also develop schedule progress "S" curve for each function and one overall schedule progress "S" curve for the total contract and submit the same to Client / Consultant for approval. Functional schedules i.e. deliverable / task wise schedule in tabular form after assigning weightages and dates to all activity milestones / major work steps for each deliverable / task shall preferably be prepared in Excel Worksheets and finalised within 2 months from LOA or within 15 days of approval of Overall Schedule whichever is earlier.

All functional schedules along with Progress S-Curves shall get approved from consultant/ Client's Home office except for Construction portion. Construction functional schedule shall be vetted and approved by Construction group of Consultant / Client. For development of Overall schedule progress "S" curve as stated above, tentative construction schedule shall be prepared initially which shall be replaced upon approval of construction schedule by Consultant/ Client.

Functional Schedules once approved by the Client/ Consultant shall not be changed without prior approval of the Client/Consultant.

Functional Schedules shall be updated on monthly basis and submitted along with Monthly Progress Report as a part of Annexure.

3.5 Resource Deployment Schedule

The Vendor / Contractor shall submit resource deployment schedule, manpower (category-wise), equipment & machinery to be deployed to achieve the schedule of progress, as per "S" curve furnished for the total contract duration for both HO services & site activities. Resource deployment schedule shall be submitted as supporting document along with functional schedules which shall be retained for information.

3.6 Catch-up Schedule

During the project execution, depending on the trend & slippage (if any), Client / Consultant may ask Vendor / Contractor to develop catch-up schedules for completion of all balance activities without change in contract completion date. This schedule shall be submitted to Client / Consultant for review. Accordingly, the "S" curve for catch-up schedule shall be made and shown along with the original schedule.

Catch up schedule shall clearly indicate details of re-scheduled activities along with resource deployment plan and ways & means to achieve revised targets.

On completion of contractual duration, catch up schedule shall be referred as "Completion Outlook" for balance activities.

"Completion Outlook" for balance activities shall not be treated as regularization of schedule for contractual commitments.

3.7 Planning Package:

On approval of all Planning documents, 2 hard copies of Planning package comprising of following documents shall be submitted for record & reference by Client / Consultant. Native files all document also shall be submitted through e-mail.

- Procedure for Planning, Scheduling and monitoring system.
- Project Physical WBS (Workload)
- Overall L-1 Schedule
- Overall Project schedule (Network).
- List of Milestones.
- Progress Measurement System WBS
- Detailed Functional schedule along with progress curves
  - Residual Basic Engineering
  - Detailed Engineering
  - Ordering
  - Manufacturing & Delivery
  - Sub-contracting / Tendering
  - Construction and Commissioning
- Overall Progress Curve with back up calculation sheet.
- HO and Site organogram clearly indicating Planning function and responsibility. Resource deployment schedule

3.8 Contract Review Meetings

The vendor / contractor shall present project status at various review meetings as required or as asked by client / consultant strictly based on agenda with fixed time.

3.8.1 Monthly Review Meeting

Level of participation : Senior person of Client / Consultant and Vendor / Contractor. In case of Vendor / Contractor, the participants shall be Project Manager or above and Construction-In-Charge or above.

Agenda : a. Action taken report on MOM of last month Review meeting.

b. Progress Status / Statistics
c. Status of Engineering, Ordering, Manufacturing & Delivery, Tendering, Construction and Commissioning.
d. Major hold ups / slippages
e. Completion outlook
f. Critical issues with Action Plan
g. Any specific point from Client / Consultant.

During the initial phase of Project, Monthly review meeting shall be held mainly at Consultant's or Clients' Home office and during Construction phase, meeting shall be held at Construction Site. Agenda based meeting with fixed timings

3.8.2 Weekly Review Meeting at Site: Agenda based meeting with fixed timings

Level of participation : Contractor / Consultant, Resident Construction Manager / Site Engineers / Job Engineers.

Agenda : a. Weekly Programme v/s actual achieved in the last week and programme for the next week with resource mobilization plan.
b. Hold-up analysis and Action Plan.

3.8.3 Management Review Meeting: Meeting shall be called on Need basis to expedite completion of work.

Level of participation : Contractor MD/ Director, Consultant Directors/ Resident Construction Manager along with Project Managers.

Agenda : a. Overall Progress and reason for delays.
b. Setting of Priorities for completion of work as per Overall Project/ Complex scenario and contractual requirements.
c. Mitigation / corrective action and catch-up plan.

3.9 Progress Reporting

3.9.1 Monthly Progress Report

The Vendor / Contractor shall submit the Monthly Progress Report on regular basis to Client / Consultant from very next month of award of the contract as per formats which will be provided to successful bidder, covering total scope of work as per the contract. This report is to be issued within five calendar days from cut-off date. Issue of the report shall be continued till completion of contract in all respects. The broad sections covered would be Introduction, Executive Summary, Progress Statistics, Updated Overall Project Schedule, Areas of Concern with Action Plan, Detailed Status and supporting annexures.

3.9.2 Weekly Flash / Activity Report

A brief report carrying status of activities performed during the week including any major concerns shall be submitted on weekly basis preferably on every Monday.

3.9.3 Weekly Progress Report (Construction)

This report shall be prepared for activities in summarized fashion as per formats which will be provided to successful bidder, and submitted by the Vendor / Contractor, every week on the next day of weekly cut-off. The weekly cut-off day shall be informed during the kick-off meeting. The broad sections covered would be Executive Summary, Summary Report of Contracts, Quantitative Construction Progress Status and Resource Deployment Status.

3.9.4 Daily Progress Report (Construction)

The Vendor / Contractor shall submit daily report to the Consultant **through an online portal for which access shall be provided to contractor at construction site. The report will be**

verified by the respective Area coordinator in online portal itself to enable availability of DPR to Project Controls-Planning for further usage. The report will cover Quantitative Construction Progress Status supported by Drawing, Material and Resource Deployment Status.

3.10 Documentation

The formats of reports, schedules and other Planning documents submitted by Vendor / Contractor shall be strictly as required by Client / Consultant. Other required formats shall be finalized during the kick-off meeting and shall be binding on the Vendor / Contractor.

3.11 Native Files of Planning Deliverables

The Vendor / Contractor shall submit native files of various planning documents (including Primavera .xer/ native files of Schedules) to Consultant as and when required for analysis purpose.

SL NO	EPC/PACKAGES	DESCRIPTION	WEIGHTED VALUE PROPOSED	REMARKS
1	UTILITY BOILER	BASIC ENGINEERING	1-2	
		DETAILED ENGINEERING	6-8	
		ORDERING	2-4	
		MANUFACTURING & DELIVERY	45-55	
		SUB-CONTRACTING/TENDERING	1-2	
		CONSTRUCTION	25-35	
		PRE-COMM/ COMMISSIONING	2-3	
		AS-BUILT	*	

* **Note:** For As Built Maximum 0.5% to be considered if defined in the contract.

Sl. No.	COMPLIANCE STATEMENT/QUERY	BIDDER'S CONFIRMATION / ANSWER
	BIDDERS TO GIVE SPECIFIC CONFIRMATION THAT FOLLOWING DOCUMENTS HAVE BEEN SUBMITTED ALONG WITH BID. (PLEASE REFER DOC. NO B957-420-2744-1002 REV 6 FOR "PROJECT PLANNING, SCHEDULING & CONTROL SYSTEM" "CLAUSE NO 2" "DOCUMENT ALONGWITH BID")	
a.	Bidder to submit proposed Overall Project Schedule in network form showing details of all Units / facilities identifying major / key milestones.	
b.	Write up on Project Planning, Scheduling, and Monitoring & Control system (proposed) in line with procedure B957-420-2744-1002 Rev.6 attached with bid document.	
c.	Organizational set up for Planning, Scheduling, Monitoring & Control at Contractor's design Office & Site Office	
d.	Progress Measurement Methodology with details such as weightage, milestones, frequency etc.	
e.	Project execution methodology	
f.	Function wise Resource Deployment Schedule (manpower & construction equipment)	
g.	Software to be used for planning & material control - Bidder to use Primavera P6 Software for Planning & scheduling activities and to identify software for material control. MS Office to be used for progress calculation.	
h.	Statement confirming compliance to the "Planning, Scheduling, Monitoring and Control System" B957-420-2744-1002 Rev.6 attached with bid document.	

Note:-

1. The bidder shall indicate in his reply in this space in the Technical compliance. In case space provided is not adequate, the reply may be furnished separately under suitable numbered annexure/attachments duly referred against the comments/query.

2. The compliance Statement /Queries are required to be categorically confirmed/answered by the bidder and the completely filled in Technical questionnaire shall be submitted together with the bid.

Bidder's signature
&
Stamp

PROCEDURE FOR SMART INTEGRATED ENGG., DIGITAL HANDOVER OF DRAWING/DOCUMENT/ 3D MODEL AND DIGITAL INTERVENTION BY EPC CONTRACTOR

PROJECT : **BINA PETROCHEMICAL & REFINERY EXPANSION PROJECT, BPREP**

OWNER : **M/s BHARAT PETROLEUM COOPERATION LIMITED.**

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

JOB NO. : **B957**

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
A	26/11/2024	ISSUED FOR ENGINEERING	MS	MK	SV

1. GENERAL

This chapter details the requirements pertaining to various drawings, documents and 3D model to be generated at various stages during the course of execution of the project by the EPC Contractor for activities associated with Smart Integrated engineering and digital handover. These stipulations are supplementary to following specifications (enclosed elsewhere in the contract):

S. No.	Spec. No.	Specification detail
1.	6-78-0001	Specification for quality management system requirements from bidders
2.	6-78-0002	Specification for documentation requirements from contractors
3.	6-78-0003	Specification for documentation requirements from suppliers

The EPC Contractor shall recognize that efficient handling of drawings and documents to be prepared by him under the contract is the key to the timely completion of the plant.

The EPC Contractor shall ensure that all drawings and documents to be submitted by him to the OWNER/CONSULTANT shall be of professional quality and conforming to the contractual requirements.

The EPC Contractor shall submit the drawings through the defined document management system for the project for review by OWNER /CONSULTANT, and shall maintain a record of drawings submitted till date at all times. Access to document management system shall be provided by client/consultant to the successful EPC Contractor which shall be utilized by the EPC Contractor for their smart engineering activities without any deviation.

Compliance of this chapter on drawings and documents is mandatory and is non-negotiable.

A pre-defined document numbering philosophy will be provided to successful EPC Contractor which shall be adopted and implemented by EPC Contractor for documents generated for this project. Document number shall also be shown in each deliverable as “Client Document Number”.

Computer aided design and drafting shall only be used. Standard, approved and well-established PC based computer programs/software packages, available in market shall only be used by the EPC Contractor and its sub-vendors etc.

All documents, before forwarding to OWNER /CONSULTANT shall be vetted in detail by EPC Contractor. Documents received without vetting will be returned without review. Also, any in accuracies/mistakes found will not only be rectified by the EPC CONTRACTOR but the EPC CONTRACTOR shall remain liable for bearing charges towards efforts spent by OWNER/CONSULTANT for discussing the same. Delay owing to these shall be to the account of EPC CONTRACTOR.

Review of the drawings/documents by OWNER/CONSULTANT would be only limited to the review of compatibility with basic designs and concepts. The review by the OWNER/CONSULTANT shall not be construed by the EPC CONTRACTOR as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and drawings.

All drawings, datasheets, specification & model etc. shall be generated by the use of authoring tools specified elsewhere in the contract document. The digital handover shall be in soft native files along with associated database.

EPC CONTRACTOR shall furnish 3D model (with complete details with respect to equipment, Piping, Civil, Structure, Electrical & Instrumentation in line with scope of work for 3D modeling) of plant with dynamic walk-through facility to check any interference, requirement of safety, operation and maintenance for getting approval from OWNER/CONSULTANT with input data. Associated data base files along with library shall also be furnished at 30%, 60% and 90% model reviews.

Each drawing submitted by the EPC CONTRACTOR shall be clearly marked with the name of the Owner, the unit designation, the specifications, title, the specification number and the name of the Project with revision No. and date. If standard catalogue pages are submitted the applicable items shall be indicated there in. All titles, notings, markings and writings on the drawings shall be in English. The template shall be approved by the consultant/client. All documents shall be prepared on the approved template.

All the Engineering design and specifications shall be normally prepared in MKS system excepting for Civil/Structural wherein, the SI system is in vogue based on applicable design codes. Upon receiving comments on Drawings/Documents, the EPC CONTRACTOR shall provide compliance report/comment resolution sheet, separately on each of the comments, document-wise, along with the subsequent submission. Comments given by OWNER/CONSULTANT shall be discussed, if required, and finalized within the agreed schedule.

The schedule of submission of Drawings/Documents shall be in accordance with project plans only. The detailed list under different category, document-wise, shall be prepared by EPC CONTRACTOR for review/records of OWNER/CONSULTANT.

The EPC CONTRACTOR shall maintain up-to-date record of drawings & document status and make regular issue of drawing/documents index **discipline wise, on monthly basis, with copies to OWNER /CONSULTANT Site &, H.O.** indicating schedule date of submission, submission date of various revisions and date of review with code of review/ approval.

2. Category of Documents and Cycle Time

The handling of documents by OWNER/CONSULTANT /EPC CONTRACTOR shall be as follows:

2.1 OWNER /CONSULTANT's Review/Records

A detailed document list clearly identifying review/records category against each document shall be developed. Following may please be noted for all the documents engineered by the EPC CONTRACTOR:

a) Review

EPC CONTRACTOR can proceed if OWNER/CONSULTANT's comments are not received within 10 working days of its receipt by OWNER /CONSULTANT. However, if major deviation to contract specification for any design deficiency is detected in the course of review after stipulated period, it shall be the responsibility of the EPC Contractor to see that such deviations and deficiencies are corrected to ensure compliance to contract without any cost and time implication to Owner.

b) Records

EPC CONTRACTOR shall submit documents for OWNER/CONSULTANT's information and proceed with the work. OWNER/CONSULTANT comments, If any, which relates any cost and/or time implication to the owner due to inadequacies/inaccuracies may be brought to the attention of EPC CONTRACTOR at any stage for incorporation without any cost or time impact to owner.

The documents falling under review category shall in general, except for drawings requiring multi-disciplinary review, be returned with comments within 10 working days.

Documents submitted without meeting pre-requisite requirements will be returned without review.

However, documents like equipment layout etc. where multi-disciplinary activity is involved, the EPC CONTRACTOR, after submission for OWNER/CONSULTANT's review, shall visit OWNER/CONSULTANT for discussion for expeditious review of documents.

In absence of visit of EPC CONTRACTOR'S engineering team at OWNER/CONSULTANT office, review time shall be 15 working days. The information category document will be retained for records only. It is EPC CONTRACTOR'S responsibility to correct the deviation, if any, to the stipulation in the bid document, without any cost or time implication to Owner.

2.2 EPC CONTRACTOR'S Review

EPC CONTRACTOR shall furnish compliance statement to OWNER /CONSULTANT's comments while submitting the next revision within 10 days from the date of release of drawings and documents by OWNER/CONSULTANT.

2.3 Control and Monitoring of documents review and submission

Drawing schedule shall indicate the following:

- Schedule/Actual submission date to owner
- Category of submission
- Receipt of comments from Owner
- Category of return status from Owner
- Issue date for Construction

This updated schedule shall be issued on fortnightly/monthly basis, as agreed, and compared with Owner's log.

Detailed listing of documents (discipline wise) which are scheduled to be submitted or re-submitted incorporating OWNER/CONSULTANT's comments shall be provided by EPC CONTRACTOR in the weekly meetings. EPC Contractor shall ensure that drawings /documents are submitted as per the agreed schedule only. Bunching of documents/out of sequence submissions and consequential delay of documents and its review thereof shall be exclusively attributable to EPC CONTRACTOR.

2.4 Pre-Requisites from EPC Contractor

2.4.1 At the kick-off meeting, the EPC CONTRACTOR must submit discipline wise list of documents and drawings index.

2.4.2 The Drawing Index (discipline wise) shall include description of drawings/ documents, category of drawings, scheduled date of submission, actual date of submission, review code received with dates. This shall be updated fortnightly/monthly, as agreed by EPC CONTRACTOR and copies issued to OWNER /CONSULTANT site and H.O. as well as Owner. Drawings submitted before finalization of drawing index shall be rejected.

2.4.3 EPC CONTRACTOR shall separately submit list of drawings/documents involving multi-disciplinary reviews, considering the OWNER /CONSULTANT departmental activities (furnished in the contract) during the kick off meeting itself. They are also highlighted in the discipline- wise document list.

2.4.4 Critical and typical drawings/documents having impact on schedule and quality should only be identified for such timely reviews in Document Control Index. This shall be adopted after receipt of drawings/documents indexes from the EPC CONTRACTOR at the kick-off meeting with mutual understanding of the EPC CONTRACTOR/concerned specialist/Owner.

2.4.5 Any deviation on Record category drawings/documents and on review category drawings observed later or in execution at site during site visit/technical review by OWNER/CONSULTANT shall be taken seriously. EPC Contractor shall rectify the same at his own cost and time.

2.4.6 EPC CONTRACTOR shall plan submission progressively so that no bunching takes place in any discipline.

2.4.7 Review period shall be reckoned from the “Date of Receipt” of documents/drawings at OWNER /CONSULTANT to the “Date of Receiving” the reviewed documents by the EPC CONTRACTOR from OWNER /CONSULTANT office. EPC CONTRACTOR shall monitor submission and receipt.

2.4.8 Documents/drawings received prior to holiday/week end shall be accounted as received on the following working day and the review period committed shall include only working days.

2.4.9 Quality of drawings/documents is the essence for a timely review. If major comments/deviations to the contract document are noticed, the drawing shall be returned in Code-3.

2.4.10 Sequence of submission of drawings is essential for proper review of documents and timely completion of the project and the same is to be adhered to. In case sequence is not maintained, the documents submitted shall not be reviewed by OWNER/CONSULTANT and the responsibility of timely execution of the plant shall remain with EPC CONTRACTOR.

2.4.11 Piping/Instrument & other engineering drawings/documents shall be issued only after the corresponding P&IDs & Process documents coming under review category are first reviewed by the concerned department in code-2 as a minimum.

2.4.12 In principle. EPC CONTRACTOR is not expected to revise drawings/documents already reviewed in Code-1.

a) If it is of utmost necessity to revise or add some minor details in Code-1 drawings, EPC CONTRACTOR shall highlight such revisions by marking “CLOUD” and providing appropriate revision nos. to such additions/alterations. EPC CONTRACTOR is also needed to provide a “BLOCK” in the drawing indicating reasons of such changes and to insert another “Review Block”. OWNER /CONSULTANT shall put relevant code for such revisions only. Code

marking given by OWNER /CONSULTANT on such revisions shall not change the category of drawing.

b) Any major change in Code-1 drawing shall call for preparation of new drawing.

2.4.13 Based on the confidence gained on EPC CONTRACTOR'S quality of drawings/documents already submitted, "Review Category" drawings could be retained as Information/Records and vice versa at the discretion of OWNER/CONSULTANT. This however, does not change the category of drawings.

2.4.14 Once a document is already reviewed in Code-2, subsequent submission due to non-incorporation of comments shall not be accounted for any contractual commitment of review period from OWNER /CONSULTANT. EPC CONTRACTOR is expected to comply with OWNER /CONSULTANT's comments in the next revision after Code-2 and is required to submit a compliance report accordingly

2.4.15 Deviation permit, submitted for seeking deviation in vendor document management system, shall be separately identified and shall not be considered as a document for timely approval/review.

2.4.16 When OWNER/CONSULTANT deploys engineers at the EPC CONTRACTOR'S work center following shall be satisfied:

- Review is limited to identified long delivery/schedule critical items only.
- Readiness of documents/drawings shall be ensured by the EPC CONTRACTOR.
- Presence of lead engineers of all disciplines of the EPC CONTRACTOR.

2.4.17 If OWNER/CONSULTANT highlights any necessary rectifications required in the construction at the time of Technical Review/Audit, construction executed based on record category drawings not complying with Bid requirement, EPC CONTRACTOR shall rectify without any impact of time and cost to Owner.

2.4.18 EPC CONTRACTOR shall submit designs drawings for review only after the corresponding GA/Equipment datasheets etc. have been coordinated in his office and reviewed by OWNER/CONSULTANT engineers at least in Code-2. Such OWNER/CONSULTANT reviewed drawings shall be furnished along with drawings/designs for timely review.

2.4.19 EPC CONTRACTOR shall open an engineering office in India for speedy document submission and to help faster review of the drawings & documents.

2.5 Approved for Construction Drawings

Drawings reviewed under Code1 & Code2 required for execution at site shall be decided by EPC CONTRACTOR and copies need to be sent to OWNER /CONSULTANT (RCM), EPC CONTRACTOR'S RCM and BPREP (site).

- "**Approved for Construction**" stamped/sticker drawings shall be issued by EPC CONTRACTOR for execution.

- "**Approved for Construction"** stamped/sticker shall be done separately on the reviewed print and not on the Title block.

- Without changing Revision **Number**, EPC CONTRACTOR to arrange adequate number of prints of documents and drawings to EPC CONTRACTOR'S RCM, OWNER/CONSULTANT RCM and BPREP (site) with transmittal.

- Copies of only reviewed or final documents like design calculations, design basis etc. shall be sent to OWNER /CONSULTANT site for records.

- Copy of such transmittal shall be sent to OWNER /CONSULTANT (HO) & BPREP (HO) for records.

2.6 Critical Drawing/documents shall be reviewed by Licensor during the course of Project execution, list of Licensor mandatory review document is enclosed elsewhere in the contract.

2.7 Mandatory compliance to the smart engineering activities at EPC Contractor's end

2.7.1 Plant Breakdown Structure (PBS) supplied by EIL to be adhered to. The SEED file and Plant Breakdown Structure (PBS) shall be provided by consultant to the successful EPC Contractor which shall be utilized by the EPC Contractor for their smart integrated engineering activities without any deviation. For any deviation in this regard prior approval need to be taken by EPC Contractor from EIL.

2.7.2 For residual engineering (process), work share to be followed. In case any new symbol is required, same shall be obtained from/ authorized by EIL.

2.7.3 All P&IDs need to be smartly developed. All the constituents of P&ID need to be intelligently mapped with database/database driven. There shall not be any graphics/symbols/texts in the smart P&IDs. There shall not be any dummy graphics/symbols/texts in main body of the P&ID.

2.7.4 3D Modeling for Piping, Equipment, Instruments & Electrical need to be database driven. Dummy graphics need to be avoided. Quality check & data connectivity shall be ensured at EPC Contractor's end before submitting the data files/documents/3D Model to the Consultant.

2.7.5 All the applicable deliverables shall be extracted from 3D model without any manual rework done thereafter. This is to maintain the consistency between 3D model and extracted deliverables.

2.7.6 Deliverables from 3D model shall be extracted only on conforming the alignment of interfaces with client model and clash free design.

2.8 Digital handover of Engineering Information

Smart Integrated engineering shall be utilized to carry out engineering activities. Intelligent Systems shall be used for the management of P&ID, Equipment layout, 3D Model, Piping, Electrical and Instrumentation design & deliverables including P&IDs, Reports, MTO, procurement etc.

The data in each such intelligent system, including the 3D Model and Intelligent P&ID's to be submitted by the EPC Contractor in a predefined Software version/format, as tabulated below. The same shall be submitted by the respective LSTK vendor/equipment suppliers strictly without any deviation.

Software versions/Format Requirements

The definition is in general terms containing (native (N), image (I), portable document format (D)) the formats in which EPC Contractor shall provide electronic versions of Documents. Acceptable applications for each format type are listed in the table below.

Data/Document Types	Authoring Software*	Version
2D CAD	S3D, AutoCAD	*/2018
Intelligent P&IDs	SPID	*
Instt. Index, Datasheet etc.	SI	*
Electrical load list/Single line diagram/Interconnection details/Cable Schedule	SEL	*
3D Model	S3D	*
2D Documents from the 3D model	S3D	*
Text Documents/Reports	MS Word 2013 or as agreed with Company	*
Datasheets/Lists	MS Excel 2013 or Adobe Acrobat as agreed with Company	*
Email	Rich Text Format	
Schedules	Primavera	*
Organization Charts/diagrams	Visio 2013, Microsoft power point or as agreed with Company	
Portable Document Format Files	PDF files shall always be directly generated from the authoring application. Scanned documents/Images which are converted to Adobe Acrobat format do not qualify as Portable Document Format files and shall be treated as image files for the purpose of format compliance.	

*Version shall be finalized during KOM.

In case documentation submitted is of authoring software mentioned below, the data has to be submitted comprehensively including native files, databases, catalogs etc., as detailed here.

SMART 3D	Project DBs in oracle/sql** (version shall be compatible with latest version of SMART 3D) along with Reference project for Catalogues, Standards, customization develop for the job etc.
INTERGRAPH SMART P&ID	SPID Project Backup along with deliverables extracted from SPID (P&ID, PDS, Line list) and database in oracle/sql** (version shall be compatible with latest version of SMART PID)
AUTOCAD	DWG/DXF files
SMART Instrumentation	SPI Project Backup (DWG + Datasheets + Tags & Attributes in excel format) and database in oracle/sql** (version shall be compatible with latest version of SMART Instrumentation)
SMART Electrical	SE Project Backup (DWG + Tags & Attributes in excel format) and database in oracle/sql** (version shall be compatible with latest version of SMART Electrical)

*Database (oracle/sql) and Version shall be finalized during KOM.

2.9 Real Time Tracking of Major Shipments for BPREP Project and Data Sharing for Use on BPREP Control Tower

2.9.1 General Requirements

The EPC Contractor (directly and/or through their transport agency) shall provide real-time tracking information for all consignments as per the following:

1. Tracking information of all shipments through all modes of transport vs. Air, Land and Sea
2. GPS tracking for all shipments exceeding INR 10 lakhs in value
3. Electronic sharing of GPS tracking data (as applicable) and consignment tracking data (through Transport Agency's Transport Management System) via REST API and on web portal of EPC Contractor or transport agency, including depiction of location of consignments on map where GPS tracking is applicable
4. Tracking details for both international and domestic shipments.

For International Shipments mandatory vessel tracking through AIS (Automatic Identification System)

2.9.2 Mandatory Tracking Information

The EPC Contractor must provide the following information for each consignment:

1. Unique consignment identifier
2. Real-time GPS coordinates for in-transit shipments
3. Scheduled, Estimated and actual departure times from point of origin
4. Scheduled, Estimated and actual arrival times at destination
5. Current location and status updates on a daily basis (GPS Status updates shall be live)
6. Total Distance, Cumulative Actual Distance Travelled, Daily Distance Travelled to be updated on Daily basis.
7. Any deviation from planned route or schedule
8. Detailed consignment route details with GPS coordinates for key touchpoints like ports, terminals and warehouses.

2.9.3 Data Sharing Protocol

The EPC Contractor shall:

1. Provide access credentials for their tracking platform as applicable
2. Share tracking data in real-time for GPS tracking and daily basis
3. Provide notification of any tracking system failures/ downtime or data gaps

2.9.4 Security and Confidentiality

1. All tracking data shall be treated as confidential information
2. Data transmission must use secure protocols
3. EPC Contractor shall comply with relevant data protection regulations

3.0 Project Monitoring and Reporting for BPREP Project and Data Sharing for Use on BPREP Control Tower

3.0.1 Client is deploying a Project Monitoring System and Control Tower for the project. The EPC Contractor shall have the following obligations wrt Project Planning, Scheduling and Monitoring. This will be read in conjunction with project management clauses specified elsewhere in the Tender/MR.

3.0.2 The EPC Contractor shall submit a comprehensive monthly progress report via the PMIS, which will include the following:

1. Executive Summary: A high-level overview of the reporting period's progress, summarizing key accomplishments and major issues encountered.

2. Progress Monitoring: Progress Monitoring/ Earned Value Management (Planned vs Actual) at project and Functional Level based on underling Deliverable List/DCI, Sub-ordering/ Material Control Index (MCI), Manufacturing Milestones and actual progress against planned schedules.

3. Project Schedule: EPC Contractor shall submit the Critical Path Method Schedule (CPM) Project Scheule in Primavera P6 or MS Project Format on a monthly basis.

4. Areas of Concern: A detailed description of any issues or risks impacting project timelines, Engineering, Manufacturing, or Sub-ordering activities. The EPC Contractor must identify bottlenecks, supply chain delays, and potential risks that may affect overall project progress.

5. Engineering Status: Detailed progress reports on engineering tasks, including design, technical drawings, and any engineering-related milestones, document approval status, pending approvals, revisions, or rejections etc. Any delays or issues affecting these deliverables must be clearly reported. EIL VDMS data shall may be available to EPC Contractor for reference.

6. Sub-ordering Status (MCI): A summary of all sub-ordering activities, including key milestones, supplier performance, and delivery timelines. Any delays or issues affecting suborders must be clearly outlined.

7. Manufacturing Status: A detailed update on the manufacturing process, including the production schedule, quality checks, and any deviations from planned timelines.

8. Dispatch Status: Detailed status of items dispatched, Packing Lists, LR Details, Transporter Details, Tracking Details etc.

3.0.3 Data Integration: The EPC Contractor shall ensure that all required data, including schedules, deliverables, and KPI inputs, are entered (manual entry, predefined templates) accurately into the PMIS system. EPC Contractor will be provided access to the PMIS System. The EPC Contractor is responsible for ensuring data integrity and timely submission.

3.0.4 Compliance with Workflows: The EPC Contractor must adhere to the defined workflows in the PMIS system for report submission, review, and approval. The EPC Contractor's reports will undergo review at multiple levels and the EPC Contractor shall address any feedback or corrections promptly.

3.0.5 Earned Value Management (EVM): The EPC Contractor is responsible for providing inputs that align with the Earned Value Management methodology, including schedule and cost data, weighted WBS, and progress updates, which contribute to the generation of project S-curves and EVM reports.

3.0.6 The reports will be submitted in PMIS predefined templates, reviewed through the PMIS workflows, and updated in the system on a monthly basis. The EPC Contractor shall ensure all data is accurate and up to date to allow for timely review and integration into the overall project progress monitoring system.

3.0.7 Failure to provide data/ info on timely basis may be considered a breach of contract.

3.0.8 Contractor shall comply with cybersecurity guidelines/advisories/acceptable use policy issued by BPCL/EIL.

3.0.9 In case, any of the systems are not deployed, or are stopped during the course of the contract; executing, reporting and monitoring of the work will continue through traditional methods, other platforms as directed by the Engineer-in-Charge.

3.0.10 Non availability of platforms will not be a reason for seeking time extension, change orders pertaining to time and/ or cost.

प्रेशर वेसल्स के सामान्य विनिर्देश

GENERAL SPECIFICATION FOR PRESSURE VESSELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	12.03.2024	REVISED AND REISSUED AS STD. SPEC.	PS	TKh	KA/NK	MN
6	28.08.2018	REVISED AND REISSUED AS STD. SPEC.	SK	TK	KJH	RKT
5	30.06.2010	REVISED AND REISSUED AS STD. SPEC.	KA	RKT	AKM/DM	N.DUARI
4	20.11.2009	REVISED & REISSUED AS STD. SPEC.	VB	RKG	AKM	N.DUARI
3	15.05.2000	REVISED AND REISSUED AS STD. SPECN.	RKT	AKM	CRMN	MI
2	15.12.1994	REVISED AND REISSUED AS STD. SPECN.	DD	AKM	VC	AS

Abbreviations:

AI	:	Authorized Inspector
ASME	:	American Society of Mechanical Engineers
DNV	:	Det Norske Veritas
IBR	:	Indian Boiler Regulations
ISO	:	International Organisation for Standardisation
NB	:	Nominal Bore
PESO	:	Petroleum & Explosives Safety Organisation
PWHT	:	Post Weld Heat Treatment

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar

Members:
Mr. K. Anjaneyulu (Co-Convener)
Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
Mr. P V S Satyanarayana
Mr. Anish Trehan
Mr. P Barik
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karanam
Mr. Aasheesh Handa (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agarwal (SCM-Inspection)

CONTENTS

1.0 SCOPE

1.1 This specification covers the general requirements for design, fabrication, workmanship, erection, inspection, testing and supply of unfired pressure vessels and is intended to supplement the minimum requirements of the applicable codes.

1.2 Supplementary specification indicating special or additional requirements shall form addenda to this specification and shall govern. Supplementary specification, when made addenda to this specification shall be referred to in the Material Requisition and / or Purchase Order. Following are the supplementary specifications:

a)	6-12-0002	Supplementary specification for carbon steel vessels.
b)	6-12-0003	Supplementary specification for low alloy steel vessels.
c)	6-12-0006	Supplementary specification for austenitic stainless steel vessels.
d)	6-12-0007	Supplementary specification for stainless steel clad vessels.
e)	6-12-0008	Supplementary specification for 3½ %Ni steel pressure vessels.

1.3 In case of conflict, the order of precedence shall be as follows:

a) Statutory Requirement
b) Engineering drawing
c) Specifications and standards
d) Codes

In general, the most stringent requirement out of the above shall govern. However, in such a case, vendor shall promptly refer the conflicts to client / EIL in writing to obtain client / EIL instruction before proceeding with manufacture. Decision of client / EIL shall be binding without any time and cost implication.

2.0 REFERENCES

2.1 Design Codes

The following codes in the edition and addenda referred to in the datasheet shall form the basis for design, fabrication, inspection, testing and acceptance of equipment:

(a) ASME Boiler and Pressure Vessel Code Section VIII Div. 1

(b) ASME Boiler and Pressure Vessel Code Section IX and Sec V.

(c) Indian Boiler Regulations- IBR (whenever applicable).

(d) The Static and Mobile Pressure Vessels (Unfired) Rules 2016 (whenever applicable).

2.2 Material Codes

Material to be used shall conform to:

(a) ASME Boiler and Pressure Vessel Code Sec. II.

(b) Indian Standard specification.

Other specifications of equivalent grade can be used only after written approval from EIL.

2.3 Regulations

National laws and regulations together with any local by-laws for the country or state wherever the vessels are to be used must be complied with by the fabricator.

3.0 DESIGN

3.1 Design Pressure

3.1.1 Design pressure specified shall be at the top of vertical vessel or at the highest point of horizontal vessel.

3.1.2 The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.

3.2 Corrosion Allowance

3.2.1 Corrosion allowance shall be added to both sides of tray support rings and other fixed internal non-pressure parts.

3.2.2 Removable internal parts (with the exception of trays) which are bolted or clamped in place, shall be provided with extra thickness equal to half the specified corrosion allowance on each surface exposed to vessel contents.

3.2.3 Full corrosion allowance shall be added to the throat thickness necessary for strength or sealing in case of fillet and seal welds on internal attachments.

3.3 During fabrication or shop/site hydro-test conditions in horizontal position, the supports for shell shall be so provided that combined stresses in any shell component (based on corroded thickness for site test) do not exceed the following:

(a) Tensile :	90% of ambient yield
(b) Compressive:	Code allowable stress

3.4 All conical reducers shall be designed as tori conical type with knuckle radius at each end as minimum 10% of the adjoining diameter, unless otherwise specified in requisition. 100% radiography shall be carried out for all weld seams of tori cone.

3.5 Statutory Approvals

3.5.1 For vessels coming under the purview of Indian Boiler Regulations, it shall be vendor's responsibility to get approval from IBR authorities pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.

3.5.2 For vessels coming under the purview of Static and Mobile Pressure Vessel rules, it shall be vendor's responsibility to get approval from Petroleum & Explosives Safety Organization (PESO) pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.

3.6 Internals

3.6.1 For support beams, allowable deflection shall be limited to L/325 where L is the length of the beam.

3.6.2 For plates, allowable deflection shall be limited to T/2 where T is the corroded thickness of plate.

3.6.3 Allowable stress at design temperature shall be as per applicable Code.

4.0 FABRICATION

4.1 Head/Dished Ends

4.1.1 Dished ends shall preferably be of seamless construction. However, dished ends with one chordal weld seam are acceptable. In such cases, the width of chordal plate shall not be less than one third of the blank diameter and chordal seam shall clear nozzle opening. Intermediate heat treatment, if considered necessary, shall be carried out by the fabricator.

4.1.2 Whenever a dished end is made of more than two plates, it must have a seamless crown plate. Whenever a nozzle or a manhole is positioned at the center of the dished end, the crown plate should be larger than the nozzle /manhole reinforcing pad.

4.1.3 Wherever hot forming and subsequent heat treatment is involved, adopted procedure shall not impair the mechanical properties of the material beyond the limits specified in respective material specification.

4.2 Nozzles, Manholes, Handholes and Attachments

4.2.1 Manhole cover shall be provided with a davit or hinge as per EIL standard and Handhole cover shall be provided with suitable lifting handles.

4.2.2 Inside edges of Manholes/Handholes shall be rounded off smooth with a minimum radius of 3mm.

4.2.3 All nozzles shall be set-in type, unless otherwise specified in requisition. Set on type nozzle for size 50 NB and below can be used with prior approval.

4.2.4 Reinforcing pads whenever required as per drawings or Code shall be of the same material or equivalent as the vessel component to which it is welded. All reinforcing pads shall be provided with two 1/8" (3 mm) NPT tapped holes located 180 apart for air soap solution test with a pressure of 1.25 kg/cm2 (g). This test shall also be required to be carried out for slip on flanges. Higher test pressures are not recommended because of accompanying risks and also because the soap bubbles have a chance to blow off. Tell-tale holes in the reinforcing pads shall be plugged with hard grease unless otherwise indicated after the hydro test of the vessel.

4.2.5 Wrapper plates, reinforcing pads, saddle plates or stiffeners of higher thickness than specified can be used provided there is no change in basic dimensions and with the approval from Inspection Agency. No separate deviation permit is required for the same.

4.3 Flanges

4.3.1 When tongue and groove or male and female faced flanges are used, groove or female face shall be in nozzle flange. However, when the nozzle is located in the bottom, the groove or female face shall be in the cover.

4.3.2 Dimensions of flanges shall be as per ASME B16.5 for sizes up to 600 mm NB (24" NB) and as per ASME B 16.47 series 'B' for sizes greater than 600 mm NB (24" NB).

4.4 Fasteners and Gaskets

4.4.1 All bolts/studs shall have ISO threading unless otherwise specified. Studs shall extend beyond nuts at least by 2 threads & studs shall be threaded to full length. Bolts/studs (to be tightened by hydraulic bolt tensioner) shall be longer than normal length by minimum 1 nut diameter.

Hydraulic bolt tensioner shall be used for following bolt sizes and conditions and shall be supplied by vendor unless otherwise specified in the Requisition:

Nominal Bolt Size	Conditions
All Sizes	When specified by Process Licensor/Project specifications
50 mm and Over	All flange joints
38 mm and to 50 mm	Class 600 and above
	Hydrogen service (Partial Pressure of Hydrogen > 7 Kg/cm2g)
	Design Temperature above 370oC
	Inlet, outlet and quench nozzle flanges of reactors/separators (#)
25 mm to 38 mm	Design Temperature above 370oC
	Inlet, outlet and quench nozzle flanges of reactors/separators (#)

Applicable only for Hydrocracker/DHDT/DHDS/VGO-HDT Reactors and Hot & Cold Separators.

4.4.2 All internal bolts shall be provided with double nuts.

4.4.3 Threads on external bolting shall be lubricated with graphite grease for working temperature up to 200°C and with Molybdenum Di-sulphide for higher temperature.

4.4.4 In addition to stamping of the specifications & manufacturer's symbol as specified in ASME material specifications, size shall be clearly punch marked on one of the ends of the stud. Similarly, the nuts shall have the size punch marked on one of the faces. In case of tapped hole the size shall be punch marked near the hole without disturbing the gasket seating area. Further for all alloy/SS metallurgy bolts & nuts shall also be identified by distinct color marking at the stud end/bolt side face.

4.4.5 Gaskets shall conform to ASME B16.20 and ASME B 16.21.

4.5 Internals and Externals

4.5.1 All removable internals shall pass through the manhole.

4.5.2 Internal baffles, tray support beams or other internals spanning a chord or diameter of the vessel shall be provided with means to allow differential thermal expansion between the part and the vessel shell.

4.5.3 Internal pressure piping shall be seamless and of same specification as the external connected piping. However internal non-pressure piping can be either seamless or welded type.

4.5.4 Internal flanges for pressure piping shall be forged flanges. However internal flanges for non-pressure piping can be fabricated from plate.

4.5.5 Tray/seal pan support rings, downcomer bolting bars and all internals, beam supports welded to the vessel shall be supplied and welded by vessel fabricator in accordance with the details furnished by EIL.

4.5.6 The internal baskets, mesh screens, support grid, distributor/mixing trays, distributor pipes, outlet collector etc. of equipment shall be fitted at shop unless otherwise specified in requisition. Equipment shall be transported along with internals fitted. Temporary wedges (if required) shall be provided for supporting the internals which shall be removed by mechanical contractor at site under vendor's supervision unless otherwise specified. Additionally, manway panels shall be provided for mesh screens, support grids, distributor/mixing trays etc. to ensure accessibility for future inspection, loading/unloading of catalyst/inert balls etc.

In case the internals are to be supplied loose as per requisition, the internal baskets, mesh screens, support grid, distributor/mixing trays, distributor pipes, outlet collector etc. of equipment shall be trial fitted,

then removed and crated for dispatch with vessel. These items should be tagged for field identification and installation.

4.5.7 All externals shall be supplied and welded by vessel fabricator in accordance with the details furnished by EIL.

4.5.8 Internal perforated plate inside the vessel shall be removable type unless specified otherwise and should be able to pass through nearest manhole.

4.5.9 Unless specified otherwise, Full support rings shall be provided below catalyst bed to support same.

4.6 Name Plate

Each vessel shall be supplied with EIL name plate and manufacturer name plate as per EIL Standards.

4.7 Welding

4.7.1 Flame cut edges shall be ground by the fabricator as required to remove slag, detrimental discoloration and non-uniformity of edges.

4.7.2 All pressure bearing butt welds shall be full penetration, double welded joints. When second side welding is not possible due to inaccessibility, single welded butt joints with root run by Tungsten Inert Gas Process (TIG) can be used to ensure full penetration. Backing strip can be used only after obtaining prior approval from EIL. For sub-zero temperatures, backing strips shall not be used.

4.7.3 Nozzles and Manways and their reinforcement pads shall be attached to vessel with full penetration welds.

4.7.4 Seams in supporting skirt shall be made with full penetration butt welds. Connections between skirt and vessel head shall be made with a smooth flat faced weld unless otherwise indicated in the engineering data sheet. Width of the weld at skirt end shall be equal to the skirt thickness and its height shall at least be twice its width.

4.7.5 All main weld seams shall be clear of nozzles, reinforcement pads, internals, tray support rings, cleats and stiffening rings by 50 mm minimum (weld edge to weld edge). In case the same is unavoidable following requirements shall apply:

a) Nozzles without reinforcing pad

i) Any weld seam having distance (weld edge to weld edge) to nozzles within 50 mm (but not fouling with weld seam) shall be fully radiographed and dye penetrant examined to a length equal to 100 mm on each side measured from nearest point to nozzle edge.

ii) Any weld seam fouling with nozzle opening shall be fully radiographed and dye penetrant examined to a length equal to 3 times of outside diameter of nozzle i.e. 1.5 times of outside diameter of nozzle on each side after installation of nozzles. Nozzle to vessel fillet weld shall be provided with smooth concave radius.

b) Nozzles with reinforcing pad

i) Any weld seam having distance (weld edge to weld edge) to reinforcing pad within 50 mm (but not fouling with weld seam) shall be fully radiographed and dye penetrant examined to a length equal to 100 mm on each side measured from nearest point to reinforcing pad edge.

ii) Any weld seam not fouling with nozzle opening but coming under reinforcement pad shall be ground flush, fully radiographed and dye penetrant examined to a length equal to portion of weld seam below reinforcement pad + 100 mm on each side.

iii) Any weld seam fouling with nozzle opening shall be ground flush, fully radiographed and dye penetrant examined to a length equal to higher of 3 times of outside diameter of nozzle i.e. 1.5 times of outside diameter of nozzle on each side or length equal to portion of weld seam below reinforcement pad + 100 mm on each side.

In case other attachments like internals, tray support rings, cleats etc. is fouling with weld seam, the weld seam portion coming under the attachment plus 100 mm length on each side shall be ground flush, fully radiographed and dye penetrant examined before welding of any such attachment.

4.7.6 Vendor shall submit welding procedure specification and qualification record to purchaser's inspector or authorized representative for approval as per ASME Boiler and Pressure Vessels Code Section IX.

Previously qualified welding Procedure Qualification Record (PQR) under EIL, CEIL, Lloyds, DNV, TUV and Bureau Veritas shall also be acceptable.

4.7.7 Welding consumables shall be as per ASME Boiler and Pressure Vessel Code Sec. II Part C and shall be indicated in fabrication drawings.

4.7.8 Welding shall not commence unless the concerned procedures are approved.

4.7.9 Only welders who are qualified in the accepted procedure shall be employed for welding.

4.7.10 All internal/external attachments (nozzles, cleats etc.) with fillet welds to the vessel pressure components in case of Hydrogen service, cyclic service and vessels with design temperature (-)29oC and lower, vessels with design temperature 370oC and higher for carbon steel and 425oC and higher for low alloy steel shall be ground smooth and generous concave contour shall be provided.

4.7.11 Minimum shell course width shall be 1 meter. Maximum no. of longitudinal seams shall be as follows:

(a)	vessels up to 2 meter diameter	:	1 seam
(b)	vessels from 2 meter up to 4 meter diameter	:	2 seam
(c)	vessels from 4 meter up to 6 meter diameter	:	3 seam
(d)	vessels beyond 6 meter diameter	:	seam nos. can be proportionately decided

4.8 Post Weld Heat Treatment

4.8.1 Vessels shall be post weld heat treated when specified on the engineering drawings. In no case shall the post weld heat treatment performed be less than that specified in the code.

4.8.2 Vessels shall be post weld heat treated as a complete unit including skirt/support, wherever practicable.

4.8.3 All flange faces shall be suitably protected against oxidation during post weld heat treatment.

4.9 Tolerances

4.9.1 Tolerances shall be as per drawing/standard/code.

4.9.2 For dimensions not provided with tolerances, fabricator shall maintain dimensions as per good engineering practice.

5.0 INSPECTION & TESTING

5.1 All vessels shall be offered for inspection to purchaser or his authorized inspector.

5.2 Inspectors shall have free access to all workshops of contractors or sub-contractors.

5.3 Inspection shall be carried out both during fabrication and before delivery and also for sub-ordered materials, if any. In addition to final inspection and certification by Inspector, Inspector's written approval shall be obtained by the manufacturer at all stages of fabrication including, but not limited to the following:

a) Raw material identification

b) Edge preparation for welding, including visual check for laminations.

c) Alignment of longitudinal seams.

d) Rolling tolerance on individual sections

e) Alignment of sections

f) Root pass clearing before welding.

g) Nozzle setting.

h) Dimensional check.

i) Radiographic / Ultrasonic Examination.

j) Dye penetrant examination/Magnetic particle examination.

k) Stress relieving.

l) Calibration records of measuring instruments.

m) Pressure Test (Hydrostatic/Pneumatic test).

n) Any other special test such as for leak, corrosion, hardness etc.

o) Surface preparation, primer and painting.

5.4 Radiography

5.4.1 The extent of radiography shall be as specified on the engineering drawings. In no case shall the radiographic examination be less than that specified in the code. However, spot radiography is the minimum requirement for all vessels.

5.4.2 When spot radiography is specified, the following requirements shall supplement the requirements specified in ASME Section VIII Division I:

Each category A or B pressure containing weld shall be spot radiographed in accordance with ASME Section-VIII Division-I, paragraph UW-52 as a minimum requirement. Each Spot radiograph shall be a minimum of six inches (150mm) in length and minimum one spot shall be selected in each circumferential & longitudinal seam. Additionally, at least one T-joint in each circumferential seam shall also be selected. Welds from each welding procedure, welded/welding operator shall be examined. DIA shall be consulted in marking the areas to be radiographed.

5.4.3 All nozzles fabricated from plate, irrespective of thickness of plate, shall be 100% radiographed. When Full radiography is specified due to Service requirement, 100% radiography shall be carried out of all butt welds including nozzle flange to nozzle neck, pipe to pipe and pipe to fitting.

5.4.4 Weld seams of formed ends shall be 100% radiographed after forming and heat treatment, if any.

5.4.5 The specified radiography of welds may be performed before or after post weld heat treatment (PWHT). If performed before PWHT, an additional radiography or alternatively, ultrasonic examination shall be performed after PWHT.

5.4.6 The technique employed and the weld quality achieved shall meet the requirement of the code.

5.4.7 If vendor intends to carry out radiography by Computed Radiography technique, then demo should be carried out under AI to prove vendor's capability to produce acceptable images meeting the Code requirements.

5.4.8 In case Supplier want to perform UT in lieu of RT based on Code para UW 51 (a) (4), the same is acceptable for Carbon Steel and Low Alloy Steel materials subject to the following:

a) The thickness of weld is greater than 13 mm.

b) The joint is either Category A or Category B joint except shell to hemispherical dished end joint. (Category of joint as defined by Code).

c) Automated recordable UT machine incorporating TOFD and pulse echo probes or TOFD and Phased Array mounted on the same chassis that automatically traverses along the joints to be inspected and displaying both results simultaneously on a single screen may be considered in lieu of RT.

d) Calibration block of similar material & thickness shall be used. Calibration block shall have suitable notches to simulate longitudinal as well as transverse cracks on outside and inside surface. Setup should be capable of detecting defects on outside as well as inside while scanning from one surface only.

e) The system that is proposed to be deployed in lieu of radiography shall be submitted along with the track record prior to use for EIL review. The Supplier shall demonstrate successfully the capability of AUT machine and the defects evaluation in the same screen during the site visit of EIL representative. Based on which, the approval of the parties and their AUT system shall be given.

f) Qualified NDT persons shall be deployed to perform UT.

g) Acceptance criteria shall be as per Code para UW 51.

5.5 All nozzle to shell welds (Root and Final run) shall be examined by magnetic particle/ Dye- penetrant examination.

5.6 Hydrostatic Test

5.6.1 All necessary precautions shall be taken to guard against the risk of brittle fracture during hydrostatic test in the shop and at site. The temperature of testing medium shall be as per Code. Prior to hydrostatic test, all weld spatter, weld stubs, scale, dirt etc. shall be removed from vessel.

5.6.2 Hydrostatic test shall be conducted at pressures mentioned in engineering drawings after complete fabrication and post weld heat treatment, as applicable. After hydrostatic testing, Equipment shall be completely dried by passing hot air for sufficient time until no further increase in relative humidity of outgoing air is observed. Alternatively vacuum drying of the equipment is also acceptable.

5.6.3 Clean potable water shall be used for hydrotest. Sea water shall not be used.

5.6.4 During hydrotest, care shall be taken to avoid local stresses in shell from exceeding 90 % of the yield strength of the material at the temporary saddle supports.

5.6.5 Vessels shall not be painted or coated either internally or externally prior to the hydrostatic pressure tested.

5.7 For all weld overlays used in hydrogen or H2S service with design temperature greater than 350oC, Hydrogen disbonding test shall be carried out. The test condition shall be representative of the actual design conditions and the procedure shall be submitted to Inspection Agency for approval. Rate of cooling shall be 100oC/hr (min.) unless specified otherwise in datasheets. Holding time shall be 48 hours unless specified otherwise in datasheets.

5.8 Vendor shall ensure that all alloy steel and stainless steel material are properly identified and finally check tested by a PMI analyzer before dispatch of equipment as per EIL Specification 6-81-0001.

6.0 SUPPLY

6.1 Surface Cleaning and Painting

6.1.1 Surface cleaning and painting shall be as per standard specification for shop and field painting (6-44-0004) or as per job specification as applicable. Paint system shall be selected as per the environments specified on engineering drawing.

6.1.2 All completed equipment shall be cleaned internally and externally to remove scale, dirt, sand, water and foreign matter.

6.1.3 All flanged faces and other machined surfaces shall be greased or protected with rust preventive coating.

6.1.4 Except for machined surfaces, all exterior surfaces of vessels and columns including skirts and integral supports shall be painted to prevent rust, corrosion or damage during transit and storage before erection and final painting.

6.2 Marking

In addition to General purchase conditions, the following requirements shall also be complied with:

6.2.1 All loose components such as studs, nuts, washers, gaskets etc. shall be packed in crates and shall be marked for the project, consignee, consigner, job number, item number, order number, gross and net weight, dimensions etc.

6.2.2 Additional indications such as North/East/South/West along with center of gravity shall be clearly marked with white paint.

6.2.3 Vessels which have been post weld heat treated or have an applied lining, e.g. lead, glass, rubber etc., shall have a suitable warning printed on the visible portion on the outside of vessel.

6.2.4 Specific marking with white paint for slinging shall be provided for all heavy lifts weighing 5 tons and above.

6.2.5 A copy of packing list shall accompany the material enclosed in a water tight envelope fastened inside a shell connection with an identifying arrow sign "Documents" applied with indelible paint.

6.2.6 If it is necessary to separate the unit into different parts for transportation all components and subassemblies shall be carefully identified and match marked to prevent any error in assembly.

6.3 Packing and Shipment

In addition to General Purchase Conditions, the following requirement shall also be complied with:

6.3.1 Packing

a) Vessels, unless provided with their own steel saddles for entire protection, shall be provided with suitable wooden/steel saddles with steel ties and tension rods. The minimum height of the saddle shall correspond to the maximum projected length of the connected attachments, plus an additional clearance of 45mm. Saddles spacing shall depend on the length of the equipment.

b) Equipment shall be provided with suitable type and adequate number of supports to prevent any deformation during transportation and handling. These supports shall not be removed until the equipment is placed in position at job site.

c) All connections/protrusions shall be suitably protected. Flanges shall be provided with bolts on metal covers (minimum 5 mm thk) using at least four bolts. (Wiring on covers is not acceptable). For ocean shipment, flanged openings shall be additionally covered with heavy plastic bags taped to nozzle. All tell-tale holes shall be plugged with hard grease before dispatch. Tapped orifices shall have threaded plugs.

d) Fragile or machined components shall be especially protected against nature during handling and transit.

e) Pre-fabricated sections shall be protected by temporary stiffeners at each non-supported end. Edges of plates for section to be welded shall also be protected.

6.3.2 Shipment

All dispatches of equipment shall be done in accordance with the relevant terms of the Purchase Order.

7.0 GUARANTEE

Unless otherwise specified in General Purchase conditions regarding guarantee, the following shall govern:

7.1 Manufacturer shall guarantee that all materials used in the equipment are new and have been submitted to regular acceptance procedure and are free from any defect regarding quality, form and appearance.

7.2 Vessel(s) shall be guaranteed for design, raw materials and workmanship for a duration as defined in General Purchase Conditions. When design has been carried out by EIL, the word design shall be excluded from the guarantee clause. The manufacturer shall be completely responsible for any design work carried out by him. EIL's approval of his design will not relieve him of his responsibility to ensure satisfactory performance of such item.

7.3 Approval of work by EIL or release of vessels for shipment shall in no way release or relieve the manufacturer of any responsibility for carrying out all provisions of this specification.

8.0 SITE FABRICATION AND ERECTION

8.1 Where size or shape of vessel makes it impossible to ship it in one piece, the fabricator shall ship number of shop fabricated sections as defined in requisition. Assembly and testing shall be completed by vessel fabricator at site in horizontal position (for erection by others) in strict accordance with the provisions of applicable order/specification.

8.2 Where size or shape of vessel makes it impossible to erect in single piece, the fabricator shall ship number of shop fabricated sections as defined in requisition. Erection, assembly and testing shall be completed by vessel fabricator at site in vertical position in strict accordance with the provisions of the applicable purchase order/specifications.

8.3 In either of the above two cases, the following additional requirements shall apply:

8.3.1 All pieces shall be shop fit up into sections and each section fit to the adjacent one by the fabricator and all pieces match marked thereafter.

8.3.2 Suitable erection lugs /tailing lugs and locating pins shall be provided by the fabricator to ensure proper fit up & handling of the equipment.

8.3.3 All radiographic requirements for welds completed in the shop shall be made by the fabricator before the part of section leaves the shop.

8.3.4 For equipment requiring PWHT, complete or local PWHT may be carried out at site.

8.4 All lifting lugs/trunnions and tailing lugs shall be designed with an impact factor of minimum 1.5 unless otherwise specified.

9.0 DATA FOLDER

Manufacturer shall complete requisite copies of data folder as required in purchase order. This folder shall contain the following information duly certified by Inspector:

a) Manufacturer's Code Certificate
b) Fabrication drawing of vessel showing 'As Built' dimensions and 'As Built' erection weight.
c) Material Test Certificates with their cast /heat and test numbers
d) Welding procedure qualification reports
e) Welder qualification reports
f) Radiographic results
g) Ultrasonic, Magnetic particle, Dye-penetrant test results (if applicable)
h) Hardness, corrosion and leak test records (if applicable)
i) Record charts showing complete heat treatment cycle (if applicable)
j) Production test coupon results (if applicable)
k) Charpy V notch test results (if applicable)
l) Record chart of pressure test (Hydrostatic and/or pneumatic)
m) Rubbing of name plate
n) Any other documentation as required in the purchase requisition/purchase order.

कार्बन स्टील वैसल्स के पूरक विनिर्देश

SUPPLEMENTARY SPECIFICATION FOR CARBON STEEL VESSELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
9	23.11.2023	REVISED AND REISSUED AS STD. SPEC.	PSV	TK	KA/NK	MN
8	26.06.2018	REAFFIRMED AND REISSUED AS STD. SPEC.	SK	TK	KJH	RKT
7	30.06.2010	REVISED AND REISSUED AS STD. SPEC.	KA	RKT	AKM/DM	N.DUARI
6	25.09.09	REVISED AND REISSUED AS STD. SPEC.	VB	RKG	AKM	N.DUARI
5	12.04.04	REVISED AND REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG

Abbreviations:

ASME	:	American Society of Mechanical Engineers
BHN	:	Brinell Hardness Number
HAZ	:	Heat Affected Zone
LWN	:	Long Weld Neck
NB	:	Nominal Bore
PWHT	:	Post Weld Heat Treatment
UTS	:	Ultimate Tensile Strength

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar

Members: Mr. K. Anjaneyulu
Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
Mr. Anish Trehan
Mr. P V S Satyanarayana
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karanam
Mr. Ayush Mathur (Project)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agarwal (SCM- Inspection)

CONTENTS

1.0 SCOPE

This supplementary specification indicating additional requirements for fusion welded carbon steel vessels shall form addenda to General Specification for Pressure Vessels (6-12-0001) in its latest revision.

2.0 DESIGN

Reinforcement for nozzle openings shall be self reinforced type for equipment where nominal thickness of shell/head exceeds 50 mm. Nozzles of size up to 50 NB LWN can be used in place of self reinforced nozzles.

3.0 ELECTRODES

3.1 Electrodes conforming to following specification shall be used. In case of any deviation, prior approval from EIL shall be obtained.

S. No.	Material to be welded		Electrode Specification
1.	General Structure Welding	:	ASME IIC SFA 5.1 E-6013
2.	Pressure Parts		
a.	Steels with UTS upto 70,000 psi	:	ASME IIC SFA 5.1 E7016/ E7018
b.	Steels with UTS upto 80,000 psi	:	ASME IIC SFA 5.5 E8016-X/ E8018-XX depending upon the alloy element.
c.	Low temperature service		
	Below 0°C and upto (-) 46°C Steels to SA-516 / 516M, SA-537 / 537M, SA-333 / 333M Gr. 6 and SA-350 / 350M LF2	:	ASME IIC SFA 5.1 E 7016-1/ E7018-1

3.2 All electrodes and fluxes shall be properly baked/dried as per manufacturer's recommendation before use.

3.2.1 All bare electrodes and fluxes shall be selected as per ASME IIC .All weld metal shall have equal or better mechanical properties than the parent metal.

3.2.2 Only dry flux shall be used.

4.0 FABRICATION

4.1 Plate Forming

4.1.1 Forming of shell plates and heads shall be carried out by machine, either hot or cold, in such a way so as to preserve the specified material properties and to produce a regular finish.

4.1.2 Magnetic particle/Dye penetrant examination shall be carried out on the outside and inside surfaces including edges of torispherical or elliptical heads in knuckle zone, after forming, for detection of cracks.

4.2 Edge Preparation

4.2.1 The preparation of edges to be welded shall be done by machining, chipping, grinding, cold shearing, Oxy- acetylene flame cutting or a combination of these.

4.2.2 Chipping shall be followed by grinding to a smooth and regular finish.

4.2.3 Oxy-acetylene flame cutting done in any circumstances, shall be followed by machining or grinding to eliminate any discolouration of material affected.

4.2.4 All welding edges shall be checked by Magnetic particle/Dye penetrant examination for detection of cracks, laminations or segregations.

4.2.5 No welding shall be carried out when ambient temperature is less than 10° Celsius unless preheating is carried out.

4.3 Heat Treatment

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

a. Cold formed dished ends or knuckles shall be stress relieved, unless otherwise specified in requisition.

b. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.

c. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.

4.3.2 Vessels in Hydrogen/Amine/ Sour (Wet H_2S)/Cyclic/Caustic/HIC service shall be PWHT.

4.4 Production Weld Tests

Production Weld Tests shall be applicable for vessels over 50 mm nominal thickness. The following requirements shall apply:

a. Two production test plate coupons representative of one longitudinal and another circumferential seam shall be provided for each procedure, position and thickness in each vessel shell.

b. One production test plate representative of the weld seams shall be provided for each procedure, position and thickness for welded dished ends/cones.

c. The production test plate shall be from material of the same heat and thickness as of shell/head/cone as applicable. During and after welding, the test plates shall be subjected to same heat treatment as and together with the course they represent. Extra coupons shall be preserved to take care of eventuality of retests.

d. The tests mentioned below shall be carried out as per methods of testing in governing codes:

i. One transverse tension test

ii. Two side bend tests with weld located in the centre of bend.

iii. Hardness test on production test coupon weld & HAZ (Hardness limitations shall comply with requirement of EIL Spec. 6-15-0091)

iv. Micro & macro examination of welds

v. Charpy V notch tests on weld and HAZ.

a. For low temperature service (0°C & colder) impact test temperature shall be lowest of minimum ambient temperature, design temperature and minimum design metal temperature.

b. For vessel over 50 mm nominal thickness used for warmer service, the test temperature shall be lower of 0°C or lowest ambient temperature of the site.

c. The acceptance criteria for energy absorption shall be as per Table A 2.15 of SA-20 / 20M. In case the acceptance criteria is not available in SA-20, then applicable design code shall be referred unless otherwise specified in requisition.

4.5 Hardness Survey

Hardness Limitation for Vessels, where PWHT is required shall comply with requirement of EIL Spec. 6-15-0091.

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STANDARD SPECIFICATION FOR BOILER QUALITY CARBON STEEL PLATES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
9	08.02.2022	REVISED AND REISSUED AS STD. SPEC.	JK	KA	NK	SM
8	19.01.2017	REVISED & REISSUED AS STD. SPEC.	RNK	SK/KJH	RKT	RN
7	30.06.2010	REVISED & REISSUED AS STD. SPEC.	KA	RKT	AKM/DM	N.DUARI
6	10.09.09	REVISED & REISSUED AS STD. SPEC.	VB	RKG	AKM	N.DUARI
5	16.04.04	REVISED & REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG

Abbreviations:

ASME	American Society of Mechanical Engineers
EN	European Norm
HIC	Hydrogen Induced Cracking
IBR	Indian Boiler Regulations
SSC	Sulphide Stress Cracking

STANDARDS COMMITTEE

SMED-I (Static Equipment) (Group code 12,13,15,26)

Mr. Nalin Kumar (Convener)
Mr. K. Anjaneyulu
Mr. Tarun Kumar (Emp no. A328) {Coordinator}
Mr. Anish Trehan
Mr. PVS Satyanarayana
Mr. Tarun Khurana
Mr. Saikat Chakraborty
Mr. Srikanth Karanam
Mr. Ayush Mathur (Projects)
Mr. S Ghosal (SMMS)
Mr. Avdhesh Agrawal (SCM)

CONTENTS

1.0 SCOPE

1.1 This specification covers requirements for carbon steel plates intended primarily for pressure vessels/heat exchangers. The steel plates shall meet the requirements of ASME Boiler and Pressure Vessel Code Section II (latest). This is intended to supplement the minimum applicable requirements of the material specification indicated in the material requisition.

1.2 Following codes, standards etc shall be followed in their latest edition and addenda, errata, amendments unless specified otherwise:

1.2.1 ASME Sec VIII Div 1

1.2.2 ASME Sec II part A

1.2.3 EN 10163: Delivery Requirements for Surface Conditions.

1.2.4 EN 10204: metallic products – Types of Inspection Documents.

2.0 GENERAL

2.1 Plates supplied to this specification shall conform to specification SA-20 of ASME sec II part A with additional requirements mentioned herein.

2.2 The tolerance on thickness of steel plates shall be positive only.

2.3 Final Rolling shall be lengthwise.

2.4 The plates shall be free from injurious defects and shall have workmanlike finish. Reconditioning/repair of plates by welding shall not be permitted. Surface conditions shall meet requirements of EN 10163 Class A Subclass 3.

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS

3.1 All plates shall be supplied in normalised condition except when the applicable material specifications require supply of plates in quenched and tempered condition.

3.2 a. One product analysis of each heat shall be carried out and reported. Chemical analysis shall be as per applicable specification.

b. The carbon content for plates shall not exceed 0.23%.

Additionally, one of the following requirements for carbon equivalent based on heat analysis, shall be also satisfied:

$$Ceq = C + \frac{Mn}{6} \leq 0.42 \quad \ldots\ldots \quad \text{(Eqn. - 1)}$$

$$Ceq = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15} \leq 0.43 \quad \ldots\ldots \quad \text{(Eqn. - 2)}$$

Equation-1 shall be used when applicable material specification specifies C and Mn only.

Equation-2 shall be used when applicable material specifies the above elements or restricted chemical requirements are specified or supplementary requirements S19 and S21 of SA-20 are specified in material requisition.

For HIC services, these requirements shall be as listed separately.

3.3 Ultrasonic Examination of Plates

a. Plates having thickness 16 mm to 50 mm (both inclusive) shall be examined ultrasonically as per SA-435.

b. For thicknesses above 50mm ultrasonic examination shall be carried out as per SA-578 and shall have acceptance standard of level-B.

c. For quenched and tempered steel plates, ultrasonic examination shall be done after the heat treatment of plates.

3.4 Simulated Heat Treatment of Test Coupons

The following heat treatment shall be conducted on the test coupons representative of heat treated plates before the specified mechanical testing like tensile, bend, impact tests, etc. to meet minimum ASME Sec. II Part - A requirements and these details shall also be recorded on the test certificates.

a. All plates supplied in Normalised condition and intended for hot rolling / hot forming:

Heat Treatment Cycle

One normalising* + One stress relieving as per UCS-56 of ASME Sec. VIII Div.1 complying with UCS-85 of ASME Section VIII Div. 1.

Note: Any other special requirement shall be specified in MR.

b. All plates supplied in Quenched & Tempered condition and intended for hot rolling/ hot forming:

Heat Treatment Cycle

One normalising* + quenched & tempering + One stress relieving as per UCS-56 ASME Section VIII Div.1 complying with UCS-85 of ASME Section VIII Div.1.

Note : Tempering temperature shall be at least 20° C above highest stress relieving temperature.

* Normalising cycle shall be as per Material Test Certificate (MTC).

c. All plates supplied in Quenched & Tempered condition and intended for cold forming:

Heat Treatment Cycle

One stress relieving as per UCS-56 ASME Section VIII Div.1 complying with UCS-85 of ASME Section VIII Div.1.

3.5 Impact test requirements shall be ascertained as per ASME Sec VIII Div.1 or Div.2 as applicable. When required, Impact testing shall be performed as per supplementary requirement of S5 of specification SA-20 and acceptance criteria for energy absorption shall be as per table A2.15 of SA-20.

3.6 If specified in the material requisition, plates shall meet the requirements of Indian Boiler Regulations (IBR).

3.7 Additional Requirements for High Thickness Plates

Plates above 50mm thickness shall meet following additional requirements:

a. Vacuum Degassing treatment as per the supplementary requirement S1 of specification SA-20. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

b. Charpy V-notch impact test as per the supplementary requirement S5 of specification SA-20.

Material meant to be used for design temperature warmer than 0°C, impact test shall be carried out at 0°C or MDMT whichever is lower and acceptance criteria for energy absorption shall be as per Table A2.15 of SA-20. Incase the acceptance criteria is not available in SA-20, then applicable design code shall be referred unless otherwise specified in material requisition.

c. Simulated heat treatment of test coupons for all plates as per Clause 3.4 mentioned above.

4.0 CERTIFIED DOCUMENTS

The supplier shall furnish certificates/documents (number of copies as specified in requisition) inclusive of all the following tests required as per specification duly certified by the Inspecting Authority before shipment of plates. The actual values obtained shall be recorded in the test certificates/documents. Material certificates shall conform to EN 10204 Type 3.1/3.2 as specified.

a. Chemical Analysis

b. Mechanical Tests

c. Data of heat treatment i.e. initial temperature, heating rate, soaking temperature, cooling rate, etc.

d. Simulated Heat Treatment of Mechanical Test coupons (S3 of SA-20) at indicated Heat Treatment Cycle (if specified in the requisition or whenever applicable)

e. Ultrasonic Examination (S8 or S12 of SA-20)

f. Charpy V-notch impact tests (S5 of SA-20 if specified in the requisition or whenever applicable)

g. Certification as per IBR (if specified in the requisition)

h. SSC and/or HIC tests (if specified in material requisition)

i Additional tests (if specified in requisition).

5.0 PAINTING AND COATING

No painting/coating of any kind is permitted on the steel plates, except stencil marking. However steel plates shall be carefully protected and packed against any damage during transit and shall be of sea worthy condition.

6.0 INSPECTION AUTHORITY

Material test certificates, duly certified by Mill's Quality Assurance Department are acceptable i.e. 3.1 certification as per EN 10204. However, if third party inspection is required specifically for plates in material requisition, all test certificates and documents shall be duly certified by the third party. i.e. 3.2 certification as per EN 10204.

भंडारण टैंक एवं वैसल के लिये वेल्डिंग योग्य स्ट्रक्चरल क्वालिटी स्टील प्लेटों का मानक विनिर्देश

STANDARD SPECIFICATION FOR WELDABLE STRUCTURAL QUALITY STEEL PLATES FOR STORAGE TANKS AND VESSELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	27.03.2023	REVISED AND REISSUED AS STD. SPEC.	NSK 27/03/23	TK 27/03/23	NK	SM
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4	15.09.09	REVISED & REISSUED AS STD. SPEC.	VB	RKG	AKM.	N.DUARI
3	08.04.04	REVISED & REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG

Abbreviations:

EN	:	European Norm
IS	:	Indian Standard

Static Equipment Standards Committee

Convenor : Mr. Nalin Kumar

Members :

Mr. K. Anjaneyulu
Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
Mr. Anish Trehan
Mr. P V Satyanarayana
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karnam
Mr. Ayush Mathur (Project)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agarwal (SCM-Inspection)

CONTENTS

1.0 SCOPE

1.1 This specification covers additional and supplementary requirements for weldable structural quality Steel Plates to IS: 2062 (latest), intended primarily for storage tanks and vessels.

1.2 Following Codes, standards etc. shall be followed in their latest edition and addenda, errata, amendments unless specified otherwise:

1.3 IS:2062, IS:1852, IS:10842 (All Parts)

1.4 EN 10163 (All Parts): Delivery for Surface Condition.

1.5 EN 10204: Metallic products – Types of Inspection Documents.

2.0 GENERAL

2.1 The maximum under tolerance permissible on the thickness of plate shall be 0.25 mm. Tolerances on other dimensions of plates shall be as per IS: 1852.

2.2 Direction of final rolling shall be lengthwise.

2.3 Reconditioning/Repair of plates by welding shall not be permitted. Surface finish shall be ground/flush smooth and shall be free from any surface imperfection.

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS

3.1 Heat analysis and product analysis shall be carried out for each heat and chemical composition shall meet the limits as specified in IS: 2062.

3.2 Y-groove weld crackability test as per IS: 10842 shall be carried out for plates conforming to Gr. E250 C having thickness 12mm and above.

3.3 Charpy impact test shall be carried out on the plates having thickness greater than 12 mm conforming to Grade E250 BR, E250 B0 & E250 C. Test temperature and acceptance criteria for energy absorption shall be as mentioned in Table-2 of the specification IS: 2062.
For Thickness less than 12 mm (for materials E250 Gr.B0 & E250 Gr.C), if required, the minimum impact energy values of reduced sizes shall be as per Fig. 2 of the specification IS: 2062.

4.0 CERTIFIED DOCUMENTS

The supplier shall furnish certificates/documents (number of copies as specified in requisition) inclusive of all the following tests required as per specification, duly certified by the Inspecting Authority before shipment of plates. The actual values obtained during tests shall be recorded in the test certificates/documents. Material certificates shall conform to EN 10204 Type 3.1/3.2 as required.

a. Chemical Analysis
b. Mechanical Tests
c. Data of heat treatment
d. Charpy V-notch impact tests
e. Y- groove crackability test

5.0 PAINTING AND COATING

No painting/coating of any kind is permitted on the steel plates except stencil marking. However steel plates shall be carefully protected and packed against any damage during transit and shall be of sea worthy conditions.

6.0 INSPECTION AUTHORITY

Material test certificates, duly certified by Mill's Quality Assurance Department are acceptable i.e. 3.1 certification as per EN 10204. However, if third party inspection is required specially for plates in requisition, all test certificates and documents shall be duly certified by the third party. i.e. 3.2 certification as per EN 10204.

पैकेज मदों हेतु प्रैशर वैसल्स का मानक विनिर्देश

STANDARD SPECIFICATION OF PRESSURE VESSELS FOR PACKAGE ITEMS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
9	02.04.2024	REVISED AND REISSUED AS STD.SPEC.	MKP	TKh	KJH/NK	MN
8	28.08.2018	REVISED & REISSUED AS STD. SPEC.	SK	TK	KJH	RKT
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5	31.05.2002	REVISED & REISSUED AS STD. SPEC.	VMP	RKG	AKM	GRR
4	09.01.1997	REVISED & REISSUED AS STD. SPEC.	KPS	AKM	CRMN	AS

Abbreviations:

API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
CD	:	Compact Disc
CS	:	Carbon Steel
DFT	:	Dry Film Thickness
EN	:	European Standards
FRP	:	Fibre Glass Reinforced Plastic
HIC	:	Hydrogen Induced Cracking
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
IS	:	Indian Standards
MT	:	Metric Ton
NB	:	Nominal Bore
RTJ	:	Ring Type Joint
SS	:	Stainless Steel

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar
Co-Convenor: Mr. K. Anjaneyulu

Members:

Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
Mr. P V Satyanarayana
Mr. Anish Trehan
Mr. P Barik
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karnam
Mr. Aasheesh Handa (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agrawal (SCM-Inspection)

CONTENTS

1.0 SCOPE

1.1 This Specification covers general requirements for material, design, fabrication, erection and testing of pressure vessels.

1.2 Vessel Sizing/Design shall be in vendor's scope, unless otherwise specified. Vendor shall submit all design parameters of vessels as per Annexure-I.

2.0 CODES, SPECIFICATIONS AND REGULATIONS

2.1 Design Codes

a) Vessels with design pressure greater than or equal to 1.0 Kg/Cm^2(g) and less than 210 Kg/cm^2(g) shall be designed, fabricated, inspected and tested as per ASME Code Sec. VIII Div.1 (latest).

b) All vessels with design pressure greater than or equal to 210 Kg/cm^2(g) shall be designed, fabricated, inspected and tested as per ASME Code Sec. VIII Div.2 (latest).

c) Vessels full of liquid and/or with design pressure < 1.0 Kg/cm^2(g) shall be designed, fabricated, inspected and tested as per ASME Code Sec. VIII Div.1 - Practice.

d) Mechanical design of self-supporting tall column shall be carried out as per guidelines given in Annexure-III.

2.2 Material Specifications

Materials to be used shall conform to:

a) ASME Section II.

b) Indian Standard Specification of equivalent grade.

2.3 Statutory Regulations

a) National laws & regulations together with local bye-laws for the country or state where vessel(s) is (are) to be erected must be complied with. Approval of design and drawings from statutory authorities shall be Vendor's responsibility.

b) Wind and earthquake loads shall be calculated in accordance with relevant Indian Standards unless otherwise specified.

3.0 DESIGN BASIS

3.1 Minimum Wall Thickness

Vessel shell and heads shall have minimum wall thicknesses calculated with design pressure and temperature, in accordance with codes, but in no case, shall the thickness be less than that determined by following formulae:

a) For carbon/Low alloy steel vessel & column* – 6 mm & 8 mm respectively (including corrosion allowance not exceeding 3.0 mm), but not less than that calculated as per following:

FOR DIAMETERS LESS THAN 2400 mm

$$\text{Wall thickness} = \frac{\text{Dia.}}{1000} + 1.5 + \text{Corrosion Allowance}$$

FOR DIAMETERS 2400 mm AND ABOVE

$$\text{Wall thickness} = \frac{\text{Dia.}}{1000} + 2.5 + \text{Corrosion Allowance}$$

All dimensions are in mm.

b) For Stainless steel/High alloy steel vessel & column* – 3 mm & 5 mm respectively, but not less than that calculated as per following for diameter more than 1500 mm.

$$\text{Wall thickness (mm)} = \frac{\text{Dia.}}{1000} + 2.5$$

Corrosion allowance, if any, shall be added to minimum thickness.

* If the vessel height (H) from base of skirt to top tangent line is greater than 5 times diameter (D) then it shall be considered as column and shall be designed accordingly.

3.2 Design Pressure

a) Design pressure shall be calculated considering higher of the following:

i) For operating pressures above 70 kg/cm²g, mechanical design pressure shall be as per designer, subject to a minimum of 77 kg/cm²g.

ii) For operating pressure up to and including 70 kg/cm²g, design pressure shall be the highest of the following:

a) Maximum operating pressure (kg/cm²g) x 1.1
b) Maximum operating pressure + 2.0 kg/cm²
c) 3.5 kg/cm²g

b) Design pressure at any lower point is to be determined by adding the maximum operating liquid head and any gradient within the equipment.

c) Equipment operating under vacuum (or partial vacuum) shall be designed for differential external pressure of 1.055 Kg/cm².

3.3 Design Temperature

Design temperature shall be calculated as per the following, unless otherwise specified elsewhere in the package:

a) For equipment operating at or above 0°C, the mechanical design temperature shall be the higher of the following:

T (des) = 65 °C
T (des) = T (max) + 15 °C
T (des) = T (relief), excluding fire relief temperatures

where,

T (max) = Maximum operating temperature expected considering different possible operations for the equipment or system, including air drying or gas drying conditions.

T (relief) = Temperature corresponding to pressure relief conditions for an operational failure case (specifically excluding fire relief case).

b) For equipment operating below 0 °C, the mechanical design temperature shall be equal to the lowest anticipated operating temperature.

c) Minimum Design Metal Temperature (MDMT) shall be lower of minimum atmospheric temperature and minimum temperature envisaged during operation.

3.4 Corrosion Allowance

Minimum corrosion allowance for carbon steel and low alloy steel vessels shall be 3.0 mm and 1.5 mm respectively, unless otherwise specified elsewhere in the package.

3.5 Allowable Stresses

3.5.1 Basic allowable stresses for shell, heads and other components etc. shall be the values specified in the design code.

3.5.2 The allowable stresses for structural members and anchor bolts shall be as specified in Indian Standard IS:800.

3.6 Wind and Seismic Loads

3.6.1 Wind load shall be calculated as per Indian Standard IS-875 and Site-specific wind data if attached with the bid package.

3.6.2 Earthquake forces shall be calculated in accordance with Site-specific spectra (along with IS-1893 procedure) provided elsewhere in the bid package. Otherwise, the same shall be as per Indian Standard IS: 1893.

4.0 MATERIALS

Unless otherwise specified, Materials of various parts of equipment shall be selected as per Table given in Annexure - II for general industrial condition/services.

4.1 Specifications of Carbon Steel Plates

4.1.1 Chemical Analysis

Plates used shall conform to latest issue of specification SA-20 with additional requirements mentioned herein.

a) Only normalised plates free from injurious defects with workmanlike finish shall be used. Reconditioning/repair of plates by welding shall not be permitted.

b) One product analysis of each heat shall be carried out and reported. Chemical analysis shall be as per applicable specifications with carbon content not exceeding 0.23%.

Additionally, one of following requirements for carbon equivalents (Ceq) based on heat analysis shall be satisfied.

$$Ceq = C + Mn/6 \leq 0.42 \quad ...(1)$$

$$Ceq = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15 \leq 0.43 \quad ...(2)$$

Equation - (1) shall be used when applicable material specifies C and Mn only.

Equation- (2) is applicable for restricted chemistry requirements or for supplementary requirements of S19 & S21 of specification SA-20.

4.1.2 **Ultrasonic Examinations of Plates**

a) Plates having thickness 16 mm to 50 mm (both inclusive) shall be examined ultrasonically as per specification SA-435.

b) For thickness above 50 mm, ultrasonic examinations shall be carried out as per specification SA-578 and shall have acceptance standard of level-B.

c) For quenched and tempered steel plates, ultrasonic examination shall be carried out after the specified heat treatment.

4.1.3 **Simulated Heat Treatment of Test Coupons**

The following heat treatment shall be conducted on the test coupons representative of heat treated plates before the specified mechanical testing like tensile, bend, impact tests, etc. to meet minimum ASME Sec. **II** Part - A requirements and these details shall also be recorded on the test certificates.

a. All plates supplied in Normalised condition and intended for hot rolling / hot forming:

Heat Treatment Cycle

One normalising* + One stress relieving as per UCS-56 of ASME Sec. VIII Div.1 complying with UCS-85 of ASME Section **VIII** Div. 1.

Note: Any other special requirement shall be specified in MR.

b. All plates supplied in Quenched & Tempered condition and intended for hot rolling/ hot forming:

Heat Treatment Cycle

One normalising* + quenched & tempering + One stress relieving as per UCS-56 ASME Section **VIII** Div.1 complying with UCS-85 of ASME Section **VIII** Div.1.

Note: Tempering temperature shall be at least 20° C above highest stress relieving temperature.

* Normalising cycle shall be as per Material Test Certificate (MTC).

c. All plates supplied in Quenched & Tempered condition and intended for cold forming:

Heat Treatment Cycle

One stress relieving as per UCS-56 ASME Section **VIII** Div.1 complying with UCS-85 of ASME Section **VIII** Div.1.

4.1.4 Charpy V-notch impact testing as per S5 of specification SA-20 to be carried out at design temperature for low temperature services.

4.1.5 Plates needed for IBR vessels shall meet the requirements of IBR (Indian Boiler Regulations).

4.1.6 Plates above 50 mm in thickness shall meet following additional requirements:

a. Vacuum Degassing treatment as per the supplementary requirement S1 of specification SA-20. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

b. Charpy V-notch impact test as per the supplementary requirement S5 of specification SA-20. Material meant to be used for design temperature warmer than 0°C, impact test shall be carried out at 0°C or MDMT, whichever is lower, and acceptance criteria for energy absorption shall be as per Table A2.15 of SA-20. In case the acceptance criteria is not available in SA-20, then applicable design code shall be referred, unless otherwise specified in material requisition.

c. Simulated heat treatment of test coupons for all plates as per Clause 4.1.3 mentioned above.

4.2 Specification of Stainless Steel Plates/Pipe/Forging

Plates used shall conform to latest issue of specification SA-480 with additional requirements mentioned herein.

a) All plates shall be hot rolled, annealed, pickled and shall have No.1 finish on both sides with reference to specification SA-480. In addition, all stabilized grade of SS (SS 321, SS 347 etc.) shall be given stabilization heat treatment.

b) Unless otherwise specified plates, pipes, forgings and fittings representative of each heat shall be subjected to inter granular corrosion tests as per ASTM A 262 practice E for all the 300 series material. The bend test specimen shall be examined at a magnification of 200 x.

c) Plates having thickness 16mm to 50mm (both inclusive) shall be examined ultrasonically as per specification SA-435.

d) For thickness above 50 mm, ultrasonic examinations shall be carried out as per specification SA-578 and shall have acceptance standard of level-B.

4.3 Applicable certificates and documents of all tests required here, duly certified by inspecting authority shall be submitted to EIL inspector before fabrication of vessel. Material Certificates shall conform to EN 10204 Type 3.1.

4.4 Material for Internal Lining/Painting

4.4.1 **FRP Lining**

i) Wherever FRP lining on inside of equipment is specified the resin used shall be vinyl ester, equivalent or better to suit the intended service.

ii) The steel surface shall be abrasive blasted as per SSPC-SP-10 and anchor profile of surface shall be 38 to 75 microns. Primer coat of polyamide cured epoxy (25 to 75 microns DFT) shall be immediately applied after cleaning to prevent rust formation before application of FRP lining.

4.4.2 **Rubber Lining**

Application of rubber lining on inside of vessels, shall be done as per Part-1, IS 4682.

4.4.3 **Painting on Internal Surface**

Surface preparation and application of Primer and Painting shall be in accordance with EIL Specification for surface preparation and protective coating.

5.0 HEADS

a) FOR CS METALLURGY:

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

1. Cold formed dished ends or knuckles shall be stress relieved, unless otherwise specified in requisition.

2. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.

3. When the completed vessel involves post weld heat treatment, heat treatment recommended in (1) above shall not be applicable.

b) FOR SS METALLURGY:

1. Cold formed dished ends of SS Vessels shall not be solution annealed unless any of the following conditions exists:

i) Specifically called for particular equipment/service.

ii) Hardness value after forming exceeds 235 BHN.

iii) Nominal thickness of plate is 16mm or above.

2. Hot formed dished ends of SS Vessels shall be solution annealed.

6.0 MANHOLES/HANDHOLES AND NOZZLES

a) Manholes shall be minimum 450 mm NB unless otherwise specified.

b) Manhole cover shall be provided with a davit or hinge.

c) Small vessels shall be provided with two 150 NB hand holes for inspection. Vessels less than or equal to 300 NB shall be provided with 2 nos.100 NB hand holes for inspection.

d) For vessels with diameter less than 900 mm and having removable internals, shell flanges shall be provided.

e) As a general rule all nozzles attachment to shell/head shall be set-in type.

f) Reinforcement for nozzle openings shall be self-reinforced type for equipment where nominal thickness of shell/ head exceeds 50 mm. Nozzles of size up to 50 NB LWN can be used in place of self-reinforced nozzles.

g) Nozzles up to 50 mm NB size shall be stiffened with 2 number of 40 mm wide x 6 mm thick stiffeners welded at 90 apart.

h) Nozzle connections used for vessels shall not be less than 40 mm NB.

7.0 FLANGES

a) Dimensions for flanges shall be as per ASME B16.5 for size up to 600 NB and to ASME B-16.47 (Series B) for size above 600 NB.

b) All flanges shall be of weld neck type. Slip on flanges are not permitted.

c) All flanges of class 900 and above shall have gasket surfaces for RTJ unless otherwise specified.

8.0 INSPECTION

All vessels shall be offered for stage-wise as well as for final inspection to Purchaser or his authorised inspector.

Inspector shall have free access to all workshops of vendor or his sub-vendors.

9.0 PRESSURE TESTING

All vessels shall be hydrostatically or pneumatically tested as per the code. In order to safeguard against the risk of brittle fracture during hydrostatic test, temperature of test fluid shall meet the requirements of UG-99 of ASME Sec. VIII Div.1 and shall preferably not be less than 16° C.

10.0 WELDING

Full penetration weld shall be employed for joining pressure parts. Where both sides are not accessible for welding, root run by tungsten inert gas process or backing strip may be used to ensure full penetration. Backing strip, if used, is to be removed after welding, wherever possible.

11.0 POST WELD HEAT TREATMENT

a) Vessels shall be heat-treated whenever it is required due to service requirement or due to code requirements. Vessels shall be post weld-heat treated as a complete unit and no welding shall be permitted once post weld heat treatment is performed. CS/LAS Vessels in Hydrogen/ Amine/ Sour (Wet H2S)/ Cyclic/ Caustic/ HIC service shall be mandatorily PWHT.

b) Wherever heat treatment on stainless steel is carried out, it shall be followed by micro etching test and IGC test as per ASTM A 262 Practice E unless otherwise specified to ascertain suitability and effectiveness of solution annealing. The bend test specimen shall be examined at a magnification of 200 x.

12.0 RADIOGRAPHY/ NON-DESTRUCTIVE TESTING

12.1 The extent of radiography shall be as specified in the package. In no case shall the radiographic examination be less than that specified in the code. However, spot radiography is the minimum requirement for all vessels.

12.2 Each category A or B pressure containing weld shall be spot radiographed in accordance with ASME Section-VIII Division-I, paragraph UW-52 as a minimum requirement. Each Spot radiograph shall be a minimum of six inches (150mm) in length and minimum one spot shall be selected in each circumferential & longitudinal seam. Additionally, at least one T-joint in each circumferential seam shall also be selected. Welds from each welding procedure, welded/welding operator shall be examined.

12.3 All nozzles fabricated from plate, irrespective of thickness, shall be 100% radiographed.

12.4 Weld seams of formed ends shall be 100% radiographed after forming and heat treatment, if any.

12.5 The technique employed and the weld quality achieved shall meet the requirement of the code.

12.6 All nozzle to shell welds (Root and Final run) shall be examined by magnetic particle/Dye penetrant test.

12.7 In case Supplier want to perform UT in lieu of RT based on Code para-UW 51 (a) (4), the same is acceptable subject to the following:

a) Material of construction is either CS or LAS.

b) The thickness of weld is greater than 13 mm.

c) The joint is either Category A or Category B joint except shell to hemispherical dished end joint. (Category of joint as defined by Code).

d) Automated UT incorporating TOFD and pulse echo probes or TOFD and Phased Array mounted on the same chassis that automatically traverses along the joints to be inspected and displaying both results simultaneously on a single screen may be considered in lieu of RT.

e) Calibration block of similar material/thickness shall be used. Calibration block shall have suitable notches to simulate longitudinal as well as transverse cracks on outside and inside surface. Setup should be capable of detecting defects on outside as well as inside while scanning from one surface only.

f) The system that is proposed to be deployed in lieu of radiography shall be submitted along with the track record prior to use for EIL review. The Supplier shall demonstrate successfully the capability of AUT machine and the defects evaluation in the same screen during the site visit of EIL representative. Based on which, the approval of the parties and their AUT system shall be given.

g) Qualified NDT persons shall be deployed to perform UT.

h) Acceptance criteria shall be as per Code para-UW 51.

13.0 FIRE PROOFING AND INSULATION

Vessels requiring insulation and/or fire proofing shall be provided with supports as per EIL standard referred in this specification.

14.0 CLEANING AND PAINTING

a) Vessels shall be cleaned internally to remove scale, rust, dirt, foreign material by wire brushing.

b) Stainless steel surfaces both inside and outside shall be pickled and passivated in accordance with specification ASTM-A380 after hydrotest, unless otherwise specified.

c) All external surfaces shall be cleaned, primed and painted in accordance with applicable EIL Specification for surface preparation and protective coating.

15.0 GENERAL

15.1 Vessel weighing more than 5.0 MT shall be provided with lifting lugs. Skirt supported vessels shall be provided with tailing lugs, if necessary.

15.2 Unless otherwise elsewhere specified, Manufacturer shall supply Mandatory spares as given below:

Gaskets : Two sets for each installed gasket.

Fasteners : 10% (minimum two in each size) of installed fasteners.

Sight/Light glass: 4 Sets for each installed glass.

15.3 Fabrication tolerances indicated in EIL Standards/Specifications shall be adhered to.

15.4 Vessel diameter 300 mm NB and below shall be made from seamless pipe only.

15.5 Rolling direction of plate for shell shall be lengthwise.

15.6 Guarantee, packing, marking on vessels and shipment, etc. to be as per package specifications.

16.0 LIST OF ATTACHMENTS

TITLE	DOCUMENT NO.
Vessel Tolerances	7-12-0001
Support for Horizontal Vessel	7-12-0002
Skirt Base Details	7-12-0004
Angle Leg Support	7-12-0006
Pipe Leg Support	7-12-0007
Bracket Support for Vertical Vessel	7-12-0008
Manhole with Hinge Cover	7-12-0009
Manhole with Davit	7-12-0010
Standard Bolt Hole Orientation	7-12-0015
Internal Flanges	7-12-0018
Fire-Proofing and Insulation Supports	7-12-0025
Internal Feed Pipe Support	7-12-0032
EIL Specification for Surface Preparation and Protective Coating	EIL specification (as applicable)

ANNEXURE - I

DATA SHEET FOR PRESSURE VESSEL

(To be filled in by the Vendor)

PROJECT:	CLIENT;
UNIT:	JOB NO.:
ITEM NO.:	PACKAGE:
EQUIPMENT:	MR. NO.:
CODE FOR DESIGN AND CONSTRUCTION	
DESIGN CONDITION	OPERATING CONDITIONS
PRESSURE (Kg/cm^2g)	PRESSURE (Kg/cm^2g)
TEMPERATURE/MDMT (°C)	TEMPERATURE (°C)
CORROSION ALLOWANCE	
SERVICE	H_2S [ ] LETHAL [ ] OTHERS [ ]
LIQUID LEVEL (mm)	
SPECIAL SURFACE FINISH INSIDE VESSEL	REQD. [ ] NOT REQD. [ ]
TYPE OF VESSEL	HORIZONTAL [ ] VERTICAL [ ]
DIAMETER (mm)	SKIRT /LEG HEIGHT
HEIGHT TL-TL (mm)	
JOINT EFFICIENCY	SHELL HEAD
RADIOGRAPHY	SHELL HEAD
POST WELD HEAT TREATMENT	
HYDROTEST PRESSURE (Kg/cm^2g)	
MATERIALS OF CONSTRUCTION	
SHELL, REINFORCEMENT PADS	
HEADS/CONES	NOZZLE NECK
SHELL FLANGES	MAN-WAY NECK
NOZZLE FLANGES	PIPE FITTINGS
INTERNAL PARTS	GASKETS(EXTERNAL)
EXTERNAL STUDS/NUTS	GASKETS(INTERNAL)
INTERNAL BOLTS/NUTS	SKIRT/LEG SUPPORT
CLIP ATTACHMENTS (EXTERNAL)	
ANY OTHER GENERAL REQUIREMENT	
NOTE: VENDOR SHALL SUBMIT COMPLETED DATA SHEET ALONG WITH OFFER WHEREVER ENGG. DRAWING IS NOT ATTACHED FOR THE VESSEL.	

ANNEXURE - II

MATERIAL SELECTION

The following table gives general guidelines for material selection for various Pressure /Non-Pressure Parts of the equipment based on design temperature wherever material of construction is not specified by the process licensor.

PRESSURE PARTS						NON PRESSURE PARTS			
DESIGN TEMP.,°C	PLATE	PIPE	TUBES, SPACERS (SEE NOTE-11)	FORGING (SEE NOTE 12)	BOLTS/STUDS/ NUTS EXTERNAL (SEE NOTE 8)	STRUCTURAL ATTACHMENT WELDED TO PRESSURE PARTS, BAFFELS, SUPPORTS, TIE RODS, SEALING, SLIDING STRIPS ETC.	INTERNAL PIPES	STUDS BOLTS NUTS INTERNAL (Note 8)	TIE RODS
CRYOGENIC									
COLDER THAN (-) 196 UPTO (-) 254	SA 240 GR.304L,304, 316,316L 347 (IMPACT TESTED)	SA 312 TYPE 304 304L,316, 316L,347	SA 213 TYPE 304 304L,316, 316L,347	SA 182, GR F 304,304L,316 347,316L	SA 320 GR B8,8C,8T STRAIN HARDENED	SAME AS PRESSURE PARTS			SS GRADE SAME AS TUBES
COLDER THAN (-) 80 UPTO (-) 196	SA 240 GR.304L,304, 316,316L 321,347 SA 353/553 GR.A	SA 312 TYPE 304 304L,316, 316L,321, 347 SA 333 GR.8	SA 213 TYPE 304 304L,316, 316L,321, 347 SA 334 GR.8	SA 182, GR F 304, F304L, F316L,316 321,347, SA 522	SA 194 GR.8, 8C,8T				
LOW TEMPERATURE									
COLDER THAN (-) 60 UPTO (-) 80	SA 203 GR E IMPACT TESTED (SEE NOTE-1)	SA 333 GR.3	SA 334 GR.3	SA 350 GR.LF3	SA 320 L7 SA 194 GR 7	SA 203 GR E	SA 333 GR.3	SA 193 GR.B8 SA 194 GR.8	CS KILLED
COLDER THAN (-) 46 UPTO (-) 60	SA 537 CL.1 IMPACT TESTED (SEE NOTE-1)	SA 333 GR.3	SA 334 GR.3	SA 350 GR.LF3	SA 320 L7 SA 194 GR 7	SA 537 CL.I	SA 333 GR.3	SA 193 GR.B8 SA 194 GR.8	CS KILLED
COLDER THAN (-) 29 UPTO (-) 46	SA 516 (ALL GRADES) IMPACT TESTED (SEE NOTE-1)	SA 333 GR.6 OR GR I	SA 334 GR.6 OR GR I	SA 350 GR LF2	SA 320 L7 SA 194 GR 7	SA-516 (IN ALL GRADES)	SA 333 GR.6	SA 193 GR.B8 SA 194 GR.8	CS KILLED
0 (ZERO) OR COLDER UPTO (-) 29	SA 516 (ALL GRADES) (SEE NOTE-3)	SA 106 GR.B (SEE NOTE 3)	SA 334 GR.6 OR 1 (SEE NOTE 3)	SA 105/ SA 266 (SEE NOTE 3)	SA-193 GR B7 SA-194 GR 2H	SA-516 (IN ALL GRADES)	SA 106 GR.B	SA-193 GR.B8 SA-194 GR.8	CS KILLED
INTERMEDIATE TEMPERATURE									
ABOVE 0 UPTO 427	SA 516 (ALL GRADES)	SA 106 GR.B	SA 179	SA-105 SA-266	SA-193 B7 SA-194 GR 2H	IS-2062/ SAME AS PRESSURE PARTS (NOTE 13)	SA 106 GR.B	SA-193 GR.B8 SA-194 GR 8	IS- 2062 (WELDABLE QUALITY) (NOTE 13)
	SA 387 GR.11 CL.1/CL.2	SA 335 GR.P11	SA 213 GR.T11	SA 182 GR.F11	SA 193 GR.B7 SA 194 GR 7	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS	SA-193 GR.B8 SA 194 GR.8	1¼ Cr.½ Mo (COMML. QLTY)
	SA 240 TYPE 304L,316L, 321 (SEE NOTE 4)	SA-312 TP 304L 316L,321 SA-376 TP 321	SA-213 TP 304L 316L, 321	SA 182 F 304L,316 L, 321	SA-193 B7 SA-194 GR 2H	SAME AS PRESSURE PARTS	SA 106 GR.B	SA-193GR.B8 SA-194 GR.8	SAME GRADE AS PRESSURE PARTS
ELEVATED TEMPERATURE									
ABOVE 427 UPTO 538	SA 387 GR.11 CL.1/CL.2 SA 387 GR.12 CL.1/CL.2	SA 335 P11 SA 335 P12	SA 213 T11 SA 213 T12	SA 182 GR F11 SA 182 GR.F12	SA 193 GR.B16 SA 194 GR7	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS	SA-193 GR.B8 SA 194 GR.8	1¼Cr-½Mo (COMML. QTLY)
ABOVE 427 UPTO 500	SA 240 TYPE 304,316,321 (SEE NOTE 4)	SA 312/ SA 376 TYPE 304,316, 321	SA 213 TP 304,316, 321	SA 182F 304, 316, 321	SA 193 GR.B16 SA 194 GR 7	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS	SA-193 GR.B8 SA 194 GR.8	SA 479 Gr. 304L,316L, 321
ABOVE 538 UPTO 593	SA 387 GR.22 CL. 1/CL.2 SA 387 GR.21 CL.1/CL.2	SA 335 P22	SA 213 T22	SA 182 GR F22 SA 336 GR F22	SA 193 GR B5 SA 194 GR.3	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS	2¼ Cr.1 Mo (COMML. QLTY)
ABOVE 500 UPTO 815	SA 240 GR.304H, 316H 321H,	SA 312/ SA 376 TYPE 304H, 316H, 321H	SA 213 TYPE 304H, 316H, 321H	SA 182 GRADES 304H, 316H,321H	SA 193 GRB8 SA 194 GR.8 (STRAIN HARDENED)	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS	SAME AS PRESSURE PARTS (Note 8)	SA 479 Gr 304H, 316 H, 321 H.

NOTES:

1. Plates are purchased to the requirement of the standard ASME SA-20, which requires testing of individual plates for low temperature service. Carbon steel material is ordered to meet the impact requirements of supplement S5, of standard ASME SA 20.

   For example, typical material specification would be as follows:

   SA 516 Gr.70: 20 mm thick Normalised with impact test requirements per supplement S5 of SA 20 at minus (-) 46 °C.

2. All permanent attachments welded directly to 9% nickel steel should be of the same material or of an austenitic stainless steel type, which cannot be hardened by heat treatment.

3. Check for impact testing requirement as per UCS-66, for coincident temperature and part thickness.

4. Selection of stainless steel material shall be based on process recommendation / process licensor.

5. This table is not applicable for atmospheric/low pressure storage tanks. Materials shall be selected as per API 650/API 620 as applicable.

6. Materials for caustic service, sour service or sour service + HIC shall be selected based on specific recommendation of process licensor.

7. Material for pressure vessels designed according to ASME Section VIII Division 2 shall be given special consideration as per code.

8. For Exchangers, Internal bolting shall be selected on the basis of shell side material solid or clad as follows:

SHELL MATERIAL	STUD	NUTS
Carbon steel & up to 1% Cr.	ASTM A 193 GR.B7M	ASTM A 194 GR. 2HM
5% Chrome	A 193 Gr. B5	A 194 Gr. 3
13% Chrome	A 193 Gr. B6 X	A 194 Gr. 6
Stainless Steel	A 193 Gr.*	A 194 Gr.*

   For low temperatures, min. quality of bolting material shall be as specified for external bolting and shall be improved if shell side materials are better.

   * Compatible / same grade of SS.

9. Non-ferrous material and super alloys are not covered above and shall be selected based on specific recommendation.

10. Material for vessel / column skirt shall be the same material as of vessel / column shell for the upper part with a minimum of 1000mm.

11. All tubes shall be of seamless construction.

12. SA 965 shall be used for Heat Exchanger non-standard SS/LAS forgings.

13. IS 2062 GR E250 Quality BR/B0 shall be used for attachments not welded to pressure parts up to temperature of 300 Deg. C maximum. In all other cases, attachments should be same as pressure parts.

ANNEXURE - III

DESIGN PHILOSOPHY OF TALL COLUMNS

Mechanical design of self-supporting tall column and its anchorage block shall be carried out considering combination of various loads.

1.0 Loadings

The loadings to be considered in designing a self-supporting tall column/tower shall include:

1.1 Internal and/ or external design pressure specified on process data sheets.

1.2 Self weight of column inclusive of piping, platforms, ladders, manholes, nozzles, trays/packed beds (including liquid hold-up) and other internals, welded and removable attachments, insulation, fire-proofing and operating liquid etc. The weight of attachments to be considered shall be as per Table-1 enclosed.

Other loadings as specified in UG-22 of ASME Code Sec. VIII Div.1, wherever applicable.

1.3 Seismic forces and moments shall be computed in accordance with IS 1893 (latest edition) or it shall be based on meteorological and seismic data of the site, if attached with the bid package. Unless otherwise specified, importance factor and damping coefficient shall be considered as 2 and 2% respectively.

1.4 Basic wind pressure and wind velocity (including that due to winds of short duration as in squalls) for the computation of forces/moments and dynamic analysis respectively shall be in accordance with IS 875 Part-3 (latest edition) or site-specific wind data if attached with the bid package. Additional wind loading on column due to external attachments like platforms, ladders, piping and attached equipment should be given due consideration.

1.5 Loadings resulting in localised and gross stresses due to attachment or mounting of reflux/reboiler, condenser, etc.

2.0 Loading Condition

Analysis shall be carried out for following conditions:

2.1 **Erection Condition** : Column (uncorroded) erected on foundation, without insulation, platforms, trays etc. but with welded attachments plus full wind on column.

2.2 **Operating Condition** : Column (in corroded condition) under design pressure, including welded items, trays, removable internals, piping, platforms, ladder, reboiler mounted on column, insulation and operating liquid etc. plus full wind, on insulated column with all other projections open to wind, or earthquake forces.

2.3 **Test Condition** : Column (in corroded condition) under test pressure, filled with water plus 33% of specified wind load on un-insulated column including all attachments shall be considered.

2.4 Earthquake and wind shall be considered not acting concurrently.

3.0 Deflection of Column

Maximum allowable deflection at top of column shall be equal to height of the column divided by 200 limited to 300mm maximum.

3.1 If the deflection of column exceeds the above allowable limit, the thickness of skirt shall be increased as first trial up to a maximum value equal to the column thickness and this exercise shall be stopped if the deflection falls within allowable limit.

3.2 If the above step is inadequate, skirt shall be gradually flared to reduce the deflection. Flaring of skirt shall be stopped if the deflection falls within limits or half angle of cone reaches maximum limit of 9 degree.

3.3 If the above two steps prove inadequate in limiting the deflection within allowable limits, the thickness of shell courses shall be increased one by one starting from bottom course above skirt and proceeding upwards till the deflection falls within allowable limits.

4.0 Stress Limits

The stresses due to pressure, weight, wind/seismic loads shall be combined using maximum principal stress theory for ASME Section VIII Div I. Thicknesses are accordingly chosen to keep the stresses within limits as per Table-2.

5.0 Skirt Support Base

Base supporting including base plate, anchor chairs, compression ring, foundation bolting etc. shall be designed based on over-turning moment (greater of seismic or wind). A minimum number of 8 foundation bolts shall be provided. Nos. of foundation bolts shall be in multiple of four.

6.0 Minimum Hydrotest Pressure

Minimum Hydrotest Pressure shall be equal to 1.3 x design pressure x temperature correction factor, as specified in ASME Code Section VIII Div I (Clause UG-99). The term test pressure shall apply to the pressure measured at the highest point of vessel in its operating position and shall be applied to the highest point in its test position.

7.0 Dynamic Analysis of Column

Dynamic analysis of each column shall be carried out for stability under transverse wind induced vibrations as per standard design practice and calculations for each column shall be submitted to EIL for approval. The recommended magnification factor for unlined towers/column shall be taken as 70 and allowable dynamic amplitude shall be limited to tower diameter divided by five.

TABLE-1

DETAILS AND WEIGHT OF COLUMN AND VESSEL WITH SKIRT ATTACHMENT

These loads/weights are minimum to be adopted in design based on their applicability. However, in case actual loads/ weights are more the same shall be considered in design.

1.	Shape factor for shell (for wind force calculation)	0.7 (minimum)
2.	Weight of trays (with liquid) to be considered, as applicable	120 Kg/m^2 (minimum)
3.	Weight of plain Ladder	15 Kg/m
4.	Weight of caged ladder	37 Kg/m
5.	Equivalent projection to be considered for wind load on caged ladder	300 mm
6.	Distance of platform below each manhole	Approx. 1000 mm
7.	Maximum distance between consecutive platforms	4000 mm
8.	Projection of Platform	900 mm up to 1 meter dia. column and 1200 mm for column dia. > 1 meter, from column insulation surface.
9.	Equivalent height of platform (for wind load computation)	1000 mm
10.	Weight of platforms	170 Kg/m^2.
11.	Platform shall be considered all around	

TABLE-2

ALLOWABLE STRESSES FOR COMBINED LOADING

VESSEL CONDITION/TEMP. TYPE OF STRESSES	CONDITIONS		
	ERECTION	OPERATING	TEST
NEW OR CORRODED	NEW	CORRODED	CORRODED
TEMPERATURE	AMBIENT	DESIGN	AMBIENT
LONGITUDINAL TENSILE STRESS	KxSxE	KxSxE	0.90xYPxE
LONGITUDINAL COMPRESSIVE STRESS	KxB	KxB	B
CIRCUMPERENTIAL TENSILE STRESS	-	KxSxE	0.90xYPxE

Where,

S = Basic allowable Tensile Stress as per Clause UG 23(a) of ASME Code Sec. VIII Div.1.

B = 'B' value calculated as per Clause UG-23(b).

E = Weld joint efficiency of circumferential weld, depending on extent of radiography.

K = Factor for increasing basic allowable value when wind or seismic load is present.

YP = Yield strength of shell material

Note: Allowable stresses in skirt to shell joint shall be as per following:

a) 0.49S, if joint is shear type.

b) 0.70S, if joint is compression type

पैकेज मदों हेतु भंडारण टैको का मानक विनिर्देश

STANDARD SPECIFICATION OF STORAGE TANKS FOR PACKAGE ITEMS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	26.04.2024	ISSUED FOR WIDER CIRCULATION	SC	TKh	KA/NK	MN
5	30.08.2018	REVISED AND REISSUED AS STD. SPEC.	RKK	TK	KJH	RKT
4	30.07.2010	REVISED AND REISSUED AS STD. SPEC.	KA	RKT	AKM DM	N.DUARI
3	21.10.09	REVISED AND REISSUED AS STD. SPEC.	VB	RKG	AKM	N.DUARI
2	29.03.04	REAFFIRMED & REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG
1	16.12.98	REVISED AND REISSUED AS STD. SPEC.	USG	AKM	CRMN	A SONI
0	28.2.90	ISSUED AS STD. SPECIFICATION	DD	AKA	PKG	RCPC

Abbreviations:

API	:	American Petroleum Institute
ASME	:	American Society for Mechanical Engineers
ASTM	:	American Society for Testing & Materials
AWS	:	American Welding Society
BHN	:	Brinell Hardness Number
HAZ	:	Heat Affected Zone
IS	:	Indian Standard
NB	:	Nominal Bore
PWHT	:	Post Weld Heat Treatment
OISD	:	Oil Industry Safety Directorate
NACE	:	National Association of Corrosion Engineers

Static Equipment Standards Committee

Convenor : Mr. Nalin Kumar
Co-Convenor: Mr. K Anjaneyulu

Members: Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
Mr. P V S Satyanarayana
Mr. Anish Trehan
Mr. P Barik
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karanam
Mr. Aasheesh Handa (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agrawal (SCM-Inspection)

1.0 GENERAL

1.1 This specification covers the requirements for design, fabrication, erection, inspection and testing of fixed roof carbon steel and stainless steel storage tanks at atmospheric pressure. But a higher internal pressure is permitted when additional requirements are met.

1.2 This specification covers the general and broad requirements for fixed roof tanks which are used in various units of Oil Refineries & Petrochemicals Plants, such as DM Unit, Waste Water Treatment Unit, Power Plant Unit, Fire Water Unit, Amine Treatment Unit, Sour Gas Treatment Unit, etc.

1.3 Requirements as stipulated in this specification shall be followed over and above the minimum requirements stated in the design code. The design data given in Project Specifications/drawings shall take precedence over requirements given herein.

1.4 Contractor shall furnish tank data sheets for each equipment indicating design code, Material Specification, Principal Dimensions, General Requirements etc. with the offer.

1.5 Detailed Design Calculations, Complete Fabrication Drawings, Testing Requirements, Certification and any other Statutory Registration of the Equipment and its design shall be furnished by the Contractor on award of contract as per Vendor Data Requirements for review.

1.6 Addenda to this specification, if any, indicating special requirements shall form a part of this specification and shall govern wherever in conflict with the provisions contained herein.

1.7 For bought out items/Components, EIL recommended Vendor list is provided in subsequent sections. In case Contractor proposes any other vendor for bought out items/ Components, then the proposed supplier shall be a reputed manufacturer. Contractor shall submit for Client/EIL approval the necessary documents regarding Proven Track Record (PTR) of the proposed supplier w.r.t the bought-out item / Components. As a minimum, two (02) sets of items shall have been supplied for tankage applications and out of these, one (01) set shall have been successfully commissioned within the last ten years from bid due date. Contractor shall place the order on the proposed supplier only after obtaining approval from Client/EIL. There shall be no cost/time implication on this account.

2.0 REFERENCES

2.1 Design Codes

The following codes in their latest edition shall form the basis for design, fabrication, inspection, testing and acceptance of storage tanks:

API STD: 650	:	Welded steel tanks for oil storage.
IS: 803	:	Code of Practice for design fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS: 875 (Part 3)	:	Code of Practice for design loads Wind Loads (other than earthquake) for building and structures.
IS: 1893 & /or Site Spectra	:	Criteria for Earthquake resistant design of structures.
IS: 4682 (All Parts)	:	Code of Practice for Lining Vessels and Equipment for Chemical Process.
API: STD 2000	:	Venting Atmospheric and Low Pressure Storage Tanks.
IS: 2007	:	Method for Calibration of Vertical Oil Storage tanks.

IS: 2008	:	Method for Computation of Capacity Tables for Vertical Oil Storage Tanks.
API: RP 2003	:	Protection against ignitions arising out of static, lightning and stray currents for Oil Tanks.
API: RP 545	:	Recommended Practice for Lightening Protection of Above Ground Storage Tanks for flammable or Combustible Liquids.
API-RP 945	:	Avoiding Environmental Cracking in Amine Units.
NACE SP0403	:	Avoiding Caustic Stress Corrosion Cracking of Carbon Steel Refinery Equipment and Piping
NACE SP0472	:	Method & Control to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments.

2.2 Material Codes

Material to be used shall conform to:

a) ASME Boiler and Pressure Vessel Code Section II
b) Indian Standard Specification.
c) American Petroleum Institute standard, API 650

2.3 Regulations

National laws and regulations together with local bye-laws for the country or state wherever the tanks are to be erected must be complied with.

3.0 DESIGN BASIS

3.1 For fixing the nominal capacity of the tank, allowance for free board (minimum 500 mm & in no case supporting roof structure be in contact with fluid), vapour space and the dead liquid space at the bottom shall be taken into account. Tank diameter and height shall be firmed up based on nominal capacity (cylinder volume). Vendor to suitably check, adjust height & inform EIL for approval.

3.2 Tanks shell shall be designed as per the code considering the liquid height up to curb angle of the shell using one-foot method. However, for seismic load calculation, operating liquid level may be considered.

3.3 Tanks shall be designed, fabricated, erected and tested in accordance with the applicable code. All design calculations shall be carried out in corroded condition.

3.4 Allowable Stresses

3.4.1 Basic allowable stresses for shell, roof etc. shall be the values specified in the design code.

3.4.2 The allowable stresses for structural members and anchor bolts shall be as specified in applicable design code.

3.5 Wind and Seismic Loads

3.5.1 Wind load shall be calculated as per Indian Standard IS 875 Part 3 or site specific wind data if attached

with the bid package. But uplift and anchorage requirements shall be calculated as per API 650 for wind load.

3.5.2 Earthquake forces shall be calculated in accordance with Indian Standard IS: 1893 or it shall be based on meteorological and seismic data of the site, if attached with the bid package. For calculation of seismic loading, procedure given in Appendix E of API 650, shall be followed.

3.6 Corrosion Protection

3.6.1 The corrosion allowance for each tank shall be as given in Tank data sheet attached with the bid package. Otherwise, it shall be determined by its intended service conditions and service life.

3.6.2 Roof Supporting Structure, if provided internally as per EIL standard, shall be protected with proper primer and painting as per the provisions of painting specification.

3.6.3 Removable internal parts, bolted or clamped in-place, shall have extra thickness equal to half of specified corrosion allowance over each exposed surface.

3.7 Roof and Supporting Structure

3.7.1 The roofing plates shall be self-supported or supported by structure. Column supported roof shall be not acceptable. The roof and it's supporting structure shall be designed to carry the dead loads, internal and external pressure as specified in process data sheet and live loads as per the design code. Roof plates shall not be attached to the supporting members but will rest on it. Supporting Structure shall not be immersed in stored media.

3.7.2 Wherever corrosion allowance for roof is more than 1mm or the tank is rubber lined, roof structure shall be provided externally. Central drum, curb angle shall be suitably modified etc. EIL standards shall be used for guidance only. However, if any protective coating like epoxy etc. is provided then roof structure may be provided inside the tank as per EIL standards. External roof structure shall be attached to roof-plate with pad plate.

3.7.3 Roof to shell joint shall be frangible type. Otherwise, suitable emergency venting devices shall be provided as per API Standard 2000.

3.8 Tank Foundation and Anchorage of the Tank

3.8.1 Anchor bolts shall be provided if required by calculation for uplift or stability for wind and seismic load. Minimum anchor bolt size shall be M24 excluding any corrosion allowance on bolt diameter. Heavy galvanized bolts and nut shall be used for anchor. If corrosion allowance is specified on anchor bolt, it should be added to the bolt diameter.

3.8.2 Tanks having design temperature more than 93°C shall have thermal barrier (suitable fire bricks) between tank bottom plate and foundation.

3.8.3 **Under-tank Leak Detection for Acid and Alkali Services:**

3.8.3.1 Acid service tanks shall be supported on piers above grade. Details of foundation lined with acid proof tiles, shall be as per EIL standard 7-67-0004 (Foundation for Acid Tanks).

3.8.3.2 Alkali service tanks shall rest on flat foundation. Foundation floor shall be lined with alkali resistant bitumen mastic. Minimum 100 mm wide drainage channels (radial and circular, depending on the size of tank) shall be provided on the top of foundation.

3.8.3.3 Thickness of tank bottom shall be determined as per API 650 Appendix-I for tank bottom supported by piers/grillage. Maximum deflection of corroded bottom plate shall not be more than half of the thickness.

3.9 Bottom Plate

3.9.1 Unless otherwise specified bottom plate slope shall be 1:100 from the centre of the tank towards the shell.

3.9.2 Butt-welded annular ring below shell (minimum 8 mm thick excluding corrosion allowance) shall be provided for all tanks of diameter 12 m and above.

3.9.3 Bottom plates of tanks which are resting on pier/grillage for under-tank leak detection shall be of butt welded construction.

4.0 APPURTENANCES AND ACCESSORIES

4.1 Size of roof / shell manhole shall not be less than 600 mm NB. Minimum number of manholes shall be as follows:

Tank Diameter	Shell Manhole	Flush Type* Cleanout Doors	Roof* Manholes
Diameter, ≤ 12 m	1	nil	1
12 m < Diameter ≤ 45 m	2	1	2
45 m < Diameter ≤ 61 m	3	2	2
Diameter, > 61 m	4	2	2

*Flush Type Cleanout door shall be provided where heavy sludge accumulation is there or when it is specified in the process data sheet.

4.2 Platforms and Stairways

4.2.1 Tanks with instruments/accessories located on the roof shall be provided with platform (Minimum size 1.2 m x 0.8 m) on roof. Platform shall be sized and located to permit easy access to those items.

4.2.2 Primary access to roof shall be by means of cage ladders for tanks with height up to 6 m and by spiral stairways for tanks with height more than 6 m. Intermediate landings shall be provided for spiral stairways, preferably at every 5 m interval.

4.2.3 Hand railing shall be provided for stairways and all around the tank roof.

4.3 Other Accessories

4.3.1 All tanks shall be provided with venting device, level indicators and earthing connections. A gauge hatch with cover for gauging and sampling purpose is to be provided on the tank if specified on tank data sheet.

4.3.2 For pressurised tank, if manual sampling or gauging is needed, slot-dipping device of 150 mm NB minimum of reputed make shall be used.

4.3.3 Emergency Vent of Suitable size shall be provided for fire exposure case as per API 2000 if needed.

5.0 MATERIAL SPECIFICATION

5.1 All materials shall be as per applicable codes and EIL Standards. Material test certificates/documents shall be submitted to Inspector for verification.

5.2 Plate material conforming to IS: 2062 or as listed in API 650 shall be used. Plates shall be in killed or semi killed condition and shall be guaranteed for weld ability. Product analysis of each heat shall be carried out.

5.3 Manhole necks and nozzle necks of 250 mm NB and above may be fabricated from same plate material as used for shell.

5.4 Requirements of impact test of materials of construction shall be complied with when needed as per API 650.

5.5 All Nozzle flanges shall be forged type. Ring type flange fabricated from plate shall not be used. For Caustic, Sour and Amine services all nozzle flanges shall be WN type.

5.6 Pipes for nozzles shall conform to API 5L, IS: 1978, A-53 or A-106. Pipes for nozzle & heating coil shall be of seamless quality.

5.7 All clips and attachments shall be fabricated from carbon steel plates of weld-able quality.

5.8 Hand rails on stairway and tank top shall conform to IS: 1239 (medium) and galvanized or painted as per Tender.

5.9 Platforms, spiral stairways/ladders and gangways shall have Electro-forged gratings or painted as per Tender.

5.10 Gaskets for manholes and nozzles above 450NB shall be 3mm thick compressed non asbestos. However, requirements of PMS (Approved Piping Material Specification) should be complied with.

5.11 Studs/bolts and nuts for all nozzles fitted with blind flanges shall conform to ASME A-193 Gr. B7/ A 194 Gr.2H. Bolts and nuts for all structural parts shall conform to IS: 1363.

5.12 Dimensions for nozzle flanges shall conform to ASME B16.5 for size up to 600 mm NB and to ASME B16.47 Series B for sizes above 600 mm NB. Dimensions for manhole flanges and covers shall be as per the design code.

5.13 Buoy of floating suction/skimmer shall be of stainless steel of grade suitable to stored product.

5.14 Materials for Alkali, Amine and Sour Water Services

5.14.1 Plate material conforming to ASTM-A516 Gr.60 shall be used for Caustic, Sour and Amine services.

5.14.2 For Caustic, Sour and Amine services all nozzle pipes shall be ASTM A 106 Gr. B.

5.14.3 For Caustic, Sour and Amine services all clips and welded attachments shall be of ASTM A 516 Gr.60.

6.0 WELDING CONSUMABLES

6.1 Selection of welding consumables shall be based on the general chemistry of deposited filler metal which shall be the same as that of the base metal. Welding electrode specification shall conform to Indian Standard IS:814/ASME Boiler and Pressure Vessels Code Section II (C). However, minimum requirement of applicable codes and Appendices shall be adhered to:

6.1.1 Low hydrogen electrodes shall be used for all manual metal arc welds of shell courses having a thickness of 12mm and above.

6.1.2 Low hydrogen electrodes shall be used for attachment welds of shell to bottom or annular plate and annular plate butt joints.

6.1.3 For all other welding, high cellulose/rutile type electrodes as per the AWS classification SFA 5.1 shall be used.

6.2 Based on above, fabricator shall furnish brand names of welding consumables to Inspecting Authority for approval.

7.0 FABRICATION AND ERECTION

7.1 During fabrication, contractor shall provide guy ropes and other means to safeguard semi-finished storage tanks against damage due to severe winds.

7.2 All welding shall be in accordance with the applicable design code and welding process shall be electric fusion shielded metal arc unless otherwise specified.

7.3 Welding procedure qualification shall be carried out as per IS: 823/ASME Boiler and Pressure Vessels Code Section IX. Welders shall also be qualified in the approved procedure as per the requirements of the Code. These qualification tests shall be arranged by the Contractor at his cost and witnessed by EIL/Owner Inspector.

7.4 Roof and Bottom plates of tank for Amine, caustic & sour water services shall be of butt welded construction.

7.5 Vertical joints in adjacent shell courses shall be offset by at least 1000mm. Vertical and horizontal joints shall also clear the nozzle welds and reinforcement pad welds and minimum distance between welds shall be as per Code.

7.6 Stiffening ring (wind girder) shall be provided on the tank as per requirements of the code. 15 mm diameter drain holes suitably staggered shall be provided on the horizontal part of the stiffening ring.

7.7 Manholes and nozzles with blind flanges/covers/companion flange shall be provided with gaskets and bolting. 10% spare bolting (Minimum 2 nos.) and 200% spare gaskets for each shall also be supplied by Contractor.

7.8 Nozzles for suction heaters and mixer attachment shall be provided with stiffeners. Jet mixer nozzle shall be furnished with a double flange and shall be oriented minimum 90° away from pump suction nozzle.

7.9 Heating coils shall be supported from tank bottom plate. Coil supports shall not be welded to tank bottom. No screwed or flanged connections shall be used inside the tank.

8.0 POSTWELD HEAT-TREATMENT

8.1 Tanks intended for Sour Services and Amine Services shall be fully stress relieved after completion of fabrication.

8.2 If it is specifically not asked for, all tanks intended for alkali / caustic services shall be stress relieved based on the concentration of the alkali solution and design temperature as per requirements of NACE SP 0403.

8.3 Completed tank may be stress relieved in-situ on final foundation or on nearby temporary foundation. In both the cases, Agency shall have past experience of carrying out PWHT of storage tanks of comparable sizes and Track record along with procedure of PWHT with tank stiffening details shall be submitted post order.

8.4 If tank is be stress relieved in-situ, necessary arrangement for isolation from foundation by providing fire bricks of adequate strength and properties shall be made over the foundation by the tank fabricator. Necessary provisions (slot) shall be kept in anchor chairs and tank bottom plate to take care of the expansion during stress relieving. Foundation and tank bottom shall be properly sealed after PWHT to prevent ingress of water.

8.5 Whenever stress relieving is required, complete tank shall be stress relieved meeting the requirements of UCS 56 of ASME B & PV Code Sec. VIII Div. 1, but without reducing the soaking temperature and increasing the time.

8.6 Hardness of base metal, weld deposit and HAZ shall be as per Clause 2.0 of EIL Specification 6-15-0091 for Caustic, Sour and Amine services.

9.0 STAINLESS STEEL TANKS

Based on process requirements or if mentioned in data sheet, a tank shall be fabricated out of stainless steel. In that case materials of components of tank shall be selected and designed as per Appendix S of API 650.

10.0 INSPECTION AND TESTING

All tanks shall be subject to inspection by EIL/Owner or a third party. The Inspector shall have free access to the contractor's shop/work site. The Contractor shall provide all facilities like tools and tackles, instruments and personnel to inspector. Approval of Inspector shall in no way relieve the contractor of his responsibility for proper execution of work.

10.1 The Inspection shall include but not be limited to:

a) Examination of materials of construction.

b) Welding procedure and Welder's qualification tests.

c) Various non-destructive tests like radiography, Dye penetrant, Vacuum box testing etc. as per code/statutory regulations or guidelines.

d) Checking of dimensions

e) Pressure testing and certification etc.

f) Hardness testing

10.2 Wherever specified in code, dye penetrant/magnetic particle examination shall be carried out on the welds. Shell weld seam as a minimum, shall be spot radiographed. Extent of radiography and acceptance criteria shall be as per the relevant provisions of the code.

10.3 The inner fillet of bottom or annular plate to shell weld shall be leak tested with penetrating oil after removal of slag prior to welding of outside fillet weld.

10.4 After completion, tank shall be hydrostatically tested by filling water and all weld joints shall be hammered and inspected for any leakage. In case of any defect, it shall be repaired and retested as per the instructions of Inspector.

10.5 Heating coil shall be inspected 25% of its weld joints by radiography. Heating coil shall be hydrostatically pressure tested with 1.5 times the design pressure.

11.0 TOLERANCES

Fabrication tolerances on shell, bottom, foundation, etc. shall be as per applicable code.

12.0 CALIBRATION

Strapping and calibration of tanks shall be done in accordance with Indian Standards IS: 2007 and IS:2008. Datum plate shall be welded to tank bottom vertically below the gauge hatch.

13.0 PAINTING

Surface preparation and application of primer and paint shall be in accordance with painting specification attached with the bid package.

14.0 GUARANTEE

The Contractor shall guarantee the tanks for design, materials and workmanship as per the General Conditions of Contract (GCC)/Special Conditions of Contract (SCC) attached with the bid package. Otherwise, guarantee shall be as follows:

Any part of tank found defective within guarantee period as defined in GCC/SCC and not having been subjected to faulty manipulation or wrong service conditions shall be promptly repaired/replaced and reassembled by the Contractor at his own cost failing which, the owner has the right to get the same replaced/repaired by others and charge the cost incurred to the Contractor.

15.0 DATA FOLDER

After completion of the job, the Contractor shall supply the following data:

Code compliance certificate, design calculations, "As Built" drawings of the tank, material test certificate, heat treatment report if any, final inspection and test certificates.

16.0 LIST OF ATTACHMENTS

1.	6-65-0061	STANDARD SPECIFICATION FOR ACID/ALKALI PROOF LINING WITH BITUMEN MASTIC
2.	6-65-0062	STANDARD SPECIFICATION FOR ACID/ PROOF TILE
3.	7-13-0001	EARTH CONNECTIONS
4.	7-13-0002	ANCHOR CHAIR
5.	7-13-0003	HOT INSULATION SUPPORTS FOR STORAGE TANKS.
6.	7-13-0004	STORAGE TANK STEAM COIL.
7.	7-13-0005	JET MIXER
8.	7-13-0006	LEVEL INDICATOR SUPPORTS
9.	7-13-0007	GAUGE HATCH WITH COVER
10.	7-13-0008	FOAM SYSTEM (FOR CONE ROOF / FLOATING ROOF TANKS)
11.	7-13-0009	DRAIN OUTLET (FOR TANKS)
12.	7-13-0010	CAGE LADDER FOR FIXED ROOF TANK
13.	7-13-0012	NAME PLATES

14.	7-13-0013	SPIRAL STAIRWAY AND HAND RAILING FOR CONE ROOF/FLOATING ROOF TANKS (WITH ELECTRO FORGE GRATING)
15.	7-13-0022	STILL-WELL FOR LEVEL TRANSMITTER (SERVO LEVEL XR) (FLOATING ROOF TANKS / CONE ROOF TANKS).
16.	7-13-0023	STILL-WELL FOR TEMPERATURE ELEMENT (CONE ROOF TANKS).
17.	7-13-0039	DEFLECTOR PLATE FOR COOLING SYSTEM
18.	7-13-0040	STRINGER TYPE SPIRAL STAIRWAY AND HANDRAILING FOR CONE ROOF /FLOATING ROOF TANKS
19.	7-13-0041	STILL WELL FOR LEVEL TRANSMITTER (RADAR TYPE) FLOATING ROOF / CONE ROOF
20.	7-67-0004	FOUNDATION FOR ACID TANK LINING
21.	7-68-0509	STEEL LADDER JOINT DETAILS
22.	7-68-0680	ROOF STRUCTURE FOR CONE ROOF TANK, JOINT DETAILS (DIA. # 40 M)
23.	7-68-0661, 7-68-0663 TO 7-68-0675	STRUCTURAL ARRANGEMENT OF CONE ROOF (WHICHEVER IS APPLICABLE)
24.	7-68-0697	ELECTROFORGED GRATING TYPE-I & TYPE-II

17.0 ANNEXURE-I (VENDOR DATA REQUIREMENTS)

SL. NO.	DESCRIPTION	MIN. NO. OF SETS (WITH THE BIDS)	MIN. NO. OF SETS (AFTER PLACEMENT OF ORDER)	
			COMPACT DISC./ELECTRONIC FORM	PRINTS
1.	Data Sheet for Tank	1	2	-
2.	Post weld Heat Treatment Procedure of the complete tank along with track record	-	2	-
3.	Mechanical Design Calculations- a) Shell, bottom, roof etc. b) Non standard and external roof supporting structure.	-	2	-
4.	General arrangement drg., giving design data, basic dimensions, thickness, nozzles and internal parts along with orientation and material specifications.	-	2	-
5.	Details of shell, bottom and roof & roof structure showing their welds, nozzles and manhole connections, internals etc.	-	2	-
6.	Details of platform, ladder and other accessories.	-	2	-
7.	Material test certificates for plates, pipes and flanges.	-	2	-
8.	Welding procedure and welder's qualification reports	-	2	-
9.	Radiographic test reports (films to be stored for 5 years)	-	2	-
10.	Heat Treatment Report	-	2	-
11.	Procedure & Report of Internal Liner / Coating	-	2	-
12.	Final Inspection Certificate and hydrostatic test certificate	-	2	-
13.	Final as built drawings (covering Sl. No. 3 & 4) for information.	-	2	-

Note
1. Items at Sl. No. 2, 3, 4 & 5 are required for review by EIL.
2. Items at Sl. No. 6 to 10 are required by Inspection Agency.
3. All drawings shall be drawn in AutoCAD R-14 or above. No hand drawings shall be accepted. All calculations shall be computerized.
4. Documents and letters shall be furnished in electronic format. The software used shall be as follows:
   a) MS OFFICE 2007 OR ABOVE
   b) ADOBE ACROBAT 9.0 OR ABOVE.
5. Number of sets with Bids or after placement of order shall be as per Tender or Requisition.

भंडारण टैंकों का मानक विनिर्देश

STANDARD SPECIFICATION FOR STORAGE TANKS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8	02.04.24	REVISED & REISSUED AS STD. SPEC.	SC	TKh	KA/NK	MN
7	30.08.18	REVISED & REISSUED AS STD. SPEC.	RKK	TK	KJH	RKT
6	30.07.10	REVISED & REISSUED AS STD. SPEC.	KA	RKT	AKM	ND
5	12.03.10	REVISED & REISSUED AS STD. SPEC.	TK	RKT	AKM	ND
4	23.03.04	REVISED & REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG
3	09.01.97	REVISED & ISSUED AS STD. SPEC.	A. KUMAR	AKM	CRMN	A.SONI

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FR	:	Floating Roof
GA	:	General Arrangement
IBR	:	Indian Boiler Regulations
IFR	:	Internal Floating Roof
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NACE	:	National Association of Corrosion Engineers
NB	:	Nominal Bore
NBR	:	Nitrile Butadine Rubber
OISD	:	Oil Industry Safety Directorate
SS	:	Stainless Steel
UTS	:	Ultimate Tensile Strength

Static Equipment Standards Committee

Convenor : Mr. Nalin Kumar
Co-Convenor : Mr. K. Anjaneyulu

Members :

Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Co-Ordinator)
Mr. P V Satyanarayana
Mr. Anish Trehan
Mr. P Barik
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karnam
Mr. Aasheesh K Handa (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agrawal (SCM-Inspection)

CONTENTS

1.0 SCOPE

1.1 This specification covers the general requirements for design, fabrication, workmanship, erection, inspection, testing and supply of storage tanks and is intended to supplement the minimum requirements of the applicable codes.

1.2 Supplementary specification indicating special or additional requirements shall form addenda to this specification and shall govern. Supplementary specification, when made addenda to this specification shall be referred to in the Bid Document.

1.3 In case of conflict, the order of preference shall be as follows:

a) Engineering drawing

b) Specifications

c) Codes

As a general rule, the most stringent requirements shall govern.

1.4 For bought out items / Components EIL recommended vendors list is provided elsewhere in the Tender. In case, Contractor proposes any other vendor for bought out items/ Components, then the proposed supplier shall be a reputed manufacturer. Contractor shall submit for Client/EIL approval the necessary documents regarding Proven Track Record (PTR) of the proposed supplier w.r.t the bought out item / Components. As a minimum, two (02) sets of items shall have been supplied for tankage applications and out of these one (01) set shall have been successfully commissioned within the last ten years from bid due date. Contractor shall place the order on the proposed supplier only after obtaining approval from Client/EIL. There shall be no cost/time implication on this account.

2.0 REFERENCES

2.1 Design Codes

The following codes in their latest edition shall form the basis for design, fabrication, inspection, testing and acceptance of storage tanks:

API Standard: 650	:	Welded steel tanks for oil storage. (Items not covered by API-650 shall be as per IS-803.)
IS: 803	:	Code of practice for design fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
API Standard: 620	:	Design and construction of large welded low pressure storage tanks.
IS: 875 (Part 3)	:	Code of practice for design loads Wind Loads (other than earthquake) for building and structures.
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IS: 2008	:	Method for Computation of capacity tables for Vertical Oil Storage Tanks.

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2.2 Material Codes

Material to be used shall conform to:

a) ASME Boiler and Pressure Vessel Code Section II
b) Indian Standard Specification.
c) API Standard 650 & 620.

2.3 Regulations

National laws and regulations together with local bye-laws for the country or state wherever the tanks are to be erected must be complied with by the fabricator.

3.0 SELECTION OF MATERIALS

3.1 All materials shall be as per EIL Engineering Data Sheet, EIL Specifications and applicable Codes.

3.2 Manhole necks, nozzle necks 250 mm NB and above may be fabricated from same plate material as used for shell.

3.3 All nozzles except manhole shall be fitted with forged flanges.

3.4 Heating coil pipes shall be of seamless quality.

3.5 All clips and attachments shall be fabricated from carbon steel plates of weldable quality.

3.6 Gaskets for manholes shall be 3mm thick compressed non asbestos.

3.7 Bolts and nuts for all nozzles fitted with blind flanges shall conform to ASTM A-193 Gr. B-7, A-194 Gr. 2H. Bolts and nuts for all structurals shall conform to IS: 1363. Bolt and nuts for Manholes shall conform to ASTM A 307 Gr. B or IS 1367 Cl. 4.6/ Cl.4.0.

3.8 Floating roof pipe supports and pipe sleeves shall be of carbon steel conforming to seamless ASTM A-106, A-53, API.5L, IS:1978 or equivalent.

3.9 For all Material of Construction, requirement of Impact Testing shall be complied with as per API 650.

4.0 DRAWINGS AND DOCUMENTS

4.1 All individual tank data sheets shall have dimensional/design data as well as material specification. Final drawing with revisions, if any, shall be issued after award of contract/purchase order.

4.2 Contractor shall submit the detailed design calculation for floating roof (FR), wherever called for in the tender document for EIL's review.

4.3 Contractor shall prepare all design calculations and fabrication drawings based on the drawings issued on award of contract/purchase order and shall include the Documents and Fabrications Drawings as per Annexure-III, which shall be considered as a minimum in general. For detailed Vendor Data Requirements refer contract / purchase order.

5.0 FABRICATION AND ERECTION

During fabrication, contractor shall provide guy-ropes and other means to secure semi-finished storage tanks against damage due to wind. A scheme shall be submitted to Engineer-in-Charge for review. Wind girders and roof shall be welded to tanks at the earliest. Before commencement of erection, contractor shall submit detailed erection scheme to Engineer-in-Charge for approval.

5.1 Plates

a) Plate edges shall preferably be sheared or machine cut as per code. All machined parts shall be suitably protected before assembly.

b) Gas cut plates shall be ground to the satisfaction of the Engineer-in-Charge.

c) All formed plates shall be match marked with paint on the concave side with numbers as shown on erection drawings.

5.2 Structure

a) Structural steel fabrication shall be carried out to the required shapes for making the structure. Electro-forged type of grating shall be provided.

b) A pre-assembly of a sufficient part of roof structure may be called for by the Engineer-in-Charge to assess the correct workmanship.

5.3 Bottom

a) Bottom slope shall be as indicated in the respective tank drawings.

b) All ATF (Aviation Turbine Fuel) floating roof storage tanks shall be provided with Apex-down bottom with central sump. All other storage tanks shall have apex-up bottom unless otherwise shown in engineering drawing.

c) Overlaps shall be properly cleaned with steel wire brush before welding.

d) Single pass welds are not permitted.

e) Arrange the laps to shed the water towards the drain.

f) Bearing plate under each leg support for floating roof tanks shall be centred and welded to the bottom plate by a continuous fillet weld of size equivalent to bottom plate thickness. Plates shall be 600 mm round or square and 10 mm thick (minimum). If bearing plate is coming on overlap, shim plates shall be used. Prior to welding of bearing plates area of bottom plate beneath the bearing plate and also underside of bearing plate shall be painted as per painting specification.

5.4 Shell

a) All vertical and horizontal shell joints shall be full penetration and full fusion welds using any one of the edge preparations permitted by the Code.

b) Top curb angle shall be lap or butt welded to the top course with flange turned outside.

c) Drain holes of 20 mm diameter suitably staggered shall be provided on the horizontal plates of the stiffening ring (wind girder).

d) Hand railing shall be provided all around top wind girder when it is used as walkway for floating roof tank.

e) Hand railing shall be provided all around for all fixed roofs.

f) Curb angle joints and stiffening ring joints shall not coincide with the vertical shell plate welds.

g) Vertical weld joints shall be offset by at least 1000 mm.

h) Holes shall not be made in shell plates for erection purposes.

i) Shell plate alignment shall be within the limits specified in code and as approved by EIL.

j) For floating roof tanks, internal surfaces of all shell courses shall be flushed and internal diameter shall be maintained in all shell courses.

k) After completion, the inside surface of floating roof tank walls shall be ground to remove any roughness liable to impair the seal.

5.5 Fixed Roof

a) The roof plate shall rest on self-supported structures as indicated in the drawing/standard.

b) All supporting structures shall be designed to carry the minimum loads as specified in codes, if the same is included in contractor's scope of work. While designing, contractor shall also consider lateral loads caused by one bay loaded and the other bay not loaded.

c) Laps in roof plate shall be 25 mm minimum. Laps shall be arranged with upper edge of the lower plate underneath the lower edge of the upper plate.

d) Roof shall be joined to the shell by means of continuous fillet (5 mm max.) weld on the curb angle. Roof to shell joint shall be frangible type, otherwise suitable emergency venting shall be provided as per API 2000 for Fire Case for Oil Tanks.

e) Roof plates shall not be welded to the supporting structure. The same shall rest on the structure.

f) Wherever corrosion allowance is more than 1mm for roof, external roof structure shall be provided. Central drum, curb angle shall be suitably modified etc. EIL standards shall be used for guidance only. However, if any protective coating like epoxy etc. is provided then roof structure may be provided inside the tank as per EIL standards.

5.6 Floating Roof

5.6.1 General

a) Floating roof of tanks less than or equal to 12m or more than 60 m in diameter shall be of double deck type construction.

b) Tanks having diameter greater than 12 m but less than or equal to 60 m, shall be of single deck annular pontoon type construction with or without buoys.

c) When floating roof is in the highest position, tank shall be capable of holding its design capacity.

d) Floating roof deck shall always be in contact with the liquid at all positions during operating conditions.

e) Floating roof shall be designed by Contractor considering design data given on each Tank drawing of tender specification.

f) Single deck annular pontoon type floating roofs of diameter more than 46 m shall be designed for elastic stability against "gross out of plane" buckling and local buckling of the outer pontoon due to radial load imposed by deflection of the centre deck. This radial load shall be the higher of the following (i) water (10" rain water in case of external floating roof & 3" fire water in case of internal floating roof) (ii) when deck is punctured.

g) Central deck of the floating roof shall be provided with at least one manhole of 750 NB in addition to the number and size of manholes required as per code. This manhole shall be provided with a ladder for stepping down to bottom when the roof is in the lowest position.

h) Deck shall have level surface with a slope towards the drain sump to avoid stagnation of foam / fire water / rainwater while floating in the product or when the floating roof is at lowest standout position.

i) Each compartment of the floating roof shall be provided with a 500 NB manhole with cover.

j) Each buoy, if provided, shall have 150 NB inspection opening with cover and bolting.

k) Central deck and pontoon shall be suitably stiffened, if required, and calculations for the structural integrity of the floating roof shall be submitted to EIL for approval.

l) Contractor shall decide the dimensions of the pontoons of the floating roof such that when it is floating on the product (of specific gravity 0.7 or the specific gravity of the stored product, whichever is lower) the maximum submergence shall be within 95% of the rim height under conditions as listed below:

i) For single deck annular pontoon type external floating roofs

- The submergence of outer rim when 254 mm rain water is accumulated on the roof.
- The submergence of inner and outer rim near the punctured compartments when deck and two adjacent pontoon compartments are punctured.

ii) For single deck annular pontoon type internal floating roofs.

- The submergence of outer rim for fire water accumulation equivalent to 75 mm water.
- The submergence of inner and outer rim near the punctured compartments when deck and two adjacent pontoon compartments are punctured.

iii) For double deck floating roof tanks

- The submergence of outer rim shall be calculated with maximum amount of water that can be accumulated on the double deck.
- The submergence of inner and outer rim near the punctured compartments when deck and two adjacent pontoon compartments are punctured

m) Contractor shall carry out buoyancy (including tilting) calculations of the floating roof for all the conditions of (l) mentioned above when it is floating on test water. Maximum submergence in water shall be clearly specified in fabrication drawing while taking care of actual floating scenario with product (of specific gravity 0.7 or the specific gravity of the stored product, whichever is lower) & the same shall be compared with actual submergence measured during floatation test as mentioned in Cl. No. 7.2.4 of this Specification.

n) Contractor shall submit design calculations for external floating roofs for

i) Buoyancy, including tilting for punctured condition, leg supports, bleeder-vent, emergency drain (if required as per datasheet / specifications for single deck) & primary drains.

ii) Deflection of deck and structural integrity of floating roof for annular pontoon type floating roofs.

iii) Deflection of deck and stresses in decks for double deck floating roof.

o) For internal floating roofs all above calculations except emergency drain are to be submitted.

5.6.2 **Seal**

a) All internal and external floating roofs, unless otherwise shown in engineering drawing, shall be provided with liquid mounted foam seal for external floating roof & vapour mounted foam seal for internal floating roof as primary seal. In addition, secondary seal shall be provided for both external & internal floating roof.

b) Liquid mounted foam seal shall have minimum 100 mm immersion in the stored product.

c) Details of foam seal and secondary seals shall be as per Annexure-1 to this specification.

5.6.3 **Floating Roof Supports**

a) Supports shall be adjustable to two positions

i) The lower position shall permit the roof to go as low as possible without interference with any internal accessories and roof seal mechanism.

ii) The upper position (for cleaning) shall provide a clearance of 2000 mm between the pontoon/double deck edges and bottom.

b) The number of leg supports shall be determined to ensure that while resting they do not deform the tank bottom and roof. For ascertaining compressive capability, the effective length of the pipe support should be taken as 1.5 times of actual length of the pipe support in clean-out position.

c) Pipe sleeves shall project sufficiently above the roof to take care of rain-water/foam flooded condition of roof and extend sufficiently below the roof to prevent escape of vapour (minimum 200 mm).

d) Pipe support length shall be readjusted after hydraulic testing of tank so as to take care of the initial settlement of the tank bottom.

5.6.4 For EFR, Rolling ladder and track shall be provided as per EIL Standard. Electro-forged type of grating shall be provided.

5.6.5 **Roof Drains**

a) Unless otherwise specified, Primary Roof drains shall be either of two types mentioned below:

i) Flexible Drain Pipe System (Stainless steel armoured clad flexible hose or the flexible hose with stainless steel carcass).

ii) Articulated Steel Pipe with Flexible Joint (Swivel type joint is not acceptable).

b) Flexible drain pipe system shall have following features:

i) Full length of the pipe shall be in single continuous length without any intermediate joints in between two end flanges. It shall have stainless steel armoured clad flexible hose or the flexible hose with stainless steel carcass.

ii) Flexible pipe must provide repetitive lay pattern without any external support of accessories like tethered assemblies, ballasting chain etc. during its full operational life. No kinking of flexible pipe shall take place during movement of the roof.

iii) As the roof starts its descent, pipe shall start forming the coil and should not slide on the tank floor.

c) Articulated Steel Pipe with Flexible Joint: Flexible joints joined with steel pipe drain system in a straight line design. Swivel joints are not acceptable. Steel pipe shall be Seamless, Schedule 40 pipes minimum.

d) The primary roof drain for EFR tanks shall be designed for complete water drainage equivalent to maximum recorded rainfall per hour for given site without allowing any accumulation of water, the deck being at the lowest operating level as indicated in Engineering Drawing.

e) The primary roof drain for IFR tanks shall be designed for complete water/foam drainage equivalent to 75 mm per hour for given site without allowing any accumulation of water, the deck being at the lowest operating level as indicated in Engineering Drawing.

f) When storage tanks are provided with heating coils, suitable isolation of flexible roof pipe drains from heating coils shall be provided as recommended by drain supplier.

g) Swing check non return valve with CI body and brass/bronze valve and seat shall be provided at the entry point of the primary drain.

h) Primary roof drain system shall have minimum guarantee/warranty period of 3 years from the date of commissioning.

i) If specifically mentioned, emergency drain shall be provided to take care of primary roof drain failure. These drains shall be equipped with water seal sump inside the roof to prevent back flow of the stored product. It should start functioning after accumulation of 125 mm of rain fall on deck.

5.6.6 Vents

a) Roof shall be provided with automatic bleeder vents designed to open before the roof reaches its lowest position and to close when the roof rises above this point. Also, same operation should follow in the clean-out position.

b) Rim vents of 150 NB at about 30 metres peripheral spacing (minimum two nos.) shall be provided for venting the dead space between stored liquid and seal where vapour mounted primary seal is installed. They shall be provided with pressure relief valve of approved make (Refer Annexure-II) set at 20 mm water column above Operating Pressure.

c) No rim vent is required where liquid mounted primary seal is installed.

5.6.7 Gauge Well/Anti-rotational Device

Gauge hatch with well pipe (including slots) shall be provided for all types of tanks. This should have continuous contact by means of strips with bottom plate of the tank. Gauge hatch size shall be as indicated in the drawing and it shall have a quick opening cover. Gauge hatch shall be spark proof type. This shall also act as anti-rotational device for floating roof tanks wherein no additional anti-rotational device is suggested. For pressurized tank, slot dipping device shall be provided.

5.6.8 **Earthing of Floating Roof**

a) Wire cables shall be provided between ladder and track and also between ladder and shell. Two such independent connection should exist in parallel.

b) Adequate number of earthing shunts shall be provided for the seal.

5.7 Post Weld Heat Treatment (PWHT)

Tanks in amine service, sour water service, caustic service (wherever required) or wherever indicated in engineering drawings shall be PWHT as per Code requirements. PWHT shall meet the requirement of UCS 56 of ASME Sec. VIII Division 1.

Necessary provisions (slots) shall be kept in anchor chairs and tank bottom plate to take care of the expansion during stress relieving. Foundation and tank bottom shall be properly sealed after PWHT to prevent ingress of water.

6.0 APPURTENANCES

6.1 Nozzles & Accessories

a) All appurtenances and accessories as shown in the respective tank drawings shall be supplied by the Contractor.

b) Manhole and nozzles with blind flanges shall be provided with gaskets and boltings.

c) Nozzle and manholes may be shop assembled.

d) Flange faces shall be varnished and protected by wooden discs using at least three bolts.

e) Suction heaters and mixer nozzles shall be provided with stiffeners.

f) All nozzles and accessories shall be prefabricated and attached to the shell plate. The prefabricated assembly shall be stress relieved prior to installation, wherever required as per code and applicable appendices.

6.2 Heating Coils

Coils shall be supported from tank bottom. Coil supports shall not be welded to tank bottom. No screwed or flanged connections shall be used inside the tank. Heating coil layout shall clear leg supports of floating roof and primary roof drain lay area.

Allowable flattening due to bending shall be as per ASME B 31.3.

6.3 Stairways, Roof Access and Handrailing

Each tank shall be provided with stairway and roof access. Handrailing, if not indicated otherwise on tank drawings, shall be provided all around. Walkway with handrails & gratings on the roof of the tank should be provided to facilitate inspection/checking of vents / flame arrestor etc. so that movement of personnel on roof is safer.

6.4 Settling Marker

Markers shall be provided on the shell, 500mm from the bottom to check tank settlement. Marker, 100 mm long of 50x50x5 mm angle shall be welded around the tank shell. The distance between settling marker is approximately 5 metres. (Minimum 8 numbers).

Shell settlement measurements shall be made after tank erection, prior to hydrotesting and during water filling at 1000 mm intervals upto maximum filling height of tank.

While taking measurement on settling markers, rim space (distance between shell and outer rim) shall also be measured at location corresponding to settling markers, for floating roof tanks.

Bottom internal measurements shall be made after hydrotesting, such measurement shall be made at all pipe support location. Additional measurements shall be made in annular plate region at 5-metre intervals around the tank shell.

7.0 INSPECTION AND TESTING

Inspection shall be co-ordinated by Engineer-in-Charge at all stages. It shall be the responsibility of Contractor to prepare a detailed inspection and test plan as per applicable code and specifications and get the same reviewed by Engineer-in-Charge prior to execution of work.

7.1 Inspection

a) All tanks shall be offered for inspection at all stages, as desired by Engineer-in-Charge.

b) Inspector or Owner's representatives shall have free access to all the contractor's shops as well as to worksite.

c) The contractor shall provide all facilities, such as access ladder, lighting, tools and tackles, instruments etc. and personnel to inspectors, for proper execution of their inspection.

d) All the inspection shall be carried out in accordance with the relevant codes and requirements of drawings and specifications.

e) Approval of the Inspector shall in no way relieve the contractor of his responsibilities for proper execution of work.

7.1.1 Welding Electrodes

Following classifications of electrodes are recommended for welding. However, minimum requirements of applicable codes and appendices shall be adhered to:

a) Low hydrogen electrodes shall be used for all manual metal-arc welds of carbon steel shell courses having a thickness of 12mm or more and for attachment of shell course to bottom or annular plates.

b) High cellulose/rutile type electrodes as per the AWS classification SFA 5.1 are acceptable for all other structural welding.

Based on above, fabricator shall furnish brand names of welding consumables to Engineer-in-Charge for approval.

7.1.2 Welding Procedure

a) Welding procedure qualification shall be carried out as per ASME Boiler and Pressure Vessel Code Section IX.

b) No welding shall be undertaken without approval of the welding procedure and welder qualification test by the Engineer-in-Charge.

7.1.3 Radiography and Inspection of Welds

a) All welds shall be inspected and tested as per Code and this specification.

b) All long seams of fabricated nozzles shall be fully radiographed.

c) Weld areas to be radiographed shall be designated by the Engineer-in-Charge.

d) Radiographs shall be taken as soon as welding of the Joint is completed. If repairs are required, these shall be carried out before starting other welds. New radiography examination of such repairs shall also be carried out by the Contractor at his own cost.

e) For heating coils, number of joints to be radiographed shall be 25% and interpretation of radiography shall be as per ASME B 31.3. Approval, from IBR, wherever required shall be contractor's responsibility.

7.1.4 **Liquid Penetrant/Magnetic Particle Examination / Ultrasonic Examination**

Whenever specified in drawing/code, liquid penetrant/magnetic particle/ultrasonic examination shall be carried out as per ASME Boiler and Pressure Vessel Code Section V and acceptance criteria shall be as per Section VIII Div. I.

7.2 **Testing**

All equipment required for testing shall be supplied by the contractor.

Openings other than those used for hydrostatic test or any other test shall be closed by plugs and blind flanges supplied by the contractor.

7.2.1 **Bottom Test**

a) A detailed description of the proposed test method shall be first submitted for approval to the Engineer-in-Charge.

b) Vacuum box testing shall be carried out for detection of leaks in the bottom.

c) The weld joints under the shell periphery shall be tested before erection and welding of first shell course.

d) Contractor shall test the tank bottom for the entire weld length in the presence of the Engineer-in-Charge and test reports shall be issued accordingly.

7.2.2 **Shell Test**

a) Bottom to shell joints shall be tested as follows:

i) Inner fillet weld shall be inspected and tested prior to welding the outside fillet weld. Leak test shall be performed with penetrating oil after removal of slag. Oil shall be removed before, welding the outer fillet.

ii) Examination for inner fillet to detect cracks shall be performed using either the liquid penetrant or magnetic particle method.

b) All welded lugs and brackets used for erection purpose shall be carefully removed from inside and outside surface of the tank to the satisfaction of the Engineer-in-Charge.

c) Contractor shall perform the hydrostatic test in the presence of Engineer-in-Charge on each tank after complete erection. Any defects observed during the test shall be repaired by the Contractor.

d) The filling height, in case of fixed roof or open roof tanks, shall be upto the curb angle and in case of floating roof tanks shall be restricted to the maximum height so that weather shield or secondary seal does not go beyond curb angle.

e) If sea water is used for testing and is to remain in tank for more than 30 days, an oxygen scavenger and corrosion inhibitor shall be added. After testing the tank, water shall be drained and tank shall be thoroughly flushed with clean fresh water. Standing water silt or other dirt left in the tank after hydrostatic testing shall be thoroughly cleaned.

f) Filling of the tank may be restricted by the Engineer-in-Charge for preloading of foundation and hydrostatic test may be extended over a period of 4 weeks or more to ensure proper settlement of the tanks.

g) On completion of tank and after cleaning, the tank shall be filled with water as follows, unless otherwise specified in the tender documents.

Filling shall be in 4 stages, 25%, 50%, 75% and 100%. After each stage a load stabilization period shall be observed:

- 24 hours between each stage for tanks with a capacity equal or more than 10,000 m^3.
- 12 hours between each stage for tanks with a capacity under 10,000 m^3.

Filling rate shall not exceed 5 meters per day.

h) When the tank is full all the welded joints shall be hammered by contractor in the presence of Engineer-in-Charge. In case of any defect, it shall be repaired and retested by the Contractor as per the instructions of Engineer-in-Charge.

i) Tank shall be emptied at a maximum water level variation rate of 5 meters per day or as per instruction of Engineer-in-Charge.

j) All weld repairs shall be done with water level minimum 300mm below the joint being repaired.

7.2.3 Fixed Roof Test

a) After filling the tank upto curb angle, all openings in the roof shall be closed and internal air pressure shall be applied equivalent to the weight of roof plates. All welded joints in roof shall be checked with soap-suds for detection of leaks.

b) Pressure testing of roof for leak detection shall be carried out as per code.

c) For vacuum test the tank shall be emptied upto 1 meter level from the bottom. The openings shall be closed and draining continued with care until the vacuum of 25mm water gauge or the design vacuum whichever is higher is obtained and checked by vacuum gauge. However, for tanks having diameter 20 m and above, design check for vacuum shall be made before proceeding with the test.

7.2.4 Floating Roof Test

Floating roof test shall be as recommended in API Standard 650 Appendix C or Appendix H and also as given below:

a) During floatation test of roof, contractor shall carry out the proof test as follows on each size of the tank selected by Engineer-in-Charge who shall also witness the test check.

i) For annular pontoon type external floating roofs, with primary drains closed, water equivalent to 10" of rainfall over the tank area shall be poured on the deck and in the stabilized state submergence of outer rim shall not exceed allowable limit as stated in Sl. No. (iv) below.

ii) For annular pontoon type external as well as internal floating roofs the condition of deck and two adjacent pontoon compartments punctured shall be simulated and the submergence of inner rim and outer rim at the punctured pontoon shall not exceed allowable limit as stated in Sl. No. (iv) below.

iii) For double deck tanks puncture condition for 2 adjacent compartments which shall cause maximum tilting as established in the design calculation shall be simulated, and the submergence of outer rim at the punctured compartment shall not exceed allowable limit as stated in Sl. No. (iv) below.

iv) The allowable limit of submergence shall be considered as 65% of rim height at any point, for tanks having stored product of specific gravity more than equal to 0.7. For stored product having specific gravity less than 0.7, the allowable limit of submergence shall be considered as 95% multiplying the specific gravity of the stored product but in no case, the same shall be more than 65% as stated above.

v) Failing to meet the above requirements contractor shall rectify the floating roof and retest at his cost till the above requirements are satisfied.

b) All compartments including buoys shall be tested for liquid tightness.

c) Sealing device shall be installed after floatation test.

7.2.5 Heating Coils

Heating coils shall be pressure tested as per engineering drawing.

7.2.6 Nozzle Reinforcing Plates

Nozzle reinforcing plates shall be pneumatically tested at 1.05 kg/cm^{2}g with soap solution. This test shall be carried out before filling the tank for hydrostatic testing.

7.2.7 Primary Drains

Drain pipes in floating roof tanks shall be pressure tested with water at 3.5 kg/cm^{2}g. During the flotation test, the roof drain valve shall be kept open and observed for leakage of the tank contents into pipe drain.

8.0 CALIBRATION

Strapping and Calibration of all tanks shall be done in accordance with IS:2007 & 2008 (Latest editions).

9.0 PAINTING

For details of primer and painting both internal & external including soil side of bottom plates, Painting specification shall be referred to.

10.0 DIMENSIONAL TOLERANCES

10.1 Shell

For tanks to have acceptable appearance and to permit proper functioning of floating roof, they shall have tolerances strictly as specified in applicable codes.

10.2 Floating Roof Tolerances

Tolerances allowed on the annular clearance between shell and floating roof shall be compatible with the requirement specified by seal manufacturer. However, the difference in gap between the shell and the periphery of the roof on completion of erection of the roof shall not exceed ± 13 mm from the nominal gap.

11.0 IDENTIFICATION, PACKING AND TRANSPORTATION

11.1 Identification

Each plate and structural member shall be clearly marked with the specification number, drawing number and assembly number.

11.2 Packing and Transportation

a) All plates shall be transported in tractor or trailor and shall not be dragged.

b) All rolled shell plates shall be packed properly to retain the shape and shall be handled carefully to avoid damage during transit.

c) Contractor shall be responsible for transportation of material fabricated in his workshop or worksite.

12.0 GUARANTEE

Guarantee, if not covered by the General Conditions of contract, shall be as following:

12.1 All equipment shall be guaranteed in accordance with conditions given in the "Special Conditions of Contract".

12.2 Any part of tank found detective within 18 months of completion or during 12 months operation and not having been subjected to faulty operations or incorrect service conditions shall be promptly replaced/repaired and reassembled by the contractor at his own cost, failing which owner has the right to get the same replaced/repaired by others and charge the cost incurred to the contractor.

12.3 Guarantee/warranty for seals and primary roof drain system for floating roof tanks shall be as per Annexure-I and Clause 5.6.5 (f) respectively.

13.0 ANNEXURES

ANNEXURE-I	:	SEALS FOR FLOATING ROOF TANKS
ANNEXURE-II	:	LIST OF RECOMMENDED MAKES FOR PRESSURE RELIEF VALVES & SLOT DIPPING DEVICE
ANNEXURE-III	:	LIST OF DOCUMENTS & DETAILS OF FABRICATION, TO BE SUBMITTED BY TANK FABRICATOR.

14.0 ANNEXURE - I

SEALS FOR FLOATING ROOF TANKS

1.0 GENERAL

This Annexure cover requirements that shall be met as a minimum for core foam and casing for primary seals for floating roof tanks. Requirement for secondary seals are also covered.

2.0 CORE FOAM

2.1 Core foam shall be of prime quality solid polyurethane foam and of octagon shape. Foam shall be of light weight having appropriate elasticity, little permanent compressive strain and shall have excellent resistance to oil and chemicals.

2.2 Core foam shall have the following properties in accordance with ASTM D-3574.

i)	Specific Gravity	0.018 to 0.022
ii)	Permanent Strain due to compression	Not to exceed 10%
iii)	Load at 25% deflection	RMA value 6.81 $\pm$ 1.36 Kgs.

2.3 Rim space of 200 mm shall be provided. Foam shall be of octagonal shape and of size 305 mm (across flat ends).

3.0 FOAM CASING

3.1 The casing material shall be oil and water resistant and compatible with stored product.

3.2 Material for foam casing shall be Nylon Fabric (1 mm thickness) equally coated on both sides with polyurethane for both liquid and vapour mounted seals.

3.3 Contractor shall furnish following characteristics of casing material post-order:

a) Original adhesion

b) Adhesion after Fuel ageing (*)

c) Original tensile strength

d) Tensile strength after Fuel ageing (*)

e) Tensile strength after 50,000 flexes

f) Volumetric swelling (*)

g) Vapour permeability

(*) Ageing in both 100% Toulene and also in 75% Toluene with 25% Iso-octane for 7 days at 25 degree centigrade.

4.0 FABRICATION OF SEAL

4.1 Tests as specified above shall be carried out in a reputed laboratory and the results shall be furnished for review/approval.

4.2 Contractor shall use proper adhesive of approved quality. Contractor shall give complete procedure for joining the pieces. The entire work shall be carried out in a clean, dry area, free of heat, sparks of flame.

4.3 Minimum length of foam and casing for foam seal shall not be less than 3 meters. Total circumferential length of foam seal shall be such that a compression of 150 mm is achieved for every 3 meters length of foam seal when installed.

4.4 Maximum seal gap width will be 4 cm and maximum gap area will be 200 cm^2/m of tank diameter.

5.0 SECONDARY SEAL

5.1 Secondary seal shall have synthetic rubber wiper seal, continuous vapour barrier membrane, galvanized compression plate of 16G thickness, SS electric shunt and all necessary hardware for installing on rim of external floating roof. Vapour barrier membrane shall have polyurethene coating on both sides of nylon fabric. Minimum thickness of vapour barrier shall be 0.4 mm. Maximum seal gap width will be 1.3 cm and maximum gap area will be 20 cm^2/m of tank diameter.

5.2 Recommended models and makes of secondary seals shall be as per EIL approved Vendor list.

6.0 GUARANTEE

The primary and secondary seals shall have guarantee/warranty for its durability and satisfactory performance for a minimum period of five years from the date of commissioning.

15.0 ANNEXURE - II

A : LIST OF RECOMMENDED MAKES FOR PRESSURE RELIEF VALVE SHALL BE AS PER EIL LIST.

B : SLOT DIPPING DEVICE SHALL BE OF REPUTED MAKE.

16.0 ANNEXURE - III

VENDOR DATA REQUIREMENTS

SL. NO.	DESCRIPTION	NO. OF SETS (WITH THE BIDS)	NO. OF SETS (AFTER PLACEMENT OF ORDER)	
			COMPACT DISC./ELECTRONIC FORM	PRINTS
1.	Document/Drawing Index along with Schedule of Submission.	-	2	
2.	Proposed Heat Treatment Procedure	-	2	
3.	GA drawing covering all details shown in EIL data sheets like list of appurtenances, lists of standards and specifications, material of construction, Tank design data, General Notes including details of test to be conducted on tank, specification and brand-name of welding electrodes to be used etc	-	2	
4.	Details of shell, bottom and roof & roof structure showing their welds, nozzles and manhole connections, internals etc.	-	2	
5.	Development, details of welding for shell showing location of nozzles, pipe support cleats & travel of stairway on developed shell	-	2	
6.	Details of spiral stairway, platforms, landings, handrails and other accessories with bill of material	-	2	
7.	Details of wind girders	-	2	
8.	Details of rolling ladder and track and Earthing connection for EFR tanks	-	2	
9.	Details of Roof Supporting Structure for fixed roof tanks	-	2	
10.	Details of shell nozzles and shell earthing cleats	-	2	
11.	Details of Seal(s) and weather shield and details of earthing shunts for FR Tanks	-	2	
12.	Details of floating roof appurtenances, roof stopper and leg supports for floating roof	-	2	
13.	Orientation of floating roof appurtenances, leg supports, plate joints, rolling ladder track etc. for FR Tanks	-	2	
14.	Details of still-wells and Bill of Material	-	2	
15.	Details of heating coil showing coil layout, details of supports and details of pipe joints, including Bill of Material	-	2	
16.	Details of insulation supports	-	2	
17.	Details of Foam System	-	2	

18.	Details of Cooling System	-	2	
19.	Plate cutting diagrams for all free issue material	-	2	
20.	Plate reconciliation statement for free issue material	-	2	
21.	Quality Control Procedure	-	2	
22.	Design calculations for floating roofs for 1) Buoyancy, including tilting for punctured condition, leg supports, bleeder vent, emergency drain & primary drains 2) Deflection of deck and structural integrity of floating roof for annular pontoon type floating roofs. 3) Deflection of deck and stresses in decks for double deck floating roof	-	2	
23.	Material test certificates for plates, pipes and flanges.	-	2	
24.	Welding procedure and welder's qualification reports	-	2	
25.	Radiographic test reports (films to be stored for 5 years)	-	2	
26.	Heat Treatment Report	-	2	
27.	Procedure & Report of Internal Liner / Coating	-	2	
28.	Final Inspection Certificate and hydrostatic test certificate	-	2	
29.	Final as built drawings for information.	-	2	

Note
1. Above drawings shall also include Bill of Material.
2. Items at Sl. No. 1 to 20 & 29 are required for review by EIL.
3. Items at Sl. No. 21 to 28 are required for review by EIL.
4. All drawings shall be drawn in AutoCAD R-14 or above. No hand drawings shall be accepted. All calculations shall be computerized.
5. Documents and letters shall be furnished in electronic format. The software used shall be as follows:
   a) MS OFFICE 2007 OR ABOVE
   b) ADOBE ACROBAT 9.0 OR ABOVE.
6. Number of sets with Bids or after placement of order shall be as per Tender or Requisition

डिएयरेटर (अन-इंजीनियर्ड) के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR DEAERATOR (UN-ENGINEERED)

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	26.03.24	REVISED & REISSUED AS STD. SPEC.	VKY	PG/AK	NK	MN
1	31.08.18	REVISED & REISSUED AS STD. SPEC.	JA	AK	KJH	RKT
0	22.03.13	ISSUED AS STANDARD SPECIFICATION	JA	AK / SKM	AP	DM

Abbreviation: -

AIA	:	Authorized Inspection Agency
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
CIB	:	Chief Inspector of Boiler
CS	:	Carbon Steel
DP	:	Dye Penetrant
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
IS	:	Indian Standard
MP	:	Magnetic Particle
NB	:	Nominal Bore
NDT	:	Non-Destructive Testing
PMS	:	Piping Material Specification
PWHT	:	Post Weld Heat Treatment
SS	:	Stainless Steel
TIG	:	Tungsten Inert Gas
UT	:	Ultrasonic Testing

SMED-I (Mass Transfer Mechanical & Systems) Standards Committee

Convenor: Mr. Nalin Kumar

Members:
Mr. Arun Kumar
Mr. Inder Kumar
Mr. Pankaj Gandhi
Mr. Jeevan Agrawal (Coordinator)
Mr. Vinodkumar Yadav
Mr. Urmilesh Tiwari
Mr. Aasheesh Handa (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agrawal (SCM)

CONTENTS

1.0 INTENT

1.1 This specification covers the general requirements for Process (Hydraulic/Thermal) & Mechanical Design, Engineering, Material procurement including bought out items, Fabrication, Inspection, Testing, Packing, Supply, Supervision during start-up and commissioning activity, PGTR, Process and Mechanical Guarantees of Deaerator comprising of Deaerating Tower along-with Storage Tank complete with internals etc. as required

1.2 Supplementary specification indicating special or additional requirements shall form addenda to this specification and shall govern.

2.0 SCOPE

Scope of work shall be as defined in the Job Specifications attached with Material Requisition /Bid Document. However, minimum scope of work shall be as defined herein unless otherwise indicated in Job Specifications.

2.1 All relevant data required for Process design of Deaerator shall be furnished to vendor in the form of Datasheet/Specification.

2.2 All the activities required to ensure the proper design and operation of Deaerator, whether explicitly stated or not, are implied.

2.3 Carry out the Process design including vessel sizing, vessel arrangement, nozzle sizing, vent sizing, equalizer and downcomer sizing etc. and submit the same in the form of Datasheet.

2.4 Carry out the Mechanical design of vessels and internals including vessel thickness, nozzle schedule, internal thickness/details etc.

2.5 Prepare the detailed General Arrangement Drawings along with part detail/fabrication drawing and bill of material for vessels and internals separately.

2.6 Procurement of Bought-out components, Fabrication, Inspection, Packing, Dispatch etc. Vendor shall get the drawings/documents reviewed/approved as per Vendor Data Requirement from Consultant/Owner prior to start of fabrication.

2.7 Vendor's scope shall also include, but not be limited to the following:

i) Suitable insulation support clips, earthing lugs etc.

ii) Platform and ladder cleats, lifting arrangement, saddle support arrangement etc.

ii) Painting on the exterior surface of Deaerator and storage tank.

iv) Supply of Spares.

v) As-built documentation

2.8 Supervision during erection & commissioning (if applicable).

2.9 Performance Guarantee Test Run (PGTR)

2.10 Vendor shall furnish a single point guarantee for complete Deaerator package. Further, if vendor desires to sub-order Process and/or Mechanical design, it shall be done only through reputed regular designer of Deaerator (or meeting Bidder's Qualification Criteria (BQC), if applicable). Proven Track Record (PTR) of sub-vendor shall be furnished for Consultant/Owner approval.

3.0 REFERENCES

3.1 Applicable codes and standards

The following codes & standards in their latest edition including their addenda at the time of bidding shall form the basis for design, fabrication, inspection testing and acceptance of the equipment:

a)	IBR	:	Indian Boiler Régulations
b)	ASME	:	Unfired Pressure Vessel Section VIII, Division I
		:	Material Specification Section II
		:	Non-Destructive Examination Section V
		:	Welding & Brazing Qualification Section IX
		:	Pipe Flanges & Flanged Fittings B16.5 / B16.47
		:	Metallic Gaskets for Pipe Flanges B16.20
		:	Nonmetallic Flat Gaskets for Pipe Flanges B16.21
		:	Power Boiler Section 1
c)	ANSI	:	American National Standard Institute
d)	ASME B31.3	:	Process piping
e)	ASME PTC 12.3	:	Power Test Code-Deaerator
f)	ASTM	:	ASTM Standards for materials
g)	4500-C02 (1989) C	:	Titrimetric Method for Free Carbon Dioxide
h)	IS	:	Indian Standards
i)	HEI	:	Heat Exchange Institute (Standards and Typical Specification for Deaerator).

3.2 Regulations

National law and regulations together with any local by-laws for the country or state wherever the vessels are to be used must be complied with by the fabricator. Approval of design and drawing from statutory authorities shall be vendor's responsibility.

3.3 In case of conflict, the order of preference shall be as follows:

i) Statutory requirements
ii) Engineering drawing / Datasheet
iii) Specifications
iv) Codes & Standards

As a general rule, the most stringent requirement shall govern.

4.0 DESIGN REQUIREMENTS

4.1 Process (Hydraulic/Thermal) Design

4.1.1 Type of Deaerator shall be as defined in the Process Datasheet.

4.1.2 Deaerator shall be capable of providing deaerated water continuously at any rate defined in Process Datasheet. In case same is not specified in PDS, it shall be taken from 10 to 100 % of the design outlet capacity (which include 10% over design).

4.1.3 The Oxygen concentration of the incoming water shall be calculated assuming the water is fully saturated with air.

4.1.4 Deaerator shall be designed for continuous operation for a service life of 25 years.

4.1.5 The normal operating level shall be upto¾ th of the diameter of storage tank from bottom unless specified otherwise in datasheet. The net storage capacity shall mean the capacity of the tank up to normal water level excluding the volume of all internal below normal level & volume contributed by dished end.

4.1.6 Arrangement for Deaeration tower may be horizontal or vertical.

4.1.7 The Storage vessel shall be sized for minimum 10 minutes retention time between NWL & LWL unless otherwise specified in Process Datasheet. Minimum LWL shall be 300 mm from bottom. The overflow level shall not be closer to the top of the vessel than 85% of diameter.

4.1.8 Deaerated water shall have less than 0.005 cc/litre (7 ppb) of dissolved oxygen and nil carbon dioxide under all operating condition.

4.1.9 Deaerating section & storage section shells shall be connected by downcomer pipes & pressure equalizing pipes. Equalizing connections between Deaerator vessel and storage vessel shall be of adequate size considering transient conditions during turn down to 100% load.

4.1.10 Nozzle sizes shall be as required to meet the velocity criteria and recommendations of HEI.

4.1.11 The Deaerator shall be provided with an internal direct contact type vent condenser, which shall facilitate removal of all non-condensable gases from the Deaerator with min. loss of steam (max. 2%) or as specified in the process datasheet. In addition to normal vent lines, start-up vent with valve and orifice shall be provided to facilitate fast venting of the vessel during start up.

4.1.12 Adequate heating system to be provided for initial heating of the water in storage tank during start-up. Steam consumption calculation for initial heating of the water to be submitted by the vendor.

4.1.13 Feed water storage tank outlet nozzle and drain nozzle to be provided with vertex breaker arrangement.

4.2 Mechanical Design

4.2.1 Deaerator shall be designed for the pressure & temperature as specified on the Datasheet and constructed in accordance with ASME VIII, Div1& IBR (if applicable), applicable Standards and Specifications. Material of construction for various components shall be as indicated in the Data sheet. These are suggested materials and are the minimum acceptable. Use of different material shall be made only after prior written approval. Vendor shall submit comparison of Mechanical and Chemical properties of suggested material. However, vendor is required to guarantee final metallurgy adopted considering operating conditions and nature of service.

4.2.2 Corrosion allowance on all carbon steel components shall be as specified on Datasheets and must be added on each wetted surface of CS internals. Design shall be based on fully corroded condition.

4.2.3 A minimum corrosion allowance of 3.0 mm shall be provided for all carbon steel parts unless otherwise specified.

4.2.4 Spray nozzles, Splash plate, Deaerator trays, Vent condenser and other elements in contact with un-deaerated water or with non-condensable gases shall be of SS-304 (min.) unless otherwise specified in Datasheet.

4.2.5 Manholes of minimum 600 NB size shall be provided on the deaerator and storage vessel for access/maintenance and installation/removal of internals. Minimum one & two manhole shall be provided each on deaerator vessel & storage vessel respectively. Manhole sizes may be increased (if required) to facilitate installation/removal of internals.

4.2.6 Deaerator trays/internals shall be designed to allow easy removal and replacement through manholes.

4.2.7 The Deaerator vessel may contain Spray nozzles or Spray pipes and Tray stacks. Spray nozzles / pipes shall be provided to ensure fine atomization of incoming condensate and rapid heating up by steam.

4.2.8 All vessel and head seams, longitudinal and circumferential, shall be 100% radio-graphed.

4.2.9 Vendor to perform WRC analysis for local stresses developed at the junction of top Saddle (for Deaerator Tower) and Storage Tank arising due to the dead weight of the Deaerator tower (with internals) and the wind/seismic loads, whichever are governing. The nozzle joint between Deaerator Tower and the Storage Tank shall also be analyzed for the local stresses at the junction.

4.2.10 The equipment shall be capable of stable operation without water hammer, surging or vibration and noise under all operating conditions including transients and start-up.

4.2.10 WIND CONSIDERATION

Unless otherwise specified, Wind load shall be calculated on the following basis:

a. Indian Standard - IS: 875 Part-III (latest edition)

b. Minimum force coefficient for cylindrical vessel shall be 0.7.

4.2.11 EARTHQUAKE CONSIDERATION

Unless otherwise specified, Earthquake forces shall be calculated in accordance with Indian Standard IS: 1893 / Site Specific Seismic Spectra (if applicable).

4.2.12 INTERNALS

a) Vendor shall be responsible for supply of all internals to meet the performance specifications as indicated in the Datasheets.

b) The internals must be of robust mechanical design and capable of withstanding thermal, hydraulic and transport shock loads. All internals shall preferably be of removable type to facilitate installation/removal of the same through the vessel manholes.

c) Necessary cleats, supports, stools etc. for the internals shall be welded inside the vessel. The material of construction shall be same as that of the vessel.

d) The internals shall be supplied as pre-installed at shop floor. No installation / site work is envisaged for internals.

e) All inside bolting shall be compatible with the internals metallurgy and shall be of minimum M10 size.

f) Minimum thickness for internal pipe shall be Sch.40S/6 mm for SS pipes and Sch80 / 12 mm for CS pipes.

g) All welded attachments for internals in SS portion shall be min. 6.0 mm thick.

h) All internals, overflow pipes etc. must be installed to prevent vibration.

4.2.13 NOZZLES

i) All nozzle connection shall be suitably reinforced to withstand forces and moments imposed by connecting piping as specified in Standard Specification attached with Material requisition /Bid. If same is not specified, all process nozzles shall be capable of withstanding the piping loads evaluated as below at the intersection of axis of the nozzle with the mid plane of the shell.

a. Effect of the torsional moment and shear forces on the shell may be ignored.

b. Radial force (N)

$$F_R = \pm (20.D^{1.2} + P.D^{0.85})$$

Effect of both positive and negative value of force shall be evaluated.

c. Moment (N.m)

i) For cylinder

$$M_L = M_C = (1.75\ D^{1.4}) + [5.0 \times 10^{-6}\ PD^{2.9}]$$

ii) For sphere

$$M_B = (2 \times M_L)^{0.5}$$

NOTATION

D	=	Nominal diameter of nozzle (mm)
F_R	=	Positive or negative radial force (N)
M_L	=	Longitudinal moment of cylinder (Nm)
M_C	=	Circumferential moment on cylinder (Nm)
P	=	Internal pressure of vessel (bar (g))
M_B	=	Resultant bending moment on the sphere (Nm)

Note: Vendor to perform WRC analysis for all nozzles connected with external piping. Vendor to consider minimum nozzle load as per EIL standard 7-12-0038. However, final piping nozzle loads shall be based on the piping stress analysis.

ii) All nozzle flanges shall be of raised face type. All nozzles including blind flanges up to 600 NB size shall be designed as per ASME B16.5/PMS as applicable. Nozzles including blind flanges above 600 NB shall be designed as per ASME B16.47 series B /PMS as applicable.

iii) All nozzles of size 50 NB & below shall be provided with 2 numbers 40 mm wide x 6 mm thick stiffeners, 90 degrees apart.

iv) Nozzle connections used for vessels shall not be less than 40 NB. However, nozzles with weld overlay shall be 80 NB minimum.

v) All nozzle flanges and Girth flanges shall be forged Weld neck type only.

vi) All nozzles shall be oriented radially. (Tangential nozzles shall preferably be avoided)

vii) All nozzles shall be set-in type, unless otherwise specified in the requisition/bid package.

4.2.14 SUPPORTS

a) Horizontal vessel shall be supported by two welded steel saddle supports.

b) Out of two supports one end shall be fixed and other support shall be free to allow thermal expansion by means of slotted bolt holes. Sliding support shall preferably be provided with low friction pads or as specified in Datasheet/Specifications.

c) Lifting lugs shall be provided for all vessels with diameter exceeding 1000 mm or vessel weight exceeding 5 metric tons. All lifting lugs shall be designed with an impact factor of 2.0 unless otherwise specified and considering 30% wind loads.

4.2.15 DESIGN REQUIREMENTS FOR DEAERATOR UNDER THE PURVIEW OF IBR (IF APPLICABLE)

a) Vendor shall carry out design calculations as per IBR and only in case of any doubt refer the same to Consultant/Owner for clarifications. All materials, fabrication, welding, testing etc. shall meet the requirements of IBR.

b) In case the equipment is manufactured in India, the design calculations and fabrication drawings after review of Consultant/Owner shall be got approved by Vendor from CIB of the State where Vendor's shop is located prior to start of fabrication and in parallel from CIB of state of installation.

When installation is not in Vendor's scope, Vendor shall also provide the necessary assistance to Owner for obtaining approval from CIB of state of installation, such as providing additional copies of calculations and drawings etc. as required by CIB of that State.

c) In case the equipment is manufactured outside India, the design calculations and fabrication drawings after preliminary review by Consultant /Owner shall be got approved by Vendor from the agency authorized by IBR in the country of fabrication and the CIB of the State where the equipment is to be installed, before the start of fabrication.

d) It shall be the responsibility of Vendor to incorporate modifications or additions required by CIB or its authorized agency and obtain the final approval. Consultant / Owner shall be kept informed and their concurrence obtained before any revision about these. All costs towards approval from CIB shall be borne by Vendor. All IBR approved design calculations and drawings shall be furnished to Consultant / Owner for final review of fabrication drawings and in equipment dossier.

5.0 MATERIALS

5.1 All materials used for fabrication shall be new & of first quality.

5.2 Carbon steel wherever specified shall conform to SA 516. Only normalized plates free from injurious defects with workman like finish shall be used. Reconditioning / repairs of plates by welding shall not be permitted. All components coming in contact with wet oxygen shall conform to SS304 (min). Further, wherever Stainless Steel is specified in the Datasheets, low carbon ("L" grade) stainless Steel shall be adopted for welded components.

5.3 Use of SA 515 material is not permitted.

5.4 Hubbed forgings (Weld Neck Flanges) shall have hubbed portion formed by forging processes. Weld neck flanges only shall be used. These shall conform to SA 105 / SA 266 for CS portion and SA 182 for SS portion. All forgings (SA 105/SA 266) above 75 mm thickness shall be ultrasonic tested as per ASTM A-388.

5.5 Pressure part plates having thickness 16 mm to 50 mm (both inclusive) shall be examined ultrasonically as per specification SA-435. For thickness above 50 mm, ultrasonic examination shall be carried out as per specification SA 578 and shall have acceptance standard of Level B.

5.6 Clad plates used for fabrication of vessel shall conform to SA263 or SA264 of ASME Boiler and Pressure Vessel Code Section II Part A.

5.7 SS (300 series) plates shall be hot rolled and shall have No.1 finish on both sides. Cold rolled plates, if permitted by requisition, shall have No. 2B finish. SS (300 series) materials for all components including non-pressure parts shall be procured with the IGC test as per ASTM A-262 (test shall be carried out, after the specified heat treatment and sensitization per specification) with acceptable corrosion rate and ensuring that Specimen after exposure shall be bent as per requirements mentioned in A262 Practice E and shall be inspected under magnification of 200 X. The bent specimen shall be free of any cracks or grain dropping. The microstructure shall be submitted to AIA for review/approval.

5.8 Nozzle flange face finish, bolts, nuts and gaskets used for flange joints on vessel shall be as per applicable piping class (PMS). Internal bolting and gaskets for standard flanges shall be SS304 (min) and spiral wound respectively. However, for plate flanges suitable full face gaskets shall be provided.

5.9 Nozzle necks, pipes and fittings shall be seamless. However, for non-pressure parts / internals ERW/Fabricated pipes and fittings are also acceptable.

5.10 All external bolts shall be stud bolts threaded to full length, each with two hexagonal nuts.

5.11 MOC for all non-pressure parts welded to pressure parts shall be same as the MOC for pressure parts.

5.12 Material shall be strictly as per datasheets. However, incase CS is specified, following material shall be adopted:

SA 516 Gr 60 / 70	-	Shell, Reinforcement Pads, Wear Plates, Lifting lugs, Nozzle Necks (if fabricated from plates), any other component directly welded to shell.
SA 105	-	Nozzle flanges & Blind flanges.
SA 266	-	Girth flange

SA 106 Gr B	-	Nozzle pipes/Piping
SA 193 B7 & SA 194 2H	-	Studs & nuts (External)
SA 193 B8 & SA 194 Gr 8		Bolts & nuts (Internal)
IS 2062 E250 Gr B / SA 283 Gr C	-	Saddle supports, supporting structure, etc.
SA 234 Gr WPB	-	Standard Fitting

6.0 FABRICATION

6.1 All pressure bearing butt weld shall be full penetration, double welded joints. When second side welding is not possible due to inaccessibility, single sided butt weld joints with root run by TIG may be used to ensure full penetration. The inside seam weld, if possible, shall be ground smooth. Nozzles, manways and their reinforcement pads shall be attached to vessel with full penetration welds. All weld seams shall be clear of nozzles, manholes and stiffening rings etc.

6.2 No. of weld seams shall be kept minimum. L-seams shall be restricted to one (1.0) number for every 2.0 meter diameter or part thereof.

6.3 Head / Dished Ends

6.3.1 Dished ends shall preferably be of seamless construction. However, dished ends with one chordal weld seam are acceptable. In such cases, the width of chordal plate shall not be less than one third of the blank diameter and chordal seam shall clear nozzle opening and such weld seams of formed ends shall be subjected to 100% radiography after forming.

6.3.2 Whenever, a dished end is made of more than two plates, it must have a seamless crown plate. Whenever a nozzle or a manhole is positioned at the center of the dished end, the crown plate should be larger than the nozzle/manhole reinforcing pad.

6.3.3 Wherever hot forming and subsequent heat treatment is involved, adopted procedure shall not impair the mechanical properties of the material beyond the limits specified in respective material specification.

6.3.4 Intermediate heat treatment, if considered necessary, shall be carried out by the vendor. Dished ends shall be torispherical (Knuckle radius 15% of outside diameter and crown radius 80% of outside diameter) or 2:1 ellipsoidal.

6.4 All flange bolts shall straddle principal centerline.

6.5 All nozzles to shell welds (Root and Final run) shall be examined by MP/ DP Test.

6.6 Pickling and passivation of stainless steel (SS) clad surfaces and internal / external surface of SS internals shall be carried out as per ASTM A-380.

6.7 Vendor shall submit Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) to AIA or authorized representative for approval as per ASME Boiler and Pressure Vessel Code Section IX or IBR (as applicable). Welding consumables shall be as per ASME Boiler and Pressure Vessel Code Sec II Part C and shall be indicated in fabrication drawings. For CS pressure parts, the electrode shall be of low hydrogen type. Welding shall not commence unless the concerned procedures are approved. Only welders who are qualified in the accepted procedure shall be employed for welding.

7.0 RADIOGRAPHY AND OTHER NDT REQUIREMENTS

7.1 All the NDT procedures shall be submitted to AIA for approval. For all NDT activities, only qualified NDT personnel/technicians shall be deployed with the approval of AIA.

7.2 The extent of radiography shall be as specified in datasheets or drawings or job specification. In no case shall the radiographic examination be less than that specified in the code. However, spot radiography is the minimum requirement. When spot radiography is specified, at least 5% of the total weld length excluding T joints shall be radiographed. Further, all 'T' joints shall be radiographed. This requirement shall supplement the ones specified in ASME Sec. VIII Div. I.

7.3 The specified radiography of welds may be performed before or after PWHT. If performed before PWHT, an additional radiography or alternatively, UT shall be performed after PWHT.

7.4 Full radiography when specified shall imply 100% radiography of all butt welds.

7.5 All full penetration welds, which cannot be subjected to radiographic testing, shall be subjected to UT. However, MP or DP examination or both at the discretion of the AIA shall be carried out if UT also cannot be performed.

7.6 All nozzles fabricated from plate, irrespective of thickness of plate, shall be 100% radiographed.

7.7 All attachment welds shall be either DP or MP tested.

7.8 Acceptance standards for radiography shall be as per ASME Sec. VIII Div. I or IBR as applicable unless stated otherwise.

8.0 HEAT TREATMENT REQUIREMENTS

All CS welds of Deaerator are required to be PWHT mandatorily. Deaerator shall be post weld heat treated in accordance with ASME code. No welding or heating is permitted after PWHT operation. Hardness of welds not to exceed 200 BHN. Vendor shall submit all the procedures for PWHT for approval.

9.0 SPARES

9.1 Mandatory Spares

a) Vendor shall supply 20% extra studs and nuts but not less than 4 studs with 8 nuts for each pair of mating flanges, interconnecting nozzles, nozzles with blind flanges etc.

b) Vendor shall supply 400% of spare gaskets other than those used for testing and/or during transportation.

c) 25% Spray Nozzles (subject to minimum 5 Nos. of each type & size)

d) 10% Random Packing (if applicable)

e) 10% Bolts/Nuts and Clamp Assemblies for internals (minimum 10 nos. of each size)

f) 100% Gaskets or Tapes for internals and internal flanges (each type and size)

9.2 Erection & Commissioning Spares

For activities to be carried out at site during erection, following erection & commissioning spares shall be supplied by the vendor:

a) Vendor shall supply 20% extra studs and nuts but not less than 4 studs with 8 nuts for each pair of mating flanges, interconnecting nozzles, nozzles with blind flanges etc.

b) 10% Bolts/Nuts and Clamp Assemblies for internals (minimum 10 nos. of each size)

c) 100% Gaskets or Tapes for internals and internal flanges (each type and size)

9.3 All spare parts furnished by vendor shall be wrapped and packaged so that they will be preserved in original as-new condition under the normal conditions of storage to be anticipated and shall be properly tagged and coded so that later identification as to intended equipment usage will be facilitated. They shall be packaged separately, clearly marked as "Spare Parts" and shipped at the same time as the equipment. Packing lists shall be furnished so that the parts can be handled without uncrating if desired.

9.4 Vendor shall provide one sets of special tools & tackles (if required) for operation and maintenance of furnished equipment.

10.0 INSPECTION AND TESTING

10.1 The inspection of all the items for the Deaerator shall be carried out by AIA (Stage-wise and Final).

10.2 The materials, fabrication and testing of Deaerator shall be open for inspection by AIA in addition to any inspection required by the specified code or by local authorities having jurisdiction over the installation.

10.3 Inspection by AIA shall not modify or reduce the obligation of the vendor to carry out his own tests and control. Should any material and/or equipment be found not in compliance with the requirements specified, the authorized inspectors or their delegates shall be entitled to irrevocably reject them, even if such non-compliance has not been evidenced in the course of inspection and/or tests.

10.4 The authorized inspector will, at the time of his initial visit, set up with the Vendor actual details of inspection stages to be witnessed or carried out; the schedule of further visits and subsequent inspection notices can be arranged between the inspector and the Vendor.

10.5 The Vendor shall notify the authorized inspector sufficiently in advance of any fabricating operations to permit him to arrive at the vendor's shop in time to witness the operations.

10.6 The Vendor shall provide to the authorized inspector, free access to his shops at all times. He shall also supply all tools and tackles to the authorized inspector for carrying out the inspection. The Vendor shall also arrange for similar facilities at his sub-vendor's shops.

10.7 The Vendor must satisfy the authorized inspector that the welding procedures, welders, electrodes, fluxes, welding wires etc. are in accordance with the requirements of the relevant codes. Further the welder's qualification tests must be carried out in the presence of the authorized inspector.

10.8 Prior to final inspection, all slag, weld spatter, loose scale, dirt, grit, paint, grease, oil and other foreign matters shall be removed in order to facilitate inspection. All reinforcing pads shall be pressure tested with air and soap solution before and after heat treatment and before final hydrostatic test.

10.9 A dimensional checking of equipment shall be carried out taking into account the tolerances shown on design specifications or applicable codes. The more stringent values shall govern. Dimensional checks are to be taken of the internal measurements of equipment together with external ones and these are to be recorded on a copy of the drawings as being the "As Built" dimensions.

10.10 Inspection and test requirements shall be as per Inspection and test plan enclosed with the specification.

10.11 Hydro Test

Vessel shall be hydro tested to pressures indicated as per codes and standards after complete fabrication and PWHT. The hydro test shall be held for 1-hour minimum. Though, Deaerator and Storage tank are to be transported to site separately, Vendor shall carry out Hydro-test in fully assembled condition at vendor's work before dispatch to site.

The Authorized Inspector shall witness Hydro-test. When Hydro-test is performed, the indicating gauge shall be connected to the upper most part of the equipment. Clean and fresh (Potable) water shall be used for testing. However, for SS lined or SS vessel, water used shall not contain more than 25 ppm chlorides. The temperature of testing medium shall preferably not be less than 16°C. After Hydro-testing, Deaerator shall be thoroughly dried by blowing dry air. During Hydro-test, care shall be taken to avoid local stresses in shell from exceeding 90% of the yield strength of the material at the temporary saddle supports.

10.12 Performance Test

a. A performance test of the Deaerator shall be conducted, within one (1) year from initial on-stream date. If the Deaerator has been in operation for a period of more than ninety (90) days, and the vendor believes that certain equipment require maintenance prior to the performance test, such maintenance will be performed by vendor.

b. Test Method for determination of O_2 content shall be ASME PTC 12.3 and Test Method for determination of nil CO_2 shall be Trimetric method.

c. The performance testing shall be done after plant stabilization for 2 hours at the design or at maximum operating load case or any intermediate load (load ranging between 10% to 100% design outlet capacity) as decided by Client. Performance requirements are as specified in Process Datasheets. Results of the performance test evaluation, including test samples and operational data along with necessary engineering calculation shall be used to determine if the system meets guarantee requirements as specified in Process Datasheet. All necessary apparatus, tools & tackles etc. for carrying out Performance Guarantee Test Run (PGTR) shall be arranged by vendor at his own cost.

Vendor to demonstrate performance parameters as specified in the Process Datasheet. In case performance could not be achieved, vendor shall modify the components of Deaerator and supply all items "free of cost" which are required to meet performance guarantees. Maximum time limit to complete this activity to full satisfaction of Client shall be 90 days from start of PGTR. In case of non-compliance, it shall amount to rejection.

11.0 PACKING AND DESPATCH

11.1 After inspection and testing at vendor shop, Deaerator shall be suitably packed for transportation. It is vendor's responsibility to ensure that the Deaerator vessel & storage vessel dispatched are complete in all respect and ready for erection at site.

11.2 Vessel shall be suitably anchored to avoid damage during transportation. All flanges shall be blanked with steel plates and gasket, to avoid damage of gasket face.

11.3 Vendor shall furnish preservation procedure taking care of all stages (i.e. Pre-installation, Transportation, Erection and up to Commissioning).

12.0 GUARANTEE

12.1 Vendor shall have total responsibility for the process/thermal design, mechanical design, selection of materials, quality of materials, fabrication and performance of complete Deaerator in accordance with the specification. This guarantee shall also include sub-ordered/bought out items forming part of the total supplies.

12.2 The guarantee period and financial liabilities of the Vendor shall be as per Owner's commercial terms and conditions or General Purchase Conditions (GPC) enclosed elsewhere.

13.0 VENDOR DATA REQUIREMENT

Vendor shall submit Process and Mechanical Design Calculation, General Arrangement Drawings, Fabrication Drawings etc. for Consultant/Owner review/approval. However, review of these documents shall not relieve the Vendor of his responsibility in any manner. Design Calculation, GAD's, Fabrication Drawings and other documents shall be submitted in accordance with the Requisition / Bid document.

हीट एक्सचेंजर्स के लिए
सामान्य विनिर्देश

GENERAL SPECIFICATION
FOR
HEAT EXCHANGERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	26-04-2024	REVISED & REISSUED AS SPECIFICATION	MKP	TKh	KA/NK	MN
5	19-09-2018	REVISED & REISSUED AS SPECIFICATION	SK	KA	KJH	RKT
4	11-06-2010	REVISED & REISSUED AS SPECIFICATION	KA	RKT	AKM/DM	ND
3	12-01-2006	REVISED & REISSUED AS SPECIFICATION	KA	PK	AKM	VJN
2	10-12-1999	REVISED & REISSUED AS SPECIFICATION	HN	PK	RKA	AS

Abbreviations:

ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BHN	Brinell Hardness Number
BTD	Bolt Tensioning Device
BV	Bureau Veritas
CIB	Chief Inspector of Boilers
CS	Carbon Steel
DIA	Designated Inspection Agency
DNV	Det Norske Veritas
DP	Dye Penetrant
FPW	Full Penetration Weld
GPC	General Purchase Condition
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
IBR	Indian Boiler Regulation
ID	Inside Diameter
IGC	Inter Granular Cracking
IS	Indian Standards
LAS	Low Alloy Steel
LTCS	Low Temperature Carbon Steel
MDMT	Minimum Design Metal Temperature
MP	Magnetic Particle
NB	Nominal Bore
NDT	Non-Destructive Testing
PO	Purchase Order
ppm	parts per million
PTC	Production Test Coupons
PWHT	Post Weld Heat Treatment
QAP	Quality Assurance Plan
SS	Stainless Steel
TEMA	Tubular Exchangers Manufacturers' Association
UT	Ultrasonically Tested
UTS	Ultimate Tensile Strength

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar
Co-Convenor: Mr. K. Anjaneyulu

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Mr. Tarun Khurana (Coordinator)
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Mr. Avdhesh Agrawal (SCM-Inspection)

1.0 GENERAL

1.1 Scope

This specification covers the requirements for residual design, engineering, materials, fabrication, workmanship, inspection and testing of shell and tube heat exchangers and is intended to supplement the requirements of the applicable Codes. EIL specifications and standards wherever indicated in the requisition shall be followed unless stated otherwise.

This specification shall not be considered limiting and it shall be Supplier's responsibility to comply with all requirements of requisition or bid documents to which it is annexed.

1.2 References

1.2.1 CODES AND REGULATIONS

The following Codes in their edition referenced in drawings or data sheets or design basis along with the other specifications enclosed with the requisition shall form the basis for design, materials, fabrication, inspection, testing and acceptance of the equipment:

(a) ASME Boiler and Pressure Vessel Code Section VIII Division I (Code), ASME Section II Part A, B, C and D, ASME Section V, ASME Section IX.

(b) TEMA (Class as specified on the drawings or data sheets or design basis).

(c) IBR, if applicable (latest edition with amendments up to date).

(d) National and local laws or regulations, as applicable.

1.2.2 FOR HEAT EXCHANGERS UNDER THE PURVIEW OF IBR:

(a) Supplier shall carry out design calculations as per IBR and only in case of any doubt refer the same to Owner and EIL for clarifications. All materials, fabrication, welding, testing etc. shall meet the requirements of IBR.

(b) In case the equipment is manufactured in India, the design calculations and fabrication drawings after preliminary review of Owner and EIL shall be got approved by Supplier from CIB of the State where Supplier's shop is located, prior to start of fabrication. Supplier shall also provide the necessary assistance to Owner for obtaining approval from CIB of State of installation, such as providing additional copies of calculations and drawings etc. as required by CIB of that State.

(c) In case the equipment is manufactured outside India, the design calculations and fabrication drawings after preliminary review by Owner and EIL shall be got approved by Supplier from the agency authorised by IBR in the country of fabrication and the CIB of the State where the equipment is to be installed, before the start of fabrication.

(d) It shall be the responsibility of Supplier to incorporate modifications or additions required by CIB or its authorised agency and obtain the final approval. Owner and EIL shall be kept informed about these. All costs towards approval from CIB shall be borne by Supplier. All IBR approved design calculations and drawings shall be furnished to EIL for final review of fabrication drawings and in equipment dossier.

1.3 Deviations

In general, no deviations from datasheets, drawings, standards, specifications and requisition shall be permitted.

Generally, no deviations shall be entertained after the Supplier has accepted the order unless it is to comply with statutory or Code requirements. All waivers and deviations after order shall be routed through the Regional Procurement or Inspection Office In charge in the prescribed format. Delay in supply of the equipment because of such deviations being not entertained or approved by Owner or EIL or any delay in processing the same by Owner or EIL shall be to Supplier's account. Any additional design work in support of such a deviation shall be performed by the Supplier and submitted along with the deviation.

1.4 Contradictory Requirements

In case of any contradiction between the requirements of the requisition, drawings and other documents forming part of the requisition, Supplier shall resolve the matter in consultation with Owner or EIL. Decision of Owner or EIL shall be binding and without any implication of cost and time, if not resolved at bidding stage.

2.0 MATERIAL SPECIFICATION

2.1 General

2.1.1 All materials used for fabrication shall be new and of first quality. All materials and accessories required for the fabrication, inspection, testing etc. of the heat exchanger shall be supplied by the Supplier unless otherwise stated. Whenever some material is to be supplied by the Owner, this shall be so indicated as Free Issue Material and the supplementary specifications in this regard shall be complied with.

2.1.2 In addition to the requirements of materials as per material specifications, materials shall also meet the requirements mentioned in this specification and other specifications enclosed with the requisition. All materials shall be certified for compliance with IBR requirements for the item(s) so specified. While procuring materials, Supplier shall stipulate additional requirements such as limits on hardness, UTS, yield strength, chemical composition, heat treatment and any other specific requirements to ensure that final requirement as per specification and Code are met with.

All materials for pressure parts and parts welded to pressure parts including materials in the scope of sub-suppliers, shall be accompanied with mill test certificates duly certified by a reputed third-party inspection agency. In the absence of mill test certificate the material shall be got tested from a reputed third-party inspection agency like CEIL, Lloyds, BV, DNV etc. and test results shall be submitted in lieu of mill test certificate. All cost towards such testing and inspection shall be borne by the Supplier. All materials shall be inspected at Supplier and sub-supplier's shop for verification prior to use on the job. The decision of DIA to accept or reject materials on the basis of such testing shall be final.

2.1.3 Wherever simulated heat treatment of test specimens is required as per Code or specification, the simulation cycle shall include one extra cycle of stress relieving for any eventuality of repair at site by Owner during the life of the equipment.

2.1.4 MDMT shall be taken as 0 °C or the design temperature specified in drawing or datasheet whichever is lower, unless specified otherwise in design basis or datasheets or drawings. For low temperature service (0°C and colder), unless exempted by ASME Section VIII, Div. 1, Paragraph UG-20 (f) and Paragraph UCS-66, all Carbon & Low Alloy Steel materials (for pressure parts and attachments to pressure parts) shall be impact tested at the MDMT or colder and meet requirements of ASME, Section VIII, Division 1, Paragraph UG-84.

2.1.5 PLATES

2.1.5.1 Pressure parts having thickness 16 to 50 mm (both inclusive) shall be UT as per SA-435.

2.1.5.2 Pressure parts having thickness >50 mm shall be UT as per ASME SA-578 Level B.

2.1.5.3 Reconditioning, repair of plates by welding shall not be permitted. Surface conditions shall meet requirements of EN 10163 (Part: 2) Class A Subclass 3.

2.1.6 TUBES

2.1.6.1 All the tubes shall be seamless and cold drawn.

2.1.6.2 Product analysis of tubes shall be carried out and reported in the material test certificates.

2.1.6.3 Tubes shall be in fully heat-treated condition as received from the mill. CS tubes shall be in annealed condition and copper alloy tubes shall be in annealed temper condition. LAS tubes shall be supplied in normalized and tempered condition.

2.1.6.4 All unstabilized SS tubes shall be supplied in the solution annealed condition and all stabilised grades of SS such as SS 321 and SS 347 shall be supplied in stabilization heat treated condition, in addition to solution annealing.

2.1.6.5 It is preferable while ordering tubes the maximum yield strength and hardness of tubes are specified such as to be lower than those of tube sheet, in order to achieve a sound expanded tube to tube sheet joint, complying with Code requirements.

2.1.6.6 "Air under water" testing shall be carried out for all tubes except non-ferrous tubes. As an alternative, tubes can be hydro tested. In case the tubes are hydro tested, hydro test pressure of tubes shall be higher of tube side test pressure or as required by Code. Water quality shall be as per Para 7.2.1 of this specification.

2.1.6.7 For requirements of U tubes refer EIL specification 6-15-0006.

2.1.7 FORGINGS

Forgings manufactured to SA-105 and SA-266 above 75 mm thickness (thickness as defined in para 3.2.9 of ASME Sec. VIII Division 2), all tube sheet forgings and all forgings of other materials, except for the standard nozzle flanges up to 8" NB and small forgings (of couplings, plugs and eye bolts) shall be 100% UT as per SA-388. Acceptance criteria shall be as per para 3.3.4 of ASME Section VIII Division 2.

2.1.8 PIPES

Dimensions and tolerances shall be in accordance with ASME 36.10 or ASME 36.19, as applicable, as per material specification.

2.2 Specific material requirements (Pressure parts and parts welded to pressure parts)

2.2.1 CS AND LTCS MATERIALS

(a) Carbon content shall not exceed 0.23%.

(b) All plates shall be in normalized condition.

(c) Use of SA 515 of any grade is not permitted.

(d) Plates > 50mm thickness shall meet following additional requirements of SA-20:

(i) Vacuum treatment as per the supplementary requirement S1. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

(ii) Charpy V-notch test as per supplementary requirement S5 of specification SA-20. Material meant to be used for design temperatures warmer than 0°C, impact test shall be carried out at 0°C or MDMT whichever is lower and acceptance criteria for energy absorption shall be as per Table A2.15 of SA-20. Incase acceptance criteria is not available in SA-20, then applicable design code shall be referred unless otherwise specified in requisition. Orientation of test bar shall be transverse to rolling direction.

e) Unless specified otherwise in requisition or bid document, all CS materials specified as HIC tested shall meet the requirements of specification: 6-79-0012 or 6-79-0013 (as applicable).

(f) All LTCS and CS charpy plate material shall be made to fine grain practice and the primary austenitic grain size shall be measured and reported in mill test certificates.

(g) CS pipes shall be SA-106 Gr. B for MDMT greater than – 29 °C, unless otherwise specified. For MDMT less than and equal to – 29 °C, CS pipes shall be SA 333 Gr. 1 or 6.

(h) Non-standard forgings (SA 266, SA 350 etc.) shall be normalized and tempered.

2.2.2 LAS MATERIALS

a) All LAS plates, pipes, forgings and fittings shall be in normalised and tempered condition. Use of C-½ Mo material is prohibited. All LAS materials shall be charpy V-notch impact tested. Test temperatures shall be lowest of minimum ambient temperature, design temperature, MDMT and –18°C (0 °C instead of –18 °C for 5Cr-1/2Mo materials). Impact energy values as per UG-84 or applicable specification, whichever is higher.

b) Accelerated cooling from an austenitizing temperature by liquid quenching followed by tempering (N + ACC. + T) is also acceptable for plates. Irrespective of thickness, LAS plates shall meet the requirements of API RP 934 (part as applicable).

c) In the case of 1¼ Cr-½ Mo and 2¼ Cr- 1 Mo materials and weldments, the maximum room temperature tensile strength for all pressure containing components, materials and welds shall be 100000 psi.

d) For LAS tubes (SA 209 and 213) hardness test shall be performed on outside of the tubes as per SA-450.

e) For LAS plates > 50 mm thickness, vacuum treatment as per supplementary requirement S1 of SA 20. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

2.2.3 SS AND OTHER HIGH ALLOY MATERIAL

a) All SS material (300 series) shall be in the solution heat-treated (fully annealed) and pickled condition. All stabilised grades of SS (SS 321, SS 347 etc.) shall be given stabilisation heat treatment, in addition to solution annealing. For all stabilized grades of stainless-steel materials soaking temperatures for stabilization heat treatment shall be 915°C + 10°C and soaking period shall be minimum of 4 hours (2 hours for thickness ≤ 3.5mm).

b) SS (300 series) plates shall be hot rolled and shall have No.1 finish on both sides. Cold rolled plates, if permitted by requisition, shall have No. 2B finish.

c) SS (300 series) materials for all components including non-pressure parts like baffles, tie rods, etc. shall be procured with the IGC test as per ASTM A-262 (test shall be carried out, after the specified heat treatment and sensitisation per specification) with acceptable corrosion rate and practices as under:

i) For all services except nitric acid service, Practice E shall be followed. Specimen after exposure shall be bent as per requirements mentioned in A262 Practice E and shall be inspected under magnification of 200X. The bent specimen shall be free of any cracks or grain dropping. The microstructure shall be submitted to DIA for approval.

ii) Nitric acid service - Practice C corrosion rate <635 micro-m per annum.

(d) For straight chrome (13% Cr.) material, maximum carbon content shall be < 0.06%. Hardness of UNS no. S41000, S41008 and S40500 shall be ≤241 BHN.

2.2.4 NON-FERROUS MATERIALS

(a) All copper based non-ferrous plates shall be procured in annealed condition.

(b) Plates for pressure parts shall be 100% UT. Supplier shall submit the procedure for UT to DIA for approval.

(c) In addition to hydro test, all tubes shall be eddy current tested in their final annealed condition.

(d) All pipe bends shall be stress relief annealed after bending.

(e) The paragraphs NF7 and NF14 in part UNF of Code are mandatory. This applies to non-ferrous cladding and weld overlay also.

2.2.5 CLAD MATERIALS

(a) Cladding shall be integrally and continuously bonded to the base metal. All clad plates shall be rolled-on or explosion bonded type.

(b) Clad plates shall be UT from the cladding surface as per SA-578. Scanning shall be 100% of the plate surface. Acceptance standard shall be level B. Clad plates shall meet the supplementary requirements of S1 of SA-578 and Integrity of clad plate shall be ensured Quality level: class-1 as per SA 263 or SA 264 or SA 265. All UT shall be undertaken after specified heat treatment of clad plates.

(c) Both base material and clad material shall meet the specification of the respective materials as stipulated in this specification.

(d) Alloy clad steel plates shall be as per SA 263 or SA 264 or SA 265. Bond between cladding and the base metal shall be checked for a minimum strength of 14 kg/mm^2 in shear for alloy clad steel plates, by conducting shear test as per applicable material specification.

(e) For copper alloy clad plates, the bond between cladding and base metal shall be checked for a minimum strength of 10 kg/mm^2 in shear by conducting shear test.

(f) During tension test of clad plates, the cladding shall be removed and the tensile properties of the base material shall meet the Code material requirements.

(g) For austenitic SS clad plates, the SS surface shall be acid pickled as per ASTM A-380. For chromium steel clad surfaces, the pickling shall be as per Supplier's established procedure. The same shall be submitted to Owner or EIL for approval.

(h) For clad components, Supplier to ensure that plate thickness after bonding and machining shall not be less than the thickness specified in drawings. Supplier to consider sufficient margin on clad and base materials so that thickness after machining and complete fabrication shall be as per the drawings. For nozzle necks with weld deposit, sufficient margin on ID shall be taken to allow for shrinkage

2.3 Non pressure parts

2.3.1 CS plates shall be minimum IS-2062 or SA 283 Gr. C or equivalent. Pipes shall be to IS 1239 or SA 53 or equivalent.

2.3.2 Saddle material shall be same as that of shell for shell design temperature > 350°C and for shell design temperature less than 0°C.

2.4 Equivalent materials

The materials for various components in a heat exchanger shall be as per Owner or EIL's requirement. This does not preclude use of equivalent or better materials. However, these deviations should be clearly indicated in the prescribed format. If an equivalent material sought by the Supplier is to a specification, other than IS or ASTM or ASME, it is necessary for the Supplier to submit the specifications of the equivalent material with complete details in English for approval.

3.0 SUPPLY

Supply shall be in accordance with requisition or bid document to which this specification is attached. It shall, however, include the following also:

3.1 Test Ring Assembly, Dummy Shell and Test Flange

a. Test ring assemblies, dummy shells and test flanges wherever required shall be designed and supplied by the Supplier. The stresses shall not exceed 90% of the minimum yield stress of the material as stipulated in material specification. Material used for fabricating these shall be of tested quality. For removable bundle with tube side test pressure higher than shell side, the bundle shall be tested outside the shell, with tube side pressurised for tube side test pressure to check tube to tube sheet joint leakage from the back of tube sheet. Test flange shall be designed accordingly.

b. Test ring assembly construction shall be stuffing box type as per fig. E-4.1.3-2 of TEMA. It is preferred that the test ring flange thickness not exceed the shell cover flange thickness, Otherwise, Supplier to provide separate bolting for assembling test ring flange to shell. Similarly, Supplier to check that the studs for stationary tube sheet bolting can be used with test flange. Else separate bolting shall be provided for assembling test flange.

c. For "U" type of floating head exchanger necessary washers, bolts and nuts for sealing of bolt holes in tube sheet to be provided during hydro test.

3.2 Accessories for Testing

All necessary accessories such as supports, blind flanges, test gaskets, bolts, nuts etc. shall be provided and supplied by the Supplier for testing of heat exchangers, in Supplier's shop and for subsequent testing

by Owner at site, whenever required.

3.3 Other Accessories

3.3.1 Supplier shall also supply tie bolts, leveling shims or intermediate supports for stacked units. In case the stacked units are transported separately, the leveling shims required for matching the nozzles shall be tack welded to the saddles and shall not be supplied loose to avoid misplacement during transit and at site. Gaskets, nuts and bolts for interconnecting nozzles (both tube and shell side) along with spares shall be supplied by Supplier. All these components shall be despatched separately with due care having been taken regarding identification of these for ease of installation.

3.3.2 Earthing lugs shall be provided on each heat exchanger and shall be located in such a way as to avoid any fouling with the exchanger foundation bolts at site.

3.3.3 Supplier to supply one set of torque wrenches for bolt size M45 (1¾") to M56 (2¼") and one BTD for bolt sizes greater than M56 (2¼"), in case these bolt sizes are being used in exchangers covered in the requisition. BTD capacity shall be 40% more than the maximum load required for hydro test condition. BTD pump shall be pneumatically and manually driven. Supplier shall supply one pump unit, required load cells, 4 heads of each size, one set of flexible high pressure main hose to connect the pump unit to loading cells, hoses common for all bolt sizes and spares as recommended by the BTD supplier. Torque values for tightening the bolts shall be mentioned in the fabrication drawings. For all studs requiring tightening by bolt tensioner, length of studs shall be longer by "one diameter / as recommended by BTD Supplier". All bolt tensioners must be satisfactorily used/demonstrated during assembly/disassembly and hydrotest at shop before dispatch.

3.3.4 Davits, if required as per design basis or drawings, shall be provided.

3.3.5 Additions like cleats for piping, ladder, platform, insulation etc. that may be required at a later stage shall be provided.

3.4 Cathodic Protection

Whenever cathodic protection is specified both sacrificial anodes and internal painting shall be provided. Separate specifications shall be provided in the requisition.

3.5 Spares to be supplied by Supplier

Following spares shall be supplied by Supplier unless otherwise specified in the Requisition:

3.5.1 BOLTING: 20% studs and nuts but not less than 4 studs with 8 nuts for each joint.

3.5.2 GASKET: 400% gaskets other than those used for hydro testing and despatch for each joint.

3.5.3 Spare bolting and gaskets shall be provided for all joints of girth flanges, floating head, channel cover, tube sheet, interconnecting nozzles, nozzles with blind flange etc.

4.0 FABRICATION

4.1 Edge Preparation

4.1.1 For CS, the edges for welding shall be made by machining, chipping, cold shearing, oxy-acetylene flame cutting or a combination of these. Chipping or cold shearing shall be followed by grinding to a smooth and regular surface. Oxy-acetylene flame cutting shall be followed by machining or grinding to eliminate any discoloration of material affected.

4.1.2 For LAS, the edges for welding shall be made by oxy-acetylene flame cutting or by machining. Cold shearing may be used for cutting thickness up to 10 mm. Oxy-acetylene flame cutting shall be used with preheat and shall be followed by machining or grinding to eliminate any discoloration of material affected.

4.1.3 For austenitic SS, the edges for welding shall be made by plasma arc, however, cold shearing may be adopted for thickness up to 15 mm. In all cases the cut edges shall be ground back or machined back by 2 to 3 mm.

4.1.4 All welding edges after cutting shall be DP or MP examined for laminations, cracks or segregation. Additionally, UT shall be carried out within, two times the material thickness of edge for LAS materials

or five times the material thickness of edge for materials when the service is low temperature or hydrogen or HIC.

4.1.5 The paragraphs NF7 and NF14 in part UNF of Code are mandatory. This applies to non-ferrous cladding and weld overlay also.

4.2 Rolling and Dishing of Plates

4.2.1 ROLLING

Rolling for bending and forming of plates shall be in the longitudinal direction of the plates. This direction shall be clearly marked on the plates.

Rerolling after welding is not normally recommended. However, if for large diameter shells, rerolling of welded shell course is inevitable, procedure for rerolling along with extent of NDT shall be submitted for approval of the DIA. All welds on the section to be rerolled must be ground flush. After rerolling all the welds on the re-rolled section must be DP checked. Such welds shall then be subjected to radiography as required by drawings and Code.

4.2.2 DISHING

All dished heads shall preferably be of single piece construction. However dished ends with one chordal seam are acceptable for shells with diameter greater than 1 m. In such cases, the chordal seam shall preferably be in the middle one-third of the blank. Dished ends shall be torispherical (knuckle radius 15% of outside diameter and crown radius 80% of outside diameter) or 2:1 ellipsoidal. Dished heads shall be subjected to DP test on knuckle portions (both inside and outside) and weld edges after heat treatment. Supplier to ensure adequacy of indicated thinning allowance for dished head. If nominal thickness indicated is not adequate then the nominal thickness should be increased accordingly, keeping minimum thickness as per item drawing. A straight face of 38 mm or 3 times the nominal thickness of dished head, whichever is more, shall be provided, but maximum straight face shall be limited to 50 mm.

4.3 Welding

4.3.1 All welding and weld overlays shall be done with electrodes, fillers and fluxes of reputed make with proven reproducibility of results. DIA shall specifically approve brand names. For CS pressure parts, the electrodes shall be of low hydrogen type. IGC test as per ASTM A262 Practice E shall be done for austenitic SS consumables, which are to be used in application involving solution annealing. Austenitic SS consumables of low carbon and stabilised grade shall also be IGC tested as per ASTM A262 Practice E. Straight chrome materials shall be welded with electrode that produces an austenitic chromium nickel weld deposit or a non air hardening nickel-chromium-iron weld deposit for both the barrier layer & final layer. Alternatively, welds that produces the same composition as Straight Chrome materials are also acceptable.

4.3.2 All welding procedures shall be submitted for approval by DIA giving all relevant details. Welding qualification records shall indicate hardness values of weld metal, HAZ and parent metal and also results of impact tests when design temperature is below 0 °C or when specifically indicated for materials being welded. No welding shall be undertaken until DIA has approved the welding procedure and welder's qualification. All welding procedures and welders shall be qualified for the particular type of welding and material in accordance with the ASME Section IX. Supplier shall be responsible for the quality of the welds performed.

4.3.3 Pressure holding joints shall be FPW. Root pass of single side welded joints shall be done with GTAW process. Backing strip for single side welded joints is not permitted. For LTCS materials, both inside and outside of welds shall be ground flush or dressed smooth. All internal welds in the shell shall be ground flush in order to insert and remove tube bundle. Also, all internal welds shall be ground flush to the extent of facilitating draining of complete equipment. All other weld may be left in the descaled condition only.

4.3.4 Longitudinal seams shall be staggered with the circumferential distance between the centres of welds being at least 5 times the thickness of the thicker-plate. Weld seams shall be located so as to avoid interference with weld seam of nozzles and external attachments.

4.3.5 Attachment to pressure part shall be of same quality as the pressure part. All LAS weld attachments to pressure retaining component shall be FPW and ground to a smooth concave contour. External

attachments like lugs, supports etc. of CS shall not be welded directly to high alloy or austenitic SS heat exchanger components. These attachments should be of the same material as the heat exchanger component. If this is not so, intermediate pad plate of the same material type as the heat exchanger component may be used. These pads shall be at least 100mm wider and longer than the attachment and shall be at least 5 mm thick. Welding of CS or LAS to austenitic SS shall be done with austenitic SS electrodes or filler wire (AWS-ASTM-E 309L or E-309 Mo L only).

Wrapper plates, reinforcing pads, saddle plates or stiffeners of higher thickness than specified can be used provided there is no change in basic dimensions and with the approval from DIA. No separate deviation permit is required for the same.

4.3.6 Partition plates of CS and 300 series SS except for low temperature service, shall be welded to channels etc. by continuous fillet welds with minimum size of 6 mm on both sides. For all other materials and for hydrogen and low temperature services, all welds involving partition plates shall be FPW. However, all pass partition plates shall be FPW up to a distance of 2" (50mm) from the gasket contact surface. Partition plates thicker than 10 mm shall be tapered to 10 mm at partition groove end except when mentioned otherwise on drawings. One weep hole of 6 mm diameter shall be provided at the center of each horizontal pass partition plate and a 5 mm radius notch on top and bottom point of each vertical pass partition plate for all multipass exchangers for effective venting and draining.

4.3.7 Welding of shell to unhubbed tube sheet shall meet the requirements of Code considering that the tube sheet is unsupported.

4.3.8 When impact tests are required on material as per Code or specification the welds shall also be qualified for impact test. In such case following special requirement shall apply to the welding procedure qualification:

i) Qualification tests shall be made on plates of the ASME specification as specified for the exchanger using welding electrodes of AWS or SFA specification and wire & flux of the specification and brand as are to be used on the job.

ii) Welding current and travel speed shall be considered essential variables in order to ensure that production welding is substantially equivalent to the procedure qualification.

iii) Welded test plates shall be subjected to a total thermal cycle sequence similar to the finished equipment. Specifically, test plates shall be held at intermediate and final stress relief temperatures for approximately the same length of time as the finished exchanger. Final cooling rate shall be approximate to that expected for the finished exchanger.

iv) Charpy V-notch impact tests shall be made on the weld and HAZ of the test plate for each welding procedure to be qualified. Test procedure shall be as per UG 84 of Code. Test temperature shall not be higher than MDMT. Impact energy requirements shall be as per Table 2.15 of SA 20 of ASME Section II Part A or UG 84 of Code whichever is higher.

4.3.9 WELD OVERLAY

4.3.9.1 Wherever cladding is specified in datasheets or drawings, weld overlays are not acceptable. However, wherever cladding is specified in the Tube sheet/ channel cover, weld overlay can also be acceptable in place of cladding.

4.3.9.2 Weld deposit overlay shall be done by a qualified welding procedure and surface shall be properly machined or ground flush after overlay. Minimum thickness of finished weld deposit shall be as indicated in the drawings or specifications. In case a higher deposition thickness and multiple weld layers are required to achieve the minimum specified undiluted deposit metal, the same shall be done only after taking prior approval from EIL. Minimum thickness of undiluted finished weld overlay from top shall be 2 mm or as specified in the drawings. For non-ferrous weld deposit, the iron dilution should be restricted to 2.5% (maximum) in the finished undiluted layer (thickness defined above). Supplier must ensure minimum thickness of undiluted finished weld overlay as per above and shall take special precautions to ensure the same. Undercutting of base material shall not be done while ensuring the minimum undiluted chemistry. Supplier to take suitable allowance on machining in this regard so that minimum undiluted thickness is guaranteed after machining. Supplier to qualify WPS/PQR and submit documents to DIA for approvals before proceeding with fabrication.

4.3.9.3 The weld overlay procedure shall be qualified on base metal of the same composition as the exchanger component and meeting the requirements of ASME Section IX.

4.3.9.4 The weld overlay shall be relatively smooth with no notches and undercuts that would act as stress raisers. All cracks, fissures and circular defects greater than 1/16 inch diameter shall be removed. Repaired areas shall be DP checked. Weld overlay shall be applied to base metal, which has been grit blasted and is smooth and clean so as to ensure full bonding. Welding overlay cladding shall be applied after any normalising but before PWHT. The weld overlay shall consist of at least 2 layers.

4.3.9.5 The alloy cladding shall be cut back at all seams to permit back welding of the base metal. Weld metal shall be ground flush and fully covered with the applicable weld deposit. The weld joint in base plate shall be 100% DP tested for detection of cracks and flaws before welding from clad side. The weld deposit shall be at least as thick as the cladding.

4.3.9.6 Shells, cones, dished heads and nozzles formed from clad plates shall be subject to UT after forming, for a minimum of 10% of the clad surface, but no less than one square feet in each 10 square feet or fraction thereof. Unbonded areas that cannot be encompassed by a 3 inch diameter circle shall be repaired by weld overlay. When repairs in excess of 5 % of the total examined area are required, the complete component shall be subject to 100% UT. Repaired areas and weld deposit overlay at weld seams shall be DP examined. UT shall be repeated for dished heads after heat treatment. UT procedures shall be in accordance with SA 578 S6 for spot examination and SA 578 S7 for 100% examination.

4.3.9.7 All weld overlays shall be 100% DP examined in accordance with the method described in ASTM-E-165. The barrier layer shall be 100% examined. When the overlay involves multiple passes (layers) and the procedure uses an intermediate heat treatment with cooling to room temperature prior to applying the subsequent layer, each layer shall be examined by DP. Where overlay is to be machined such as for flange facing, machined surface shall be 100 % examined after final PWHT. If 100% of overlay is examined prior to the final PWHT, overlay shall be spot examined (not less than 10% of the surface) after heat treatment.

4.3.9.8 Samples of the weld overlay shall be taken to perform chemical analysis to the specified depth. The number and location of samples and method of taking samples shall be approved by DIA. However, they shall be representative of each exchanger component for each type of welding process. Report of chemical analysis shall be submitted to DIA for approval.

4.3.9.9 For all weld overlays used in hydrogen or H_2S service with design temperature greater than 350°C, Hydrogen disbonding test shall be carried out. The test condition shall be representative of the actual design conditions and the procedure shall be submitted to DIA for approval. Rate of cooling shall be 100°C/hr (min.) unless specified otherwise in datasheets. Holding time shall be 48 hours unless specified otherwise in datasheets

4.3.9.10 PTCs are required for CS welds above 50 mm thickness and for LAS welds above 25 mm or when required by the Code or when specified in the requisition. The following shall apply: -

a) Two PTCs representative of one longitudinal and another circumferential seam shall be provided for each procedure, position and thickness.

b) PTC shall be from material of the same heat and thickness as that of parent metal. During and after production welding PTC shall be subjected to same heat treatment as and together with the course they represent. Extra PTC shall be preserved to take care of eventuality of retests.

c) The tests mentioned below shall be carried out as per methods of testing in Code:

i) One transverse tension test.

ii) Two side bend tests with weld located in the center of bend.

iii) One hardness test on PTC weld and HAZ. The acceptable limits are 200 BHN for CS, 225 BHN for P3 and P4 materials and 235 BHN for P5 as per EIL specification no. 6-15-0091.

iv) Micro and macro structural examination of welds.

v) For CS, charpy V notch tests on weld and HAZ shall be carried out. For MDMT < 0°C, impact test temperature shall be MDMT. For MDMT > or equal to 0°C, the test

temperature shall be 0°C. The acceptance criteria for impact energy shall be as per table a 2.15 of SA 20 of ASME Section II part A or UG-84 of Code whichever is higher.

vi) For LAS, charpy V notch test on weld and HAZ shall be carried out. Test temperature and acceptance criteria shall be as per clause 2.2.2 (d) (ii).

4.4 Tube to Tube Sheet Joints

Requirements of EIL specification no. 6-15-0003 shall be complied with for welded tube-to-tube sheet joints and that of EIL specification no. 6-15-0004 shall be complied with for expanded tube-to-tube sheet joints.

Wherever expanded tube to tube sheet joint are specified and Supplier is not able to meet the Fr value in mock up, EIL reserves a right to ask supplier to provide strength welded tube to tube sheet joint without any cost & delivery implication.

4.5 Hardness Limitations

Hardness limitation for CS materials, welds and HAZ wherever specified on drawings or datasheets shall be ensured as per Specification 6-15-0091. Hardness limitation for LAS materials, welds and HAZ shall always be ensured as per Specification 6-15-0091. Hardness limitation compliance for tube-to-tube sheet welded joints shall be established/verified on a mock-up with simulation heat treatment

4.6 Nozzle flanges, Nozzles and Reinforcing Pads

4.6.1 FLANGES

Unless otherwise indicated, dimensions, drilling, facing and tolerances for nozzle flanges (and blind covers if required) shall be as per ASME B 16.5 (for size up to 24" NB) and ASME B 16.47 series B (for sizes above 24" NB) for the respective class. Weld overlays, wherever specified or required, shall be in addition to the thickness as per these standards. Boltholes on these nozzle flanges shall straddle principal vertical and horizontal centerlines of equipment. If the component to which nozzles are attached is subsequently stress relieved, it shall be Supplier's responsibility to maintain true gasket faces by machining or otherwise. If distortion is expected, final machining operation should be done after stress relieving; sufficient machining allowance for this purpose should be available. All flange faces shall be suitably protected against oxidation during post weld heat treatment. Gaskets, for flanges to ASME B 16.5 and B16.47, shall be as per ASME B16.20.

4.6.2 NOZZLES

4.6.2.1 Nozzle pipes shall be attached to the heat exchanger components by FPW. Attachment welds using only inner and outer fillet welds are not permitted. Unless otherwise indicated on the datasheets or drawings, necks of all nozzles shall be flush with the inside of the heat exchanger component. Inside corners of nozzle pipes at shell and channel inside diameter shall be radiused. All nozzles 2" NB and below, except long weld neck, shall have two stiffeners (40 mm x 6 mm) at right angles.

4.6.2.2 Whenever nozzle inside is required to be overlaid, these shall be done by weld overlay or cladding. Minimum nozzle ID before weld depositing to be 50 mm in such cases. Liners are not acceptable.

4.6.3 REINFORCING PADS AND TESTING

Reinforcing pads whenever required as per drawings or Code shall be of the same material or equivalent as the heat exchanger component to which it is welded. All reinforcing pads shall be provided with two 1/8" (3 mm) NPT tapped holes located 180 apart for air soap solution test with a pressure of 1.25 kg/cm^2 (g). This test shall also be required to be carried out for slip on flanges. Higher test pressures are not recommended because of accompanying risks and also because the soap bubbles have a chance to blow off. Tell-tale holes in the reinforcing pads shall be plugged with hard grease after the hydro test of the exchanger. No grub screws to be provided.

4.7 Bolts, Studs etc. and Tapped Holes

4.7.1 Metric threads shall be used for all non-standard flanges. However, ASME flanges may have threads as per American standards. All inch bolting and threading shall conform to ASME B 1.1 except for size 1"

and above where it shall be 8 threads per inch. Metric bolting and threading shall conform ISO-R261 shall be followed except for size M24 and above, where it shall have 3 mm pitch.

4.7.2 Studs shall extend beyond the nut by about 10 mm and shall be threaded full length except when square ends are required for use with BTD, in which case the extension shall be as per BTD manufacturer's recommendation. The studs for extended tube sheets and the studs for use with connecting piece shall also have square ends.

4.7.3 All nuts shall be of heavy series only and nut seating faces shall be machined or spot faced.

4.7.4 Threads on external bolting, plugs etc. shall be lubricated with graphite grease for working temperature up to 200°C and with Molybdenum Disulphide for higher temperatures.

4.7.5 Tapped holes on the channel side face of clad tube sheet for removable bundles shall be fitted with plugs of a material similar to channel side material in contact with tube side fluid.

4.7.6 For extended tube sheets, tapped holes shall be provided for girth bolting.

4.7.7 All floating head bolting to have 2 mm wide and 0.5 mm deep groove at both ends to prevent mix up with other bolts.

4.7.8 In addition to stamping, the specifications and manufacturers symbol as specified in ASME material specifications, on one of the ends the size of the studs shall be clearly punch marked. Similarly, the nuts shall have the size punch marked on one of the faces. In case of tapped hole, the size shall be punch marked near the hole without disturbing the gasket seating area. Further for all alloy/SS metallurgy bolts & nuts shall also be identified by distinct colour marking at the stud end/bolt side face

4.8 Assembly and Handling

4.8.1 Supplier shall be responsible for taking adequate preventive measures to ensure the quality and finish of materials and to avoid any rusting.

4.8.2 Suitable method of alignment like dowels etc. shall be provided for proper assembly of channel, channel covers, stationary tube sheet etc.

4.8.3 Stacked exchangers shall be assembled in the shop for a trial fit. Special care shall be exercised in truing up connecting nozzle flanges.

4.8.4 'T' wherever indicated on drawings, denotes match mark for assembly and shall be punched on all mating parts.

4.8.5 Lifting lugs shall be provided as per standard for lifting of channels, channel covers, floating heads, shell covers, test rings, test flanges etc.

4.8.6 In case of removable bundles the following are required: -

(a) Stationary tube sheets shall be drilled and tapped at vertical (0°) position for attaching eyebolts; or a lifting lug of adequate thickness shall be welded with 25 mm (minimum) diameter hole.

(b) Drilling and tapping as above shall be carried out on floating tube sheet.

(c) Last support plate shall be drilled (25 mm diameter hole) for lifting the assembled bundle. Local stiffening may be necessary to withstand the bundle load., which shall be designed by the Supplier.

4.8.7 Pulling eyebolts made from forged CS shall be provided for all removable bundles. These shall be sent loose along with the spares. Insert piece shall be provided for all clad tube sheets. Material of insert piece shall be same as that of cladding material.

4.8.8 Stationary tube sheet shall be drilled and tapped for tie rods. Care should be taken to ensure that holes are not drilled through.

4.8.9 Interchangeable and 180° rotatable bundles shall have common pass-partition groove arrangement in the respective tube sheet. For exchangers where bundles are specified to be interchangeable, the same shall be ensured at the Supplier's shop by actually inserting the bundles or using a template consisting of 4 full diameter baffles, each spaced at a distance equal to the baffle pitch.

4.8.10 Jackscrews shall be provided on all girth flanges.

4.9 Descaling, pickling and passivation shall be done for all SS parts in accordance with ASTM A-380. The Supplier shall furnish details of the procedure for approval to DIA.

4.10 No distortion whatsoever shall be permitted on the gasket seating surfaces due to tube-to-tube sheet welding, shell to tube sheet welding, PWHT etc. If distorted, the same shall be machined subsequently.

4.11 Fabrication Tolerances and Finish

4.11.1 The dimensional tolerances shall be within the limits indicated on EIL drawings and standards. Where tolerances are not specified, these shall be in accordance with the requirements of TEMA and Code.

4.11.2 All edges and corners including baffle holes shall be deburred (or rounded, if shown).

4.11.3 Finish of all machined components shall be minimum 12 microns (500 RMS) unless otherwise indicated. Parts subjected to UT shall have minimum finish of 6 microns.

4.11.4 Tube sheet face shall be flat within +/- 1.5 mm (camber).

5.0 NON-DESTRUCTIVE TESTS

5.1 All the NDT procedures shall be submitted to DIA for approval. For all NDT activities, only qualified NDT technicians shall be deployed with the approval of DIA.

5.2 The extent of radiography shall be as specified in datasheets or drawings or job specification. Radiography shall be performed after PWHT. In case radiography is carried out before PWHT, then UT shall be carried out on the welds after PWHT.

5.3 Minimum extent of radiography shall be spot, unless full radiography is specified in the drawings or required as per specification or Code.

Each category A or B pressure containing weld shall be spot radiographed in accordance with ASME Section-VIII Division-I, paragraph UW-52 as a minimum requirement. Each Spot radiograph shall be a minimum of six inches (150mm) in length and minimum one spot shall be selected in each circumferential & longitudinal seam. Additionally, at least one T-joint in each circumferential seam shall also be selected. Welds from each welding procedure, welded/welding operator shall be examined. DIA shall be consulted in marking the areas to be radiographed.

5.4 Full radiography when specified shall imply 100% radiography of all butt welds including nozzle flange to nozzle neck, pipe to pipe and pipe to fitting.

5.5 All welds of nozzle necks fabricated from plate, irrespective of diameter, thickness of plate and radiography specified, shall be 100% radiographed.

5.6 Weld seams of formed heads shall be 100% radiographed after forming and heat treatment.

5.7 All nozzle to shell welds and unhubbed tube sheet to shell welds shall be DP or MP checked at the root run and final weld.

5.8 All welds, which cannot be fully radiographed such as nozzle to shell, shell to unhubbed tube sheet, unhubbed floating head to cover etc., shall be 100% UT after final PWHT. Fillet welds and welds which cannot be radiographed or UT (i.e. pass partition plate to channel and floating head etc.), the root run shall be DP checked and the welds shall be finally MP checked after PWHT.

5.9 All attachment welds shall be either DP or MP tested.

5.10 If vendor intends to carry out radiography by Computed Radiography technique, then demo should be carried out under AI to prove vendor's capability to produce acceptable images meeting the Code requirements.

5.11 If radiography is being substituted by UT for the final closing seam as permitted by Code, MP shall be carried out in addition to UT.

5.12 In case Supplier want to perform UT in lieu of RT based on Code paragraph UW 51 (a) (4), the same is acceptable subject to the following:

a) Material of construction is either CS or LAS.

b) The thickness of weld is greater than 13 mm.

c) The joint is either Category A or Category B joint except shell to hemispherical dished end joint. (Category of joint as defined by Code).

d) Automated UT incorporating TOFD and pulse echo probes or TOFD and Phased Array mounted on the same chassis that automatically traverses along the joints to be inspected and displaying both results simultaneously on a single screen may be considered in lieu of RT.

e) Calibration block of similar material/thickness shall be used. Calibration block shall have suitable notches to simulate longitudinal as well as transverse cracks on outside and inside surface. Setup should be capable of detecting defects on outside as well as inside while scanning from one surface only.

f) The system that is proposed to be deployed in lieu of radiography shall be submitted along with the track record prior to use for EIL review. The Supplier shall demonstrate successfully the capability of AUT machine and the defects evaluation in the same screen during the site visit of EIL representative. Based on which, the approval of the partics and their AUT system shall be given.

g) Qualified NDT persons shall be deployed to perform UT.

h) Acceptance criteria shall be as per Code paragraph UW 51.

6.0 HEAT TREATMENT

6.1 PWHT shall be done if required by datasheets, drawings, specifications, Code etc. PWHT when mentioned on the drawings shall be over and above the requirements of specifications or Code. No welding or heating is permitted after PWHT. All machining operations shall preferably be carried out after PWHT (also refer clause 4.6.1). It shall be the responsibility of the Supplier to leave sufficient allowance for this purpose. Supplier shall submit all the procedures for PWHT to DIA for review.

6.2 During PWHT of assemblies of fixed tube sheet exchangers, care shall be taken to ensure that differential stresses are not caused between tubes, shell and tube sheet. The temperature differential between shell and tubes during PWHT to be minimised (not to exceed 25°C) and the rate of heating and cooling shall not exceed 25-30°C per hour. For this purpose, thermocouples shall be installed on various components and compliance assured.

6.3 Heat treatment of SS clad assemblies shall be at reduced temperature to avoid sensitisation of SS materials. The soaking time shall be increased accordingly as per Code.

6.4 Heat treatment of non-ferrous clad assemblies, if required, shall be performed with extra care, at reduced temperatures to avoid differential thermal expansion. The soaking time in such a case shall be increased accordingly as per Code.

6.5 Heat treatment of CS and LAS dished heads shall be as follows:

a) Stress Relieving for:

(i) Cold formed dish heads up to 16 mm thick.

(ii) Cold formed floating head cover up to 16 mm thick if fiber stretch exceeds 5%.

b) Normalizing for CS and normalising and tempering for LAS:

(i) Hot formed dish head and floating head dish if not formed in normalising range.

(ii) Cold formed dish heads for thickness greater than 16 mm.

(iii) Cold formed floating head dish above 16 mm thick.

This heat treatment need not be given if same heat treatment is given subsequently on sub-assembly. Thicknesses specified above are nominal.

In case of LAS plates, it shall be fabricator's responsibility to ensure that mechanical properties of material are not impaired during any cold / hot forming process and subsequent stress relieving heat treatment. Tests to demonstrate suitability of process shall be carried out by fabricator.

6.6 SS components shall be solution annealed in the following cases.

i) Cold formed dished heads with nominal thickness of 16 mm or above.

ii) Hardness value of dished heads after cold forming exceeds 235 BHN.

iii) Hot formed shells, cones, dished heads.

After any heat treatment on austenitic SS, IGC test shall be carried out as per clause 2.2.3 (c)

6.7 All LAS welds shall be PWHT.

6.8 If stress relieving is indicated on shell side or tube side and the service on either side is lethal or low temperature or if specifically indicated in the datasheet or drawings, the welded tube-to-tube sheet joints of CS or LTCS material shall be stress relieved.

6.9 For LAS materials, preheating procedure shall be established in the welding procedure and got approved by DIA. Preheating by resistance or induction-heating method is preferred. Preheating shall extend uniformly to at least three times the thickness of joint but not less than 50 mm on both sides of the weld. Temperature indicating crayons shall be used for assessment of correct pre heat temperature.

7.0 INSPECTION AND TESTING

7.1 Inspection

7.1.1 The inspection shall be carried out by DIA. The materials, fabrication and testing of exchangers shall be open to inspection by DIA in addition to any inspection required by the specified Code or local authorities having jurisdiction over the installation.

7.1.2 Inspection shall be carried out both during fabrication and before delivery and also for sub ordered materials. In addition to final inspection and certification by DIA during the course of manufacture, DIA's written approval shall be obtained by the Supplier at various stages of fabrication. For this purpose, Supplier shall prepare his QAP, defining the stages of fabrication, hold points for his own inspection and that by the DIA or Code or Statutory Authorities etc. The QAP shall be discussed with DIA before start of job and mutually agreed. The various stages of fabrication to be inspected (either by Supplier or DIA or both) shall include but not limited to the following:

(a) raw material identification and verification of mill test certificate.

(b) edge preparation for welding, including visual check for laminations.

(c) alignment of longitudinal and circumferential seams.

(d) rolling tolerances on individual section.

(e) alignment and fit up of sections and components.

(f) root pass clearance before further welding and cleaning.

(g) profile and thinning of dished ends and toriconical pieces after forming.

(h) checking of tube sheet after drilling including checking of tube layout patterns, tube holes, pass partition locations, visual check for laminations.

(i) tube sheet to shell set up for fixed tube sheet exchangers, prior to welding.

(j) tube to tube sheet joint expansion or welding.

(k) visual check of shell inside and tube bundle insertion.

(l) welding of expansion bellows or joints, if required.

(m) review of NDT reports and heat treatment charts.

(o) final visual and dimensional inspection.

(p) witnessing of hydro test.

7.1.3 The presence of DIA shall not modify or reduce the obligation of the Supplier to carry out his own tests and control. If any material and/or equipment are not found in compliance with the specified

requirements, DIA or his delegate shall be entitled to irrevocably reject them, even if such non-compliance has not been evidenced in the course of inspection and/or tests.

7.1.4 DIA will, at the time of his initial visit, set up with the Supplier actual details of inspection stages to be witnessed or carried out; the schedule of future visits and subsequent inspection notices can be arranged between DIA and the Supplier.

7.1.5 The Supplier shall notify DIA sufficiently in advance of any fabrication operations to permit arrival at the Supplier's shop in time to witness these.

7.1.6 The Supplier shall provide to DIA, free access to his shops at all times. He shall also supply all tools and tackles to DIA for carrying out the inspection. The Supplier shall also arrange for similar facilities at his sub-contractor's shops.

7.1.7 The Supplier must satisfy DIA that the welding procedures, welders, electrodes, fluxes, welding wires etc. are in accordance with the requirements of the Code and specifications. Further the welder's qualification test must be carried out in the presence of DIA.

7.1.8 Prior to final inspection, all slag, weld spatter loose scale, dirt, grit, paint, grease, oil and other foreign matter shall be removed in order to facilitate inspection. All reinforcing pads and slip on type flange welds shall be pressure tested with air and soap solution before and after heat treatment (if any) and before final hydrostatic test.

7.1.9 A dimensional check of equipment shall be carried out taking into account the tolerances shown on drawings, standards, specifications or Code, the more stringent values shall govern. Dimensional checks are to be taken of the internal measurements of equipment together with external ones and these are to be recorded on the drawings as being the "As Built" dimensions.

7.2 Hydrostatic Tests

7.2.1 Hydrostatic tests shall be witnessed by DIA. When hydrostatic tests are performed the indicating gauge shall be connected to the upper most part of the equipment. Testing water shall be clean potable water. Seawater shall not be used. For SS equipment, water used for these tests shall not contain more than 25 ppm chlorides. Minimum metal temperature during hydrostatic tests shall be as per Code. Test pressures shall be maintained for at least one hour. Shell and tube sides shall be tested separately, unless otherwise mentioned on the drawing. For tube sheets designed for differential pressure, special care shall be taken during testing. Equipment drawings shall clearly indicate if tube sheets have been designed for differential pressure. Drying out as per clause 9.1 shall be carried out immediately after hydro test.

7.2.2 All vertical exchangers shall be tested in vertical position. Alternatively, exchanger may be tested in horizontal position with test pressure modified with prior approval of Designer.

7.2.3 Stacked exchangers with nozzles interconnected shall be hydro tested in stacked condition except when the hydro test pressure of the individual exchanger is different.

7.2.4 Actual torque values applied for tightening of bolts during hydro test to be recorded/indicated in hydro test reports

8.0 STAMPING, NAME PLATES AND WARNING PLATES

8.1 Each exchanger shell shall be fitted with an SS nameplate.

8.2 Warning plates, if required, shall be provided.

8.3 The following exchanger parts shall have the item number stamped except for heat exchangers in low temperature service in which case the item number shall be marked with non-removable ink:

Shell girth flanges, shell cover flange, channel girth flanges, flat channel cover, stationary and floating tube sheets, floating head cover flange, floating head backing ring, connecting pieces, test rings, test flanges and other main removable parts.

9.0 PROTECTION AND DESPATCH

9.1 After completion of all testing and inspection, the inside of complete equipment shall be thoroughly drained and dried out. Equipment shall be completely dried by passing hot air for sufficient time until no further increase in relative humidity of outgoing air is observed. Dry out shall be done simultaneously on

both shell and tube sides. Alternatively, vacuum drying is also acceptable. After drying, the equipment shall be purged and filled with dry N_2 at 0.25 kg/cm^2. The equipment shall be provided with pressure gauge to monitor N_2 pressure, and ½" non-return valve. All threaded holes, other than tell tale holes for testing, shall be suitably protected with steel bar plugs. All nozzles not provided with blind flange shall be provided with steel covers, temporary gaskets and bolts.

9.2 Shop Painting

Surface preparation, Primer application and finish paint shall be required as per applicable specification enclosed elsewhere in the requisition. In absence of any requirements in the requisition following shall be complied:

All CS and LAS external surfaces, except gasket faces and machined surfaces, shall be primer painted. Surfaces to be painted shall be prepared for painting by removing loose mill scale, rust, oil, grease and other films or substances harmful to the adhesion of paint by an approved method such as shot blast cleaning. The surface shall be prepared to near white finish as per SSPC-SP-10 [SA 2 ½ Swedish standard (SIS-05-5900)]. The primer shall be inorganic zinc silicate (65-75 microns dry film thickness) for design temperatures up to 400°C and Heat Resistant Silicone Aluminium Paint (20 microns dry film thickness) for design temperatures between 400 °C and 540 °C, unless stated otherwise.

9.3 The equipment item number, PO number and Owner name and address shall be painted in bold white paint letters written with stencil, on the heat exchanger.

Sliding end of exchangers shall be painted as "CAUTION-SLIDING END" in black on the primer coating in the shop.

9.4 Dispatch of Equipment

No heat exchanger shall be released for shipment until it has been approved by DIA. Heat exchangers shall be despatched after the operations as required by clauses 9.1, 9.2 and 9.3 have been carried out and shall be despatched in as-tested condition. In case stacked exchanger shells are despatched separately the Supplier shall provide additional set of gaskets for interconnected nozzles other than the gaskets included in spares. Heat exchangers shall be securely anchored for despatch in order to prevent any shifting and damage during transportation. Expansion joints and bellows shall be suitably protected against any possible damage by providing tie bars before boxing up. Packaging shall be suitable for rail or road transport and also sea worthy if transported by sea. Spares shall be despatched separately in a box and marked with PO number, item number and Owner's name and address.

Supplier shall provide sling mark identification on all heat exchangers with respect to center of gravity of the equipment.

No equipment shall be despatched until a written clearance is obtained from Owner or EIL regarding Piping Clips and Structural Cleats on individual equipment.

10.0 SUPPLIER'S GUARANTEES

The Supplier shall be completely responsible for the compliance to Code requirements, residual design, detailing, fabrication, materials and workmanship of the exchangers as per the stipulations of the requisition and its attachments. In this regard, it may be noted that review by Owner or EIL shall not relieve the Supplier of his responsibility of meeting all requirements and ensuring satisfactory performance of the equipment. Guarantee period shall be as per GPC of Owner.

वेल्डेड ट्यूब से ट्यूबशीट जोडों के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR WELDED TUBE TO TUBESHEET JOINTS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	20 05 19	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	NK 20/05/19	KA	KJH	RKT
4	07 06 13	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	TK	KA	RKT/SC	DM
3	28 01 08	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	KA	PK	AKM	VC
2	01 09 99	REVISED AND REISSUED AS STANDARD SPECIFICATION	HN	PK	RKA	AS
1	04 05 89	ISSUED AS STANDARD SPECIFICATION	RKA	BSG	VKM	RNS

Abbreviations:

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
OD	Outside diameter
TEMA	Tubular Exchangers Manufacturers' Association
TIG	Tungsten inert gas shielded arc

Static Equipment Standards Committee

Convenor: Mr. KJ Harinarayanan

Members:
Mr. Sanjay Mazumdar
Mr. K Anjaneyulu
Mr. Arun Kumar
Mr. Inder Kumar
Mr. Tarun Kumar
Mr. Anish Trehan
Ms. Srikanth Karanam
Mr. Neeraj Agarwal (Projects)
Mr. S Ghosal (Process)
Mr. T Kamalakannan (SCM)

CONTENTS

1.0 SCOPE

1.1 This specification covers minimum requirements for the welding and testing of tube to tubesheet joints of shell and tube heat exchangers and air coolers. It is the Fabricator's responsibility to furnish sound, leak free joints. For the purpose of this specification, the terms "joints" shall be construed to mean "tube-to-tube sheet joints".

2.0 APPLICABLE CODES AND STANDARDS

The latest edition of the following codes and standards shall be complied with:

a) ASME Section VIII Division I
b) ASME Section V
c) ASME Section IX
d) TEMA for tubular exchangers
e) API 661 for air coolers
f) AWS

3.0 WELDING PROCESS AND JOINT DETAIL

3.1 Manual or automatic Tungsten Inert Gas shielded Arc (TIG) welding shall be used. All joints shall be made by using minimum two weld passes. The first pass should be preferably made without filler wire to ensure root fusion. The second or final pass shall be with filler wire. Any other welding process can be used only after obtaining written approval from the Authorised Inspector.

3.2 Joint detail shall be as indicated on the Purchaser drawings by giving reference to figure numbers in Appendix-1 of this specification. In absence of any Purchaser drawings or indication regarding type of joint, Figure 2 or Figure 3 shall be used depending upon whether tube thickness is > 2 mm or < 2 mm respectively.

4.0 WELDING PROCEDURE QUALIFICATION

4.1 Welding Procedure Specification shall be compiled by the Fabricator and submitted to the Authorised Inspector for approval before the qualification tests are performed. Mock up test shall commence only after approval is obtained from the Authorised Inspector.

4.2 Welding procedure qualification test is required to be carried out if:-

a) Authorised Inspector requires the test to be carried out.

b) There exists no previous qualification tests within last three years for the proposed combination of tube and tubesheet P number and group number (as per ASME Section IX), tube outside diameter (OD), tube thickness, tubesheet thickness, tube pitch, tube pitch pattern, welding procedure and joint detail. All other factors remaining same, the procedure test need not be repeated if the job tubesheet thickness exceeds 40 mm and qualification exists for 40 mm or higher tubesheet thickness.

For plug type air coolers additional procedure qualification test is required to be performed for any of the following conditions:

i) The job has lower clearances between tube and any of the header plates like top/bottom/end/stiffener/pass partition plate compared to earlier tests.

ii) The job has lower plug size for the same tube size compared to earlier tests.

iii) The job has higher plugsheet thickness compared to earlier tests.

c) Code or requisition or bid document requires the test to be carried out.

4.3 If required as per 4.2 above, the Fabricator shall perform a procedure qualification test, at least two weeks before the scheduled beginning of production. Procedure shall be qualified for the same hand position as is being proposed for production. Procedure test shall consist of the welding of nine tubes for square pitch and eight tubes, (three, two and three tubes per row arrangement) if on a triangular pitch. This shall be done for each set of combination of tube and tubesheet P number and group number, welding procedure, joint detail, tube OD, tube thickness, tube pitch, tube pitch pattern, tubesheet thickness. Additionally for air cooler, tests shall be done for each tube size with lowest plug size, lowest clearance between tube and any of the header plates, and the lowest plugsheet thickness to be used on the job. Thickness of the tubesheet used for procedure testing shall be same as used for job, except that for carbon steel and austenitic stainless steel materials, it need not exceed 40 mm, unless otherwise indicated. Refer Appendix-2 of this specification for test specimen details.

4.4 The following data report (six copies) shall be furnished for review to Authorised Inspector with the weld samples as outlined below.

a) Complete details of welding procedure employed indicating various machine settings, welding rods, inert gas composition & purities, flow rate, weld sequence etc.

b) Mechanical properties and chemical composition of tubesheet, tubes and filler metal.

c) The hardness of the weld, the tube, the tubesheet heat affected zone and the tubesheet base metal after each pass.

d) The complete test sample shall be cut (by sawing) as per Appendix 2 of this specification. These shall then be subjected to various tests etc. as outlined below:

i) Section 1 shall be polished, etched and microphotographed for examination of depth of weld, penetration and definition of boundaries. The minimum leak path of each weld shall be not less than the nominal thickness of the tube. The weld leg shall also be measured and shall be minimum 1.4 times the nominal thickness of the tube.

ii) Section 2 (two specimens) shall be subjected to tear test. These specimens shall be tongue bent to show the extent of weld penetration. The underside of the weld shall show evidence of adequate & uniform weld penetration.

iii) A section 10 mm thick containing the tube end welds shall be sawed from section 3 and radiographed for weld quality. The radiograph shall be submitted to Authorised Inspector. No cracks or crack like or visual defects are acceptable. Acceptance shall be as per Appendix 4 of ASME Section VIII Division 1. In case the radiograph is not acceptable, welding procedures shall be suitably modified so that proper weld and acceptable radiographs are obtained. These shall be proved by retests.

iv) Section 4 shall be etched and polished and given to Authorised Inspector.

e) A tension strength test shall be carried out as per ASME Section VIII Division I Appendix A. This strength test shall be performed at room temperature for each combination set of tube and tubesheet P number and group number, tube OD, tube thickness and joint detail. The breaking loads shall be at least equal to the load required for breaking the tube using the minimum specified ultimate tensile strength of tube as indicated in certificates issued by the tube supplier. When tube material is to a

specification which does not call for mechanical tests to be performed, ultimate tensile strength of the tube material shall be considered as four times the allowable stress at room temperature as indicated by the ASME Section II Part D, or other relevant code. Failure of the test piece at the weld shall not be a cause for rejection in case the minimum strength is attained, but the fracture should be examined for any evidence of faulty workmanship.

4.5 Fabricator is advised to satisfy himself that the procedures employed are the best for the job and would enable him to give workmanship guarantee for the equipment. Authorised Inspector's approval shall in no way relieve the Fabricator of his responsibility and guarantee to supply the equipment as per the conditions of the purchase order.

5.0 WELDERS QUALIFICATION

The purpose of this operator qualification test is to demonstrate that both the welding operator and the welding machines are capable of producing satisfactory joints. Once welding procedures have been qualified as above, welding operators employed on welding shall be required to prove their ability by making test samples similar to that prescribed above for welding procedure qualification. Welding operators may be qualified based on para 4.4 d (i), 4.4 d (ii), and 4.4 d (iii) above only, provided same welding machines & welding procedures are used. This welding operator qualification test should also be carried out if the welding operator has not executed similar welding six months prior to production. Repeat tests may be called for in the course of manufacture to determine the consistency of operator or machine to produce sound welds.

6.0 PREPARATION OF TUBES AND TUBESHEET

6.1 Tubeholes shall be to special close fit tolerance as per TEMA for shell and tube exchangers and as per API 661 for air coolers. Tube holes shall be free from any burns and the bundle side edge of tube holes shall be chamfered or radiused. Tube holes shall have smooth finish to 63 AARH.

6.2 Prior to assembly, the tubesheet and tube ends (inside and outside for a distance equal to the tubesheet thickness + 30 mm) shall be cleaned and degreased to free from dirt, grease etc. It is essential that the solvent used for degreasing be chloride free and sulfide free and non residue forming. The solvent should not lead to any possible fire hazard.

6.3 The tubes shall be positioned in the tubesheets by 30° tapered drift pin.

6.4 Before welding tube to tubesheet, the tubesheets shall be heated to a temperature as required to remove any last traces of moisture or solvent which may remain after the cleaning operation. Any specific requirement for application of preheat shall be established as a part of the welding procedure qualification test and should account for increased restraint offered by the larger assembly during production.

7.0 WELDING

Tubes shall be individually welded, using the procedure approved by the Authorised Inspector. Systematic welding procedure shall be adopted so as to result in minimum tubesheet distortion. All tubes are to have initial pass completely cleaned as necessary, visually examined and tested as per para 8.1 below, if required, before subsequent layers are applied. Welds shall be suitably finished and any spillage or spatter on tubesheet removed. Spillage of weld metal into the bores of tube is not permitted.

8.0 EXAMINATION OF JOINTS

8.1 Joints shall be subjected to air-soap solution test after first weld pass with air at 1.25 kg/cm^2 (g). Procedures outlined in ASME Section V, Article 10 shall be followed.

8.2 After completion of welding, the tubesheet face, the welds and internal tube surfaces to a distance of 25 mm beyond the fusion line must be cleaned thoroughly by wire brushing and examined carefully for surface defects. Defects such as cracks, surface breaking porosity, slag inclusions and lack of fusion are not acceptable.

8.3 After the visual inspection, a liquid penetrant examination in accordance with ASME Section VIII Division I, Appendix-8 & Section V, Article 6 shall be done. Before conducting this test, the faces of the carbon steel tubesheets shall be cleaned thoroughly by wire brush and solvents to remove all weld slag, rust and scale.

8.4 When specified on the drawings or requisition, a halide test shall be performed after the tests as per para 8.1, 8.2, and 8.3 above have been successfully completed. Procedures for halide test shall be as per ASME Section V, Article 10, Appendix - III Halogen diode detector probe test.

8.5 After the final tube expanding (refer para 9.0) has been completed, the liquid penetrant examination as outlined in para 8.3 above shall be repeated.

8.6 Whenever a halide test has been specified, an envelope test shall also be done as a further test for leaks after final tube expanding. For this test, tubesheets shall be securely wrapped in plastic sheets and the shell allowed to remain under test pressure with halogen tracer, for a period of 10 to 12 hours. Then with the detection set at a maximum sensitivity, the probe shall be inserted through the plastic cover at the bottom of the tubesheets and readings taken to observe if any leakage has occurred.

8.7 Final acceptance hydraulic pressure test shall be conducted after tube expansion at hydrotest pressure for at least one hour.

9.0 TUBE EXPANDING

After the tests outlined in 8.1, 8.2, 8.3, and 8.4 have been successfully completed and all leaking welds repaired, the tubes shall be "contact expanded" with a PARALLEL type expander. Contact expanding is intended to bring the tube OD into contact with the tube hole. Contact expanding shall begin 12 mm from the tubesheet face and extend to 3 mm from the back face. The contact expansion shall have thinning of 3-5% which shall be ensured by measuring the inside diameter of tubes.

10.0 REPAIRS

If leaks are found during any of the above testing procedures these shall be reported to the Authorised Inspector and after obtaining his approval, repairs shall be made by removing the defects down to sound parent metal and repeating the qualified weld procedures. All weld repairs shall be retested in accordance with procedures outlined in para 8.0 above.

11.0 TEST AND REPAIR REPORTS

Test and repair reports shall be included in the Data Folder. These reports shall also indicate the number of leaks discovered on each test and the extent of the repair done.

APPENDIX 1 - JOINT DETAILS

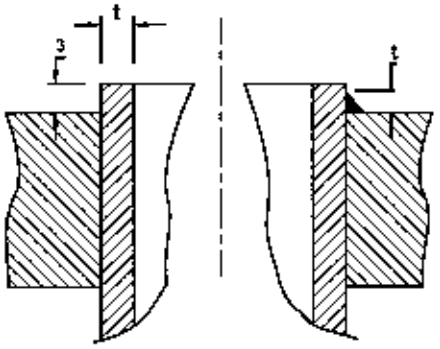


FIG-1

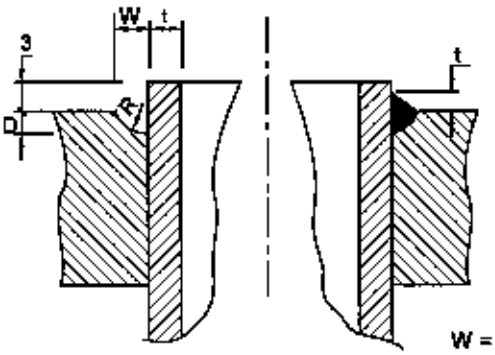


FIG-2

W = t
R = t
D = t FOR t ≤ 3
AND
= 0.6t FOR t > 3

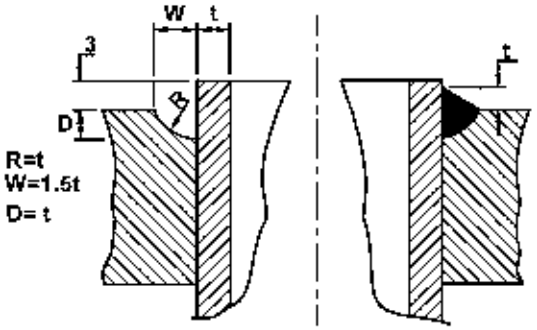


FIG-3

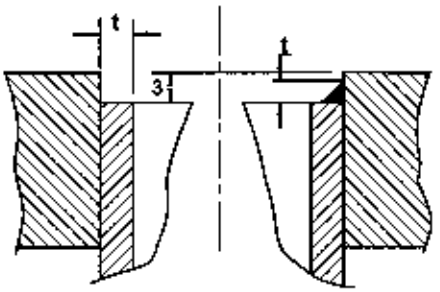


FIG-4

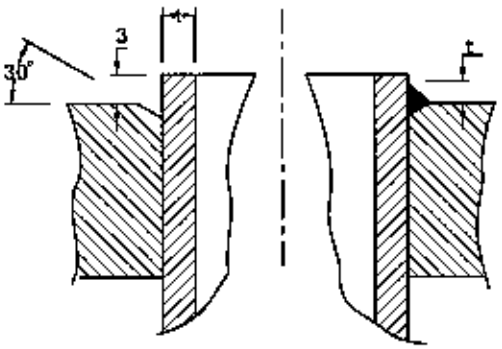
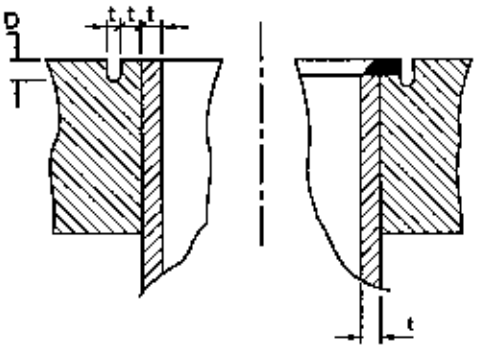


FIG-5



D = 1.5t TO 2t

FIG-6

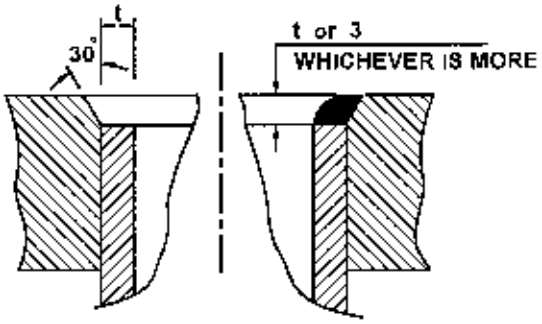


FIG-7

APPENDIX 2 - DETAILS OF TEST SPECIMENS

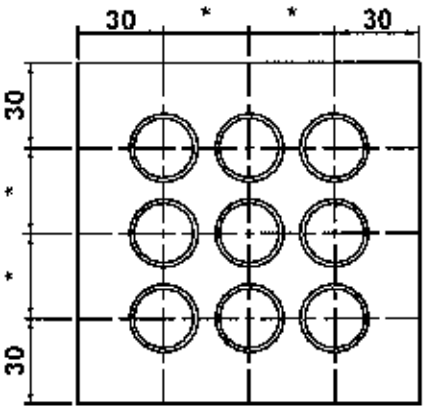


FIG-11

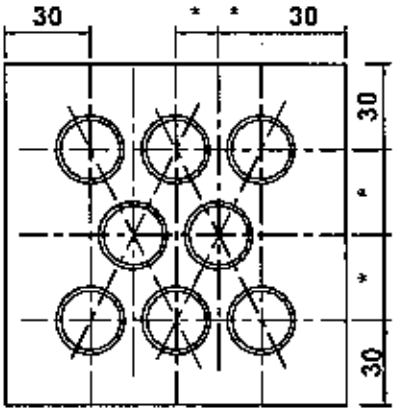
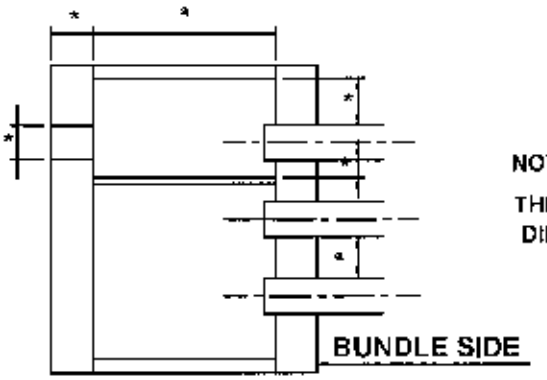


FIG-12



NOTE:-

THE MOCKUP ASSEMBLY SHOULD HAVE THE DIMENSIONS/THICKNESS MARKED '*' AS PER JOB

FIG-13 FOR PLUG TYPE AIRCOOLERS

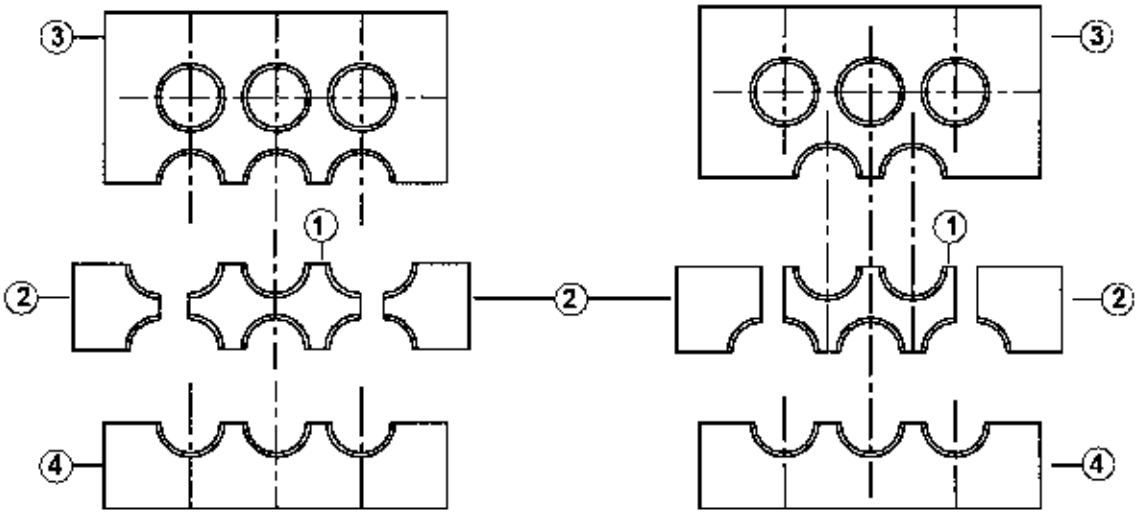


FIG-14

FIG-15

LEGEND

1. FOR MICROPHOTOGRAPHIC EXAMINATION
2. FOR TEAR TEST
3. FOR RADIOGRAPHIC EXAMINATION

एक्सपान्डेड् ट्यूब से ट्यूबशीट जोडों के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR EXPANDED TUBE TO TUBESHEET JOINTS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	05-12-24	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKP	TKh	KA/NK	MN
5	01-05-19	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	NK	KA	KJH	RKT
4	07-06-13	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	TK	KA	RKT/SC	DM
3	24-01-08	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	KA	PK	AKM	VC
2	16-07-99	REVISED AND REISSUED AS STANDARD SPECIFICATION	HN	PK	RKA	AS
1	04-05-89	ISSUED AS STANDARD SPECIFICATION	RKA	BSG	VKM	RNS

Abbreviations:

ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
ID	Inside diameter
OD	Outside diameter
SS	Stainless steel
TEMA	Tubular Exchangers Manufacturers Association

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar
Co-Convenor: Mr. K. Anjaneyulu

Members:

Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
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Mr. Srikanth Karnam
Mr. Aasheesh Handa (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agrawal (SCM-Inspection)

CONTENTS

1.0 SCOPE

This specification covers the minimum requirements of expanded tube-to-tubesheet joints for shell & tube heat exchangers and air coolers. It is the fabricator's responsibility to furnish sound, leak free joints. For the purpose of this specification, the term "joints" shall be construed to mean "tube-to-tube sheet joints".

2.0 APPLICABLE CODES

The latest edition of the following Codes and Standards shall be complied with:

a) ASME Sec. VIII Div. 1 (Code)
b) TEMA for tubular exchangers
c) API 661 for air coolers.

3.0 JOINT CONFIGURATION

Joint with two grooves as per 7-15-0006 shall be used unless specified otherwise.

4.0 PROCEDURE TESTING

4.1 Procedure testing is required to be carried out in any of the following cases:

a) Authorized Inspector of Purchaser or EIL requires it to be carried out.

b) There are no previously established procedures for Fr values (Factor of Reliability) in the last five years with the same combination of tube and tubesheet material, outside diameter (OD) and thickness of tubes, tube hole groove detail and length of expansion (excluding contact expansion).

c) Code or specification or the equipment drawing requires it to be carried out.

d) The length of expansion in the job is less than existing qualification length of expansion of same materials, tube size, tube hole groove detail. However, if qualification exists for length of expansion of 51 mm or more for the same combination of materials, size of tubes, tube hole grooving details, and the length of expansion for the job is 51 mm or more, the procedure testing need not be repeated. The length of expansion to be considered excludes any contact expansion.

e) If previously established procedure of the fabricator is to be used, Authorized Inspector has the option of asking for a demonstration of the procedure to satisfy himself of its accuracy or to confirm the suitability of the expanding equipment or control unit. With time, the equipment used for expansion may change its characteristics and Authorized Inspector may like to check this by actual procedure tests.

4.2 Procedure test shall demonstrate % thinning vs machine setting and shear load test as per the requirements given below.

4.2.1 A sample tubesheet of same material and thickness as required for the job shall be drilled and/or reamed to achieve the required surface finish as per clause 6.0 and grooved as per 7-15-0006. Tube hole dimensions shall be as specified in clause 6.0 and as far as possible tube holes shall be prepared to cover the complete range of tolerance allowed. Tubesheet thickness used for procedural testing shall be as per item drawing or specification except that it need not exceed 55 mm. Diameter of tube holes drilled in the sample tubesheet shall be measured accurately. Hardness of tubesheet shall be measured and reported.

4.2.2 At least eight tubes from the same heat shall be selected with extreme tolerances as far as obtainable from the given lot of tubes to the satisfaction of the Authorized Inspector. The OD, inside diameter (ID) & hardness of these selected tubes shall be measured and reported.

4.2.3 One of these tubes shall be selected and positioned in the tube hole and assembly held in the same position as shall be adopted for production. Tube expander to be used for production shall be set at an estimated low value and tube shall be expanded inside the tube hole. Expander setting shall be increased until the thinning is in the range of 8-10% for all materials, except for non-ferrous and stainless steel, in which case it shall be 6-8%. In no case shall the % thinning exceeds the values given in clause 8.1. The thinning figures are to finally such that these can result in achieving the required Fr value. It shall be the fabricator's responsibility to ensure the same.

Percentage thinning is defined as follows:

$\%\ \text{thinning} = [1-(D_h-ID_f)/(OD-ID_i)] * 100$

Where

D_h = Tube hole diameter in tubesheet
ID_f = ID of tube after complete expansion
OD = OD of tube before expansion
ID_i = ID of tube before expansion.

4.2.4 Expander setting thus found shall be tested on the remaining tubes and thinning shall be checked to be within the range specified above. Results of these tests (reporting combination number and % thinning achieved and various diameters used for calculation of thinning) shall be reported to the Authorized Inspector.

4.2.5 Samples prepared above, shall be cut in two halves along the axis of the tubes to show the flow of metal into the grooves. These cut-sections shall be presented to the Authorized Inspector who shall check the samples for flow of metal into the grooves and also check the expansion length. Authorized Inspector's approval shall be obtained on the same.

4.2.6 Fabricator is advised to satisfy himself that settings reported and to be used in the production shall be the best for the job, will enable him to achieve the required Fr value and give workmanship guarantee for the equipment. Authorized Inspector's approval shall in no way relieve the fabricator of his responsibility and guarantee to supply the equipment as per the conditions of the purchase order.

4.2.7 Shear load tests shall be carried out as per clause 4.21 of ASME Sec VIII Div-2. Fr value of the joint shall be established and shall be demonstrated to be greater than or equal to Fr (test) required as per clause 4.21 of ASME Sec VIII Div-2. For nonferrous and stainless steel combination of tubes & tubesheet a minimum Fr value of 0.7 shall be achieved. Actual value shall be reported in the test reports.

5.0 CARE OF TUBES

5.1 Ends of the tubes (tubesheet thickness + 100 mm) shall be subjected to careful visual inspection. These shall be cleaned to remove scales, rust, grease and dirt and should subsequently be cleaned by using a suitable sulfide free and chloride free solvent to get rid of oil and grease. The solvent should be non-residue forming and should not lead to any possible fire hazard. The area should be defect free and should have no scoring marks, rough surface etc. No repair is permitted on defective tubes unless approved by Authorized Inspector. In case a repair is done using an approved procedure, the tube dimensions after repair shall be within limits laid down by the tube material specification, otherwise the tube shall be discarded.

5.2 At least 10% tubes (subject to a minimum of 20 tubes per shell) shall be tested for hardness at the tube manufacturer's shop (This shall be taken care during sub-ordering). The hardness

measured should not be greater than the maximum hardness reported in the mockup. Tubes with greater hardness shall be rejected. Further hardness testing shall be done, if required by Authorized Inspector.

6.0 TUBE HOLES IN TUBESHEETS

Tube holes in tubesheets shall be drilled as per TEMA special close fit for shell and tube exchangers and as per API 661 special close fit for air coolers. For example, metric tube of size 20 mm OD, the nominal size of tube holes shall be 20.20 mm with tolerances as $\pm$ 0.05 mm, for 25 mm OD tubes, nominal size of holes shall be 25.25 mm with tolerances as $\pm$ 0.05 mm and so on.

Tube holes in tubesheets shall be drilled or drilled and reamed to final size and surface finish. Grooves shall be machined in the tube holes as per 7-15-0006. Tube holes shall have no burrs or scoring marks and shall be circular with parallel sides and normal to the tubesheet surface. Longitudinal and spiral scratches are not permitted. Edges of the tube holes shall be deburred and chamfered as per the figure in 7-15-0006. Tube holes shall have surface finish to 63 AARH or better & shall be cleaned prior to assembly.

7.0 ASSEMBLY AND EXPANSION

7.1 Care shall be taken during assembly to avoid scoring of tube holes in tubesheet or outer surface of the tubes. The tubes shall be positioned so that their projection from the tubesheet is as per 7-15-0006. For vertical shell & tube exchangers, the tubes are required to be flush with top tubesheet unless specified otherwise.

7.2 Tube expanders used by the fabricator shall be electronically or pneumatically or hydraulically controlled type and shall be in good condition and shall have the Authorized Inspector's approval. The tube expanders shall have 'stops' to prevent the rollers approaching nearer than 3 mm to the back of the tube sheet.

7.3 Expansion of tube into tubesheet shall be done as per the established procedure.

7.4 Tubes shall be expanded for the full thickness of the tubesheet leaving 3 mm (minimum) at the backside face of the tubesheet. However, for tubesheet thickness more than 55 mm, the expansion may be limited to 51 mm from the tube side face and remaining portion to be contact expanded leaving 3 mm (minimum) to 6 mm (maximum) at the back of tubesheet. Contact expansion shall have thinning of 3 - 5% which shall be ensured by measuring the ID of tubes.

7.5 Care shall be taken to avoid any distortion of the tubesheet or gross deformation of the ligaments. It is suggested that tubes be expanded systematically in small, diametrically opposite groups. The tube expansion shall be uniform on the whole expanded length. There shall be no abrupt transition at junction with unexpanded zone.

7.6 A check shall be made of the percentage thinning on tubes selected by Authorized Inspector and the results recorded and compared against percentage thinning figures of the procedure test.

8.0 TESTING

8.1 After expansion of all joints is completed on the job tubesheet, tubesheet face and the internal surfaces of the tubes to a length of about 15 mm shall be thoroughly cleaned. Any grease or oil shall be suitably removed using proper solvent or steam jets. These joints shall then be subjected to pneumatic air-soap solution test of 1.25 kg/cm^2 (g). Leaking tubes shall be further expanded, in the presence of Authorized Inspector after the reasons for the leakage are

ascertained and accepted by the Authorized Inspector. If the % thinning is greater than 15% for carbon steel and low alloy steel combinations and 12% for non ferrous and stainless steel combinations, then the defective tube shall be replaced and re-expanded.

8.2 Joints shall also be subjected to hydrostatic leakage test at a test pressure indicated in the drawings or requisition for at least one hour. Leaking tube, if any, may be further expanded keeping the guide lines given above in view.

9.0 INSPECTION

Inspection of the equipment shall be carried out as per the purchase order by the Authorized Inspector. For expanded tube to tubesheet joints, following stages of inspection shall be observed and reported:

a) Agreement regarding expansion procedure. If procedure testing is to be carried out, then all preparations, cut samples, test results etc. shall be inspected by the Authorized Inspector.

b) Inspection of tube ends. Special attention shall be paid to tube dimensions & hardness. These shall be within the specified tolerances.

c) Approve any repair procedure to rectify defective tube end.

d) After tube holes in the tubesheet have been drilled, and / or reamed and grooved, all tube holes shall be given a careful check for:

   i) Tube layout pattern and locations.

   ii) Tube holes meeting requirements of clause 6.0 above. Also, it is to be checked that grooves in tube holes are located properly and of required dimensions.

   iii) Minimum ligament width as per TEMA or API as applicable.

e) Check the tube projection before expansion is to be started.

f) Agree to the sequence of expanding tubes into the tubesheet holes.

g) Check for distortion of tubesheet and thinning of tubes after expansion is complete.

h) Witness pneumatic & hydrostatic testing.

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STANDARD SPECIFICATION

FOR U-TUBES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.11.23	REVISED AND REISSUED AS STD. SPEC.	MKP	TK	KA/NK	MN
5	22.09.17	REVISED & REISSUED AS STD. SPECN.	SK	KJH	RKT	RN
4	15.11.11	REVISED AND REISSUED AS STD. SPECN.	KA	RKT	AKM/SC	DM
3	17.02.06	REVISED & REISSUED AS STD. SPECN.	AKM	PK	AKM	VJN
2	01.09.99	REVISED & REISSUED AS STD. SPECN.	AKM	PK	RKA	AS

Abbreviations:

AI	:	Authorized Inspector
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing and Materials
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
MD	:	Maximum or minimum outside dimension at bent portion
OD	:	Outside Diameter
TEMA	:	Tubular Exchangers' Manufacturers Association

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar

Members:
Mr. K. Anjaneyulu
Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
Mr. P V S Satyanarayana
Mr. Anish Trehan
Mr. Saikat Chakraborty
Mr. Piyush Suryavanshi
Mr. Mittal Kumar Patel
Mr. Srikanth Karanam
Mr. Ayush Mathur (Projects)
Mr. Prabhakar Choudhary (SMMS)
Mr. Avdesh Agarwal (SCM-Inspection)

CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for materials, manufacture, inspection and testing of U-tubes required for installation in shell and tube heat exchangers.

2.0 CODES AND SPECIFICATION

The following standards/ specifications with latest edition shall be used :

ASME Section II Part A & B
ASME Section VIII Division 1
TEMA
IBR, if applicable
EIL Specification No. 6-15-0001

3.0 MATERIAL

3.1 Tubes required for the manufacture of the U-bends shall meet all the requirements of EIL Specification No. 6-15-0001 and the Codes mentioned above.

3.2 Tube thickness specified in the datasheets and/or drawings are minimum before forming.

3.3 Low carbon austenitic Stainless steel type 304L, 316L in solution annealed condition or stabilized austenitic stainless steel grades 321, 347, 316 Ti in solution annealed followed by thermal stabilization heat treatment condition shall be used. The other austenitic stainless steel type may be used with the restriction of Carbon content similar to its equivalent Low Carbon grade.

4.0 MANUFACTURE

4.1 All U-tubes shall be formed from a continuous length of tubing, free of girth welds.

4.2 The minimum mean radius of U-bends of tubes shall be 2 times the OD of the tube, unless specified otherwise.

4.3 U-tubes shall be manufactured only from seamless tubes. Welded tubes shall not be used.

4.4 All U-bends shall be cold formed.

4.5 Thinning

Thinning of tubes after bending shall be as per TEMA. One tube for each material and size shall be bent to the specified minimum radius and cross sectional thickness measured at 4 points i.e. 0°, 30°, 60° & 90° from tangent line of U-bend.

4.6 Flattening

4.6.1 Flattening after bending shall be within the range given below unless approved otherwise:

Minimum radius of bend	Flattening
Up to 2 x OD	± 10%
Greater than 2 x OD	± 5%

4.6.2 Flattening shall be calculated as below:

$$\% \text{ Flattening} = \frac{MD - OD}{OD} \times 100$$

4.7 Centre to Centre Distance

Centre to centre distance shall be measured at the tangent line of the U bend and shall have the following tolerances:

Bend Radius	**Tolerance (mm)**
R < 5 x OD	± 1.0
R ≥ 5 x OD	± 1.5

4.8 The bent portion shall be substantially uniform in curvature and shall not exceed ± 1.5 mm of nominal centre line radius.

4.9 Permissible deviation from the plane of bend shall not exceed 1.5 mm as measured from the point of tangency.

5.0 HEAT TREATMENT

5.1 Killed Carbon Steel, Low Temperature Carbon Steel, 3½% Ni, Low Alloy Steel U-tubes up to 5 times tube OD bend radius shall be stress relieved after bending over U-tube plus 300 mm (min) beyond the point of tangency.

5.2 U tubes up to 5 times tube OD bend radius shall be subjected to solution annealing heat treatment after bending over U- tube plus 300 mm (min.) beyond the point of tangency for low carbon austenitic stainless steel types 304L, 316L or stabilized grades austenitic stainless steel type 321, 347, 316Ti.

5.3 For copper and copper alloys, U-tubes shall be stress-relief annealed after bending over U bend plus 300 mm on each straight length beyond the point of tangency, irrespective of bend radii.

5.4 For nickel and nickel alloys and titanium and titanium alloys, U- tubes shall be heat treated if it is specified in the datasheets/ drawings. The heat treatment procedure for U-tubes shall be agreed with the consultant/owner.

5.5 For duplex stainless steel and super duplex stainless steel tubes heat treatment shall be done only if specified in the data sheets/drawings.

5.6 For ferritic stainless steel and martensitic stainless steel, U-tubes shall be stress relieved only if specified in datasheet/drawings. Stress relieving, if applicable shall be carried out, on the U-bend plus 300 mm (minimum) beyond the point of tangency.

5.7 Tube bending lubricants, oil, grease, etc., shall be removed from U-bends before stress relieving. Internal surfaces of austenitic stainless steel tubes above mentioned shall be checked for cleanliness by blowing close fitting acetone soaked felt plugs. Dry, oil free air or nitrogen shall be used for blowing the plugs. If plugs show more than a light gray discoloration, the tubes shall be recleaned and retested.

5.8 Temperature during heat treatment shall be controlled through the use of optical pyrometers or emission pyrometers or both. Temperature indicating crayons, lacquers or pellets shall not be used.

5.9 Methods for Heat Treatment

5.9.1 **Electric Resistance Heat Treatment**

5.9.1.1 Heat treatment by electric resistance heat treatment is acceptable for most materials except ferritic and martensitic SS and chrome-moly steels, and is always recommended for austenitic stainless steel.

5.9.1.2 The close control of tube temperature during heat treatment shall be monitored with the use of thermocouples or calibrated optical pyrometer on the straight tangent near a U- bend. The heat treatment temperatures among the readings shall not be deviated by ±15°C as specified in the Code.

5.9.2 **Furnace Heat Treatment**

5.9.2.1 U-Tubes shall be properly supported above the furnace floor.

5.9.2.2 Establish a procedure on lines similar to Cl. 5.9.1.2. Proposed procedure shall be submitted to the AI and approval obtained prior to actual heat treatment.

5.10 Heat treatment temperatures by furnace and/or electric resistance methods shall be as given in the respective product specification or in the Code, subject to a maximum variation of ±15°C. The stress relief heat treatment temperature shall be at least 25°C below the minimum tempering temperature used for the original material.

In the case of duplex stainless steel, cooling after the solution annealing shall be carried out by using forced air, inert gas blast or water quenching.

5.11 The applicable stainless steels U-tubes as mentioned above in this specification shall be pickled and passivated as per ASTM A380 after heat treatment, employing a previously qualified procedure acceptable to Purchaser/ EIL.

6.0 INSPECTION & TESTING

6.1 All U-bends shall be visually inspected to detect any harmful effect.

6.2 All U-bends with bend radii less than 5 times the tube OD shall be inspected for thinning, flattening, centre to centre distance, bend curvature and for the deviation from the plane of bend, to ensure conformance to the limits specified. U-bends with bend radii greater than 5 times the tube OD shall be inspected randomly at the discretion of the AI, subject to a minimum 1 tube per one bend radius batch.

6.3 For austenitic stainless steels above mentioned, IGC corrosion test shall be carried out as per ASTM A262 practice-E after final heat treatment unless stated otherwise. Specimen after exposure to the IGC environment shall be bent as per A262 practice-E and shall be examined with minimum magnification of 200x. The acceptance criterion is that the bent specimen shall be free of any cracks or grain dropping. The microstructure shall be submitted to Purchaser/EIL or AI for approval.

6.4 After heat treatment and final cleaning of U-bend tubes, the same shall be subjected to hydro-testing at a pressure of 70 kg/cm^{2}g or tube side test pressure (whichever is greater) prior to assembling the tube bundle. Minimum holding time shall be 2 minutes. Hydrotest reports shall be submitted to Purchaser/EIL or AI for approval.

वेंडर-परिकल्पित शेल एवं ट्यूब हीट एक्सचेंजर्स के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR VENDOR-DESIGNED SHELL AND TUBE HEAT EXCHANGERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	26.04.24	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKP	TKh	HCP/NK	MN
5	17.09.18	REVISED AND REISSUED AS STANDARD SPECIFICATION	KS	KA	KJH	RKT
4	22.03.10	REVISED AND REISSUED AS STANDARD SPECIFICATION	KA	RKT	AKM	DM/ND
3	26.03.04	REVISED AND REISSUED AS STANDARD SPECIFICATION	JV	PK	SSA	SKG
2	20.06.98	REVISED AND REISSUED AS STANDARD SPECIFICATION	RV	PK	RKA	AS

Abbreviations:

API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
BHN	:	Brinell Hardness Number
CAF	:	Compressed Aramide Fiber
CS	:	Carbon Steel
EJMA	:	Expansion Joint Manufacturers' Association
FEA	:	Finite Element Analysis
FEM	:	Finite Element Method
FV	:	Full Vacuum
HTRI	:	Heat Transfer Research Institute
IBR	:	Indian Boiler Regulations
ISO	:	International Organization for Standardization
LAS	:	Low Alloy Steel
MDMT	:	Mean Design Metal Temperature
NB	:	Nominal Bore
OD	:	Outer Diameter
SS	:	Stainless Steel
TEMA	:	Tubular Exchangers Manufacturers' Association
WRC	:	Welding Research Council

Static Equipment Standards Committee

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Mr. Prabhakar Choudhary (SMMS)
Mr. Avdhesh Agrawal (SCM-Inspection)

1.0 GENERAL

1.1 Scope

1.1.1 This specification is intended to cover minimum requirements for thermal and mechanical design of shell & tube heat exchangers. It shall be read in conjunction with EIL specification no. 6-15-0001, which covers requirements for materials, fabrication, workmanship, inspection, testing and supply of unfired shell and tube type heat exchangers.

In case thermal design is furnished by Purchaser, clause 2.2 on Thermal Design is not to be considered.

1.1.2 The intent of this specification is to supplement, amend or limit the reference codes and standards mentioned.

1.1.3 This specification shall not be considered limiting and it shall be Vendor's responsibility to comply with all requirements of Material/Purchase Requisition/Bid documents to which this specification is attached.

1.2 References

Following codes and standards etc. shall be followed in their latest editions and addenda, errata, amendments unless specified otherwise:

1.2.1 TEMA Standards (Class shall be as per data sheet/drawings else Class R shall be applicable)

1.2.2 ASME Section II

1.2.3 ASME Boiler and Pressure Vessel Code Section VIII, Division 1, Unfired Pressure Vessels (hereinafter referred to as Code)

1.2.4 API Standard 660, Shell and Tube Heat Exchangers for General Refinery Services/ ISO 16812 Petroleum and natural gas industries – Shell and Tube Heat Exchangers.

1.2.4 National, State and local laws and codes such as IBR etc.

1.2.5 EJMA Standards

1.2.6 EIL Project Design Basis

1.2.9 Licensor Drawings, Specifications and Standards attached with the bid package

1.2.8 EIL Specifications and Standards attached with the bid package

2.0 DESIGN

2.1 General Requirements

Exchangers shall comply with the above referenced codes and standards etc. and shall be suitable for ASME Code stamping when required.

2.1.1 Vendor shall strictly follow the design information issued by the Purchaser. Any comment and/or reservations shall be resolved with the Purchaser at the bidding stage. Reservations/ deviations not accepted during bidding stage shall not be reopened during the job execution.

2.1.2 Material of construction may be specified in the requisition/datasheets in general terms. Material shall conform to relevant ASME Specification or equivalent. Castings shall not be used.

2.1.3 Design Pressure

a) The design pressure shall be as indicated on respective drawings/data sheets. However, minimum design pressure shall be 5 kg/cm^{2}g.

b) Parts subjected to both shell & tube side fluids shall be designed for higher of two pressures, unless specified otherwise. In case of FV on any one side, the design pressure on other side shall be increased to account for negative pressure of side under vacuum.

c) When design pressure is specified as FV the same shall be taken as external pressure of 1.055 kg/cm2g.

d) Where tube bundles are designed for the differential pressure, Vendor shall provide visible warning plate adjacent to name plate outlining test pressure regulations.

2.1.4 Design Temperature

a) The design temperature shall be as indicated on respective drawings/data sheets.

b) Parts in contact with both shell & tube side fluids, shall be designed for more severe of the temperature conditions

c) MDMT shall be taken as lower of 0°C or the design temperature unless lower MDMT is specified elsewhere.

2.1.5 Tube to Tubesheet Joints

Tube to tube sheet joints shall be "expanded in grooves" type except that the tube-to-tube sheet joint shall be "strength welded" for following cases:

a) When specified in Process Licensors' requirements/Datasheets.

b) When "seal welded joint" is specified in Process Licensors' requirements/Datasheets.

c) Service requirements such as lethal service, product quality contamination not tolerable, hazards of intermixing of shell and tube fluids etc.

d) When ratio of tube OD/thickness < 6 for non ferrous and < 8 for ferrous materials.

e) For H_2 service with partial pressure > 7 kg/cm^{2}g (except when brass material is used).

f) For materials where reliable expanded joints are difficult to achieve e.g. duplex materials.

g) When tube hardness or yield strength exceeds that of tube sheet.

h) Low temperature service.

i) When shell or tube side design pressure >50 kg/cm^{2}g & design temperature > 400°C.

j) When shell or tube side design pressure > 70 kg/cm^{2}g.

k) For different co-efficient of thermal expansions of tube and tube sheet materials, the limitation of design temperature as per ASME Section VIII Division 2, Clause 4.21.1.1 f (2) shall apply, and may warrant welded joints.

2.1.6 Extended type tube sheet shall be used with stab in bundles, with bolt holes of tube sheet threaded. Also, the studs in this case shall be square ended for holding/tightening.

2.2 Thermal Design

2.2.1 Vendor's thermal designs shall be vetted by EIL on HTRI's Xist computer software (latest version) for adequacy, including safety against failure due to flow-induced vibration and acoustic vibration. This is the minimum requirement and Vendor shall make necessary changes in design to ensure compliance to HTRI. However, Vendor can provide higher area/more conservative design as per their design practices and shall submit the thermal design calculations/computer outputs for EIL review.

The requirement specified in this clause 2.2.1 is not mandatory for pre/inter/after condenser or any heat exchangers which are a part of vacuum ejector systems/hybrid ejector systems. Vendor can use in house software for thermal design of such heat exchangers and shall submit the thermal design calculations/computer outputs for EIL review. Other sections (i.e. 2.2.2. to 2.2.7) to be taken care for vacuum ejector system.

2.2.2 Maximum overall heat transfer coefficients may be specified for certain services based on operating experience. For these items, the allowable pressure drops on shell side and tube side should be utilised as fully as possible. However, the Vendor is responsible for performance of the equipment as per the requisition.

2.2.3 Minimum velocity of cooling water inside tubes shall be 1.0 m/sec. Cooling water velocity inside tubes shall be kept as high as the allowable pressure drop permits, but not > 4.0m/sec for Titanium, 2.0m/sec for Admiralty Brass & Cu-Ni and 2.5m/sec for CS, LAS and SS tubes. For all metallurgy, minimum and maximum velocity constraints to be followed, unless otherwise specified.

2.2.4 Vibration

It is Vendor's responsibility to check and confirm that exchangers are free from any flow induced vibrations. The statements of TEMA clause numbers G-5.4 and RCB-4.56 referring to vibrations are not acceptable.

2.2.5 Baffles

Baffles should be either single segmental or double segmental. Triple-segmental baffles shall not be used. "No tubes in window" design may be used to avoid flow-induced vibrations.

2.2.6 Impingement Plate

Impingement plate shall be no closer to the inlet nozzle than is required for escape height and flow area. Vendor shall perform bundle entrance and exit area calculations, and submit to EIL/Purchaser for approval.

a) Impingement plates shall be a solid plate that extends at least 50mm beyond the nozzle bore. It shall be of sufficient size so that the distance from the projected inside of the nozzle to the edge of the plate, in any direction, is at least equal to the distance of the plate from the nozzle opening.

b) Perforated impingement plates are not permitted.

2.2.7 For other special applications such as kettle reboilers, kettle steam generators, slurry handling, HF acid service, Hydrogen service etc. applicable special constructional features as indicated in the requisition shall be applicable.

2.3 Mechanical Design

Mechanical Design of heat exchangers shall be done on an internationally reputed software such as PV Elite etc. No hand calculations are acceptable.

During the design of shell & tube heat exchangers, consideration must be given to the stresses induced at operating, alternate operating, empty, hydrotest, start-up, shutdown, steam out, dry out and other upset conditions.

2.3.1 Nozzles

a) All flanges shall be of weld neck type.

b) Integral reinforced nozzles in accordance with ASME Section VIII Division 1, Figure UW-16.1 (g) are required if any of the following conditions is applicable:

i) The design pressure exceeds 50 kg/cm^{2}g.

ii) The design temperature is ≤ -10°C or ≥ 400 °C.

iii) Plate thickness in case of CS exceeds 50 mm and in case of LAS exceeds 25 mm.

c) Exchanger units shall be designed for the additional external loading from the connected piping etc. Same shall be as per EIL standard 7-12-0038 unless specified otherwise.

Vendor shall check the exchanger including nozzle flanges for these nozzle loads internal/external pressure and verify these loads by calculations. Stress calculations shall be carried out as per WRC Bulletin No. 107/297. WRC 107 shall be used for nozzles on dished ends and WRC 297 shall be used for nozzles on cylindrical shell.

In case of failure due to WRC, FEM analysis/PD 5500 analysis can be carried out to establish the adequacy of provided configuration.

d) Where exchanger centre line is sloping with respect to horizontal, the flange faces of nozzles shall be true horizontal/ vertical as applicable.

2.3.2 Girth Flange Joints

a) All girth flanges shall be of forged hub type and shall have confined gasketed joints.

b) Tube sheets welded to shell/channel shall be provided with 'forged hub' in accordance with ASME Section VIII Division 1, Figure UW-13.3 when full radiography is required (refer clause 2.3.11 (b) (ii) to (vii) below).

c) Floating head flanges shall be provided with 'forged lip' in accordance with figure 1 b) (flanged and dish construction) of API 660 when full radiography is required as per clause 2.3.11 (b) (v), (vi) and (vii) below.

d) All girth flanges, floating head flanges & other internal flanges (such as for single pass floating head exchangers) shall be designed for full bolt load. In gasket seating conditions bolting area provided shall have the following minimum design margin over the code requirements:

i) 10% for floating head flange and other internal flanged joints.

ii) 5% for girth flanges.

2.3.3 Bolting and Flange Closures

a) All bolting shall conform to SA193 Grade B7 with nuts in accordance with SA194 Grade 2H unless specified otherwise.

b) For floating head flanges and other pressure holding internal joints, the bolts shall conform to SA193 Grade B7M with nuts in accordance with SA194 Grade 2HM, unless specified otherwise.

c) Vendor of exchanger unit shall guarantee tightness compatibility of their closure designs. This, especially, pertains to closures where designer amalgamates components having different thermal expansion properties.

2.3.4 Baffles/Support Plates

Minimum thickness of baffles and support plates shall be as per TEMA or twice the shell side corrosion allowance whichever is more. A suitable notch cut shall be provided at the top and bottom of each baffle and support plate for venting and draining of shell side of exchanger.

To avoid vibration in exchangers, the tube bundle design shall include the following:

a. For baffles spaced < 300 mm apart, the tube hole diameter shall not exceed the OD of the tube plus 0.5 mm. For baffles spaced 300 mm or more apart or for the support plates the tube hole diameter shall not exceed the OD of the tube plus 0.4 mm.

b. Tube holes in tube sheets shall be finished to the diameters and tolerances specified by TEMA for special close fit.

c. Use a full periphery distribution belt at the shell inlet or provide internal distribution space and impingement protection.

2.3.5 Sliding Strips/Rails

Sliding strips shall be provided for removable exchanger bundle with shell diameter greater than 450 mm, to facilitate insertion & pulling out of the bundle. Vendor may provide the same in smaller diameters also.

In kettle type shells, provide sliding rails continuously welded to shell for removable bundle, in order to facilitate sliding of bundle while being pulled out. Also, bundle retainer shall be provided for positioning and safety of the tube bundle.

2.3.6 Accessories for Testing

For testing of exchangers with removable bundle, following accessories shall be supplied:

a) Provide test ring for testing tube-to-tube sheet joint for all floating head type exchangers. The test ring shall be generally as per TEMA type, refer FIG. E-4.1.3-2.

b) Test flange shall be provided for the following cases:

i) For floating head exchanger when tube side test pressure is higher.

ii) For exchanger with U-tube bundle and non-extended tube sheet when channel is B-type and shell side test pressure is higher.

iii) For exchanger with U-tube bundle and non-extended tube sheet when tube side test pressure is > shell side test pressure.

iv) For stab in bundle & non-extended tube sheet.

c) Dummy shell shall be provided for the following cases.

i) For stab in bundle when shell side test pressure is higher than tube side.

ii) For floating head exchangers without shell cover (T type floating head).

d) For stacked exchangers, hydro test shall be carried out with all required interconnections made. This will require as many number of test rings as the number of exchangers in one stack, and in case of U-tube with bonnet type channel head or BES type exchangers, as many test flanges as number of exchangers in stack.

e) Any other accessory required due to special design.

2.3.7 Expansion Joints

For fixed tube sheet heat exchangers, whenever required, thick expansion joints shall be used. The thick expansion joints shall be flanged and flued type only. Thin expansion joints shall be avoided as far as possible. Written approval from EIL/Purchaser shall be taken prior to use of the thin expansion joints.

Requirements as noted below shall be followed with regard to expansion joints:

i) All CS thick expansion joints shall be stress-relieved. SS thick expansion joints need not be solution annealed.

ii) For SS thick expansion joints, use only low carbon or stabilized grade of steel.

iii) All expansion joints shall be provided with internal sleeve and shall have suitable venting/draining provision.

iv) Vendor shall submit design calculations showing actual spring load, actual deflection, total combined stresses and calculated cycle life based on actual dimensions, materials used and also fabrication procedure for review.

v) Thick expansion joints shall be designed per TEMA and ASME Section VIII Division 1 (UHX-17 and Appendix 5), while thin expansion joints shall be designed as per EJMA and ASME Section VIII Division 1(UHX-16 and Appendix 26).

vi) Material of thick expansion joint, sleeve, transition piece etc. shall be same as that of shell.

vii) All welds shall be 100% radiographed.

viii) Design cycle life shall be 500 startup/shut down cycles and 7000 operating cycles in the case of thin expansion joints & 750 operating cycles in case of thick expansion joints, unless specified otherwise.

For single pass floating head exchangers, internal thin expansion joints shall be provided to take care of bundle movement. Internal thin expansion joints shall be designed for full design pressure on each side with other side at ambient or specified vacuum condition. Internal thin expansion joints shall be hydraulically or mandrel formed type and such that permit easy replacement at site. Such thin expansion joints shall be of Alloy 600, Alloy 625, Alloy 800 or Alloy 825 materials.

The thin expansion joint/s shall be procured from reputed manufacturers only with adequate experience.

FEA of thick expansion joints

FEA of thick expansion joints of fixed tube sheet heat exchangers shall be carried out meeting the requirements of Section 5 of TEMA 9th Edition. Fatigue evaluation of the thick expansion joints shall be carried out in accordance with RCB-8.7 of TEMA 9th Edition guidelines. Description of computer

programs, assumptions, complete analysis and computer output with results shall be furnished to EIL. Computer programs shall have third party validation. In case of in-house programs hand calculations shall also be submitted.

Flanged and flued joints designed as per ASME Section VIII Division 1 and Section VIII Division 2 must meet following multiple Code requirements defined in:

- VIII-1 Part UG – allowable stresses, minimum thickness, etc.
- VIII-1 Part UHX -- load cases to be considered and method
- VIII-1 Mandatory Appendix 5 – details for designs of flanged and flued joints
- VIII-2 Part 5 – Fatigue

The stress analysis report to be submitted for EIL review shall include the following:

i) Introduction

   a) A brief description of the numerical method including the name and version of computer software used for the analysis to understand the applicability, input, output and validation of the software.

   b) Any assumptions used in the analysis.

   c) Copy of any literature referred to in the report.

ii) Basic inputs (dimensions, design data, material data, and loads etc.) and description of model geometry (including element type(s) for finite element analysis) for each model.

iii) Lengths of the modelled portions for different components at the junction.

iv) Prescribed boundary and loading conditions in each model.

   a) Points of application of the external loading.

   b) Description (with supporting literature) of any equivalent mathematical model used for the application of loads.

v) Description of the numerical analysis procedure (i.e. static analysis, thermal analysis (temperature and stress), buckling analysis, natural frequency analysis, dynamic analysis).

vi) A report on checking for aspect ratio and skewed angle for the elements.

vii) Colour plots of relevant results (numerical model, deformed plot, contour plots of thermal and stress results, and stress linearization results for all SCL's or any other items, wherever applicable). Black and white plots are not acceptable.

viii) Method used to validate the numerical model (i.e. mesh sensitivity review and equilibrium check for finite element analysis, e.g. check of hoop stress in component away from structural discontinuity and a check to ensure that global equilibrium is achieved between applied loads and reactions at specified boundary conditions).

ix) Summary of stress intensities (membrane, bending and total) at critical locations/ sections for all individual load cases separately (e.g. pressure load, individual nozzle load components, thermal load, seismic load) as well as for all relevant load combinations. The locations of these stresses must be clearly shown in the model mentioning the corresponding element/node numbers.

x) The results of fatigue analysis according to ASME Section VIII Division 2, Part 5.

xi) Codal stress intensity checks for all categories of stresses for all relevant load combinations.

xii) A3/A4 size copy of referred/relevant drawings.

xiii) Electronic storage of analysis results including input files and output files that contain numerical analysis results.

A stress analysis report, which ignores the above requirements, is liable to be rejected.

2.3.8 Equipment Supports

Supports shall be designed to withstand the most severe combination of live and dead loads anticipated during the normal life of the heat exchangers.

When EIL standards for equipment supports are not furnished to Vendor or are not followed by him following or equipment size falls beyond the range of EIL standards shall be ensured:

a. Equipment supports for heat exchangers shall be designed to withstand a pulling force of not less than 1.5 times the bundle weight, taken at the centre line of the exchanger. Analysis shall be based on L.P Zick's criterion. The exchanger supports shall also be adequate to ensure structural stability of the exchanger in basic configuration as required considering all superimposed loads. Detailed calculations shall be submitted to this effect.

b. Vertical exchangers shall be supported by lugs welded to wrapper plate in such a way that the shell is not overstressed or deformed. Alternate methods such as skirts, lugs or trunnions may be considered where necessary.

c. The shear stress for support shall be limited to 40% of the material yield strength.

d. In case of stacked exchangers, the lower shell(s) of stacked exchangers shall be designed to appropriately consider the load of upper shell(s) without distorting the lower shell and causing bending of tube bundles.

e. It shall be ensured that centre of gravity falls between the saddle supports for the horizontal heat exchangers and is below the bracket supports for the vertical heat exchangers for stability of the heat exchangers. Centre of gravity of heat exchangers shall be clearly marked on the drawings.

2.3.9 Vents, Drains and Other Connections

a) When tube side fluid is steam, a 40 NB (flanged) operating vent connection shall be provided in the channel cover or bonnet head at high point of second pass.

b) When shell side fluid is steam, 40 NB (flanged) shell side operating vent connections shall be provided as follows:

i) Horizontal units - one vent, located below centerline at the end opposite the inlet.

ii) Vertical units - two vents required, one below horizontal centerline at the end of steam travel and one near the top.

c) For total condensing service, provide a flanged 40 NB vent nozzle on top of shell at end opposite to shell inlet. For stacked units, provide a vent nozzle in each shell. Rating, flange facing etc. shall be equal to that provided for main shell side nozzles.

d) All vertical fixed tube sheet exchangers shall additionally be provided with proper vent/drain through tapped holes in tube sheets.

2.3.10 Gaskets

Gaskets shall be made in one piece. This shall however not mean exclusion of gaskets made integral by welding, provided the weld area is not harder than the adjoining material and has the same corrosion resistance. Where galvanic corrosion is envisaged, gasket material shall be compatible with or nobler than the surrounding materials.

a) Copper and brass gaskets are not permitted when fluids contain H_2S or amines.

b) Aramide filler used for jacketed gaskets is not to be of compressed type.

c) Asbestos is not to be used

d) CAF gaskets when used shall be 2 thick and shall be used only in utility services like air, water, and steam up to 150oC and with nozzle flange rating of up to 150 psig. CAF gaskets shall not be used at temperature less than 0oC, and for vacuum service (except in steam). These gaskets shall not be used in internal joints/flanges.

e) Solid metal gaskets & metal of jacketed gaskets shall be dead soft annealed.

f) Hardness of the solid metal gasket shall be at least 15-20 BHN lower than the gasket seating face.

g) For duplex and super duplex heat exchangers - alloy 625 spiral wound or alloy 625 Jacketed Aramide shall be used.

2.3.11 Radiography

a) The minimum extent of radiography shall be spot.

b) Heat exchangers which fall under the following categories shall be fully (100%) radiographed:

i) For exchangers under IBR
ii) Where the relevant design code and/or specification does not permit a lower class of construction.
iii) All Cr-Mo steels
iv) Low temperature service
v) Lethal service.
vi) Whenever required by Code based on adopted thickness and material of construction.
vii) Special services such as Hydrogen service, wet H_2S (Sour gas service) etc.

3.0 DESIGN REVIEW & VENDOR DATA REQUIREMENT

The Vendor shall submit the mechanical & thermal design calculations in accordance with the requisition/bid document. EIL's review of calculation shall not relieve the Vendor of his responsibility in any manner. The fabrication drawings and other documents shall also be submitted in accordance with the requisition/bid document.

4.0 GUARANTEE

Unless otherwise specified in General Purchase Conditions (GPC) regarding guarantee, the following shall govern:

The Vendor shall guarantee the equipment for design, materials, workmanship and specified

performance for a period as specified in GPC. Defects/short falls, if any, shall be made good by the Vendor at his cost by repair and/or replacement without any delay.

5.0 PATENT INFRINGEMENT

Vendor shall defend any and all infringement suits in which the Purchaser and/ or EIL is made a defendant, alleging patent infringement on equipment purchased from Vendor. Vendor shall pay all costs and expenses incident to any such litigation. It being further agreed and understood, however, that Purchaser and/or EIL shall have the right to be represented therein by counsel, of their own selection and paid by them. Vendor shall pay all damages, profits and/or cost which may be awarded to the plaintiff in any such litigation; and, in general, shall defend Purchaser and/or EIL against all claim or demand of every kind to which they may be subjected under the patent laws, in connection with equipment purchased under this specification.

एयर कूल्ड हीट एक्सचेंजर्स के लिए सामान्य विनिर्देश

GENERAL SPECIFICATION FOR AIR COOLED HEAT EXCHANGERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	08-05-2024	* REVISED & REISSUED AS STANDARD SPECIFICATION	MKP	TKh	KA/NK	MN
5	18-09-2018	REVISED & REISSUED AS STANDARD SPECIFICATION	SK	KA	KJH	RKT
4	18-08-2010	REVISED & REISSUED AS STANDARD SPECIFICATION	KA	RKT	AKM DM	ND
3	25-03-2009	REVISED AND REISSUED AS STANDARD SPECIFICATION	KA	PK	AKM	ND

Abbreviations:

ACHE	Air-cooled heat exchangers
AI	Authorised Inspector
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing of Materials
AWS	American Welding Society
BIS	Bureau of Indian Standards
BHN	Brinell hardness number
BV	Bureau Veritas
CA	Corrosion Allowance
CAF	Compressed Aramide Fibre
CCE	Chief Controller of Explosives
CIMFR	Central Institute of Mining & Fuel Research
CS	Carbon Steel
DFT	Dry Film Thickness
DNV	Det Norske Veritas
DP	Dye Penetrant Test
DPDT	Double pole double throw
FM	Factory Mutual
FRP	Fibre Reinforced Plastics
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
HP	Horse Power
HTRI	Heat Transfer Research Institute
IEC	International Electrochemical Commission
I/P	Current to pneumatic converter
LAS	Low Alloy Steel
LP	Liquid Penetrant Test
LTCS	Low temperature CS
MDMT	Minimum design metal temperature
MP	Magnetic Particle Test
NACE	National Association of Corrosion Engineers
OD	Outside Diameter
PESO	Petroleum & Explosives Safety Organization
PTC	Production test coupons
SS	Stainless steel
SPDT	Single pole double throw
STAAD	Software for structural design
UL	Underwriters Laboratory
UST	Ultrasonically Tested

Static Equipment Standards Committee

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Mr. Avdhesh Agrawal (SCM-Inspection)

A. SCOPE

This specification covers the general requirements for the thermal and mechanical design, materials, fabrication, workmanship, inspection, testing and supply of ACHE and is intended to supplement the minimum requirements of the applicable codes and standards.

In case Purchaser furnishes thermal design, Clause-7.0 under Section-7 of this specification on thermal design is not to be considered. In case thermal and mechanical designs are done and engineering drawings furnished by Purchaser, then details given in these engineering drawings take precedence over this specification.

This specification shall not be considered limiting and it shall be Vendor's responsibility to comply with all requirements of Material Requisition/Purchase Requisition/Bid Documents (referred to as enquiry documents), to which this specification is attached.

B. SPECIFIC REQUIREMENTS

The Standard applicable for ACHEs shall be API Standard 661, Seventh Edition July 2013 except to the extent modified hereunder. The section, paragraph and figure numbers refer to those used in API 661. "New" applies to entirely new paragraph presently not included and to be inserted in the numbering order of API-661. "Addition" applies to an addition to the original Para. "Modified" applies to modification of applicable portion of the API-661 Para.

4. GENERAL

4.1 The pressure design code shall be ASME Section VIII Division 1, unless specified (Modified) otherwise. Hereinafter referred to as'Code.

4.4 (Addition) For ACHE to be installed in India, Vendor shall comply with all applicable local regulations like approval from CIMFR, PESO, and CCE etc. for all electrical and instrument items.

4.6 (Addition) Service of the ACHE (sour service or wet hydrogen sulphide service) shall be as indicated in the Requisition.

5. PROPOSALS

5.11 (New) The proposal shall include power consumed by the motor and required motor HP.

6. DOCUMENTATION

Vendor shall furnish documents as per Vendor Data Requirements specified in the requisition.

7. DESIGN

7.0 (New) **Thermal Design**

7.0.1 The Vendor shall do thermal rating when specified. Thermal design proposed by the Vendor will have to be in order as per HTRI software. This includes adequacy of heat transfer area and tube and airside pressure drops. If any modifications are required to be carried out by the Vendor in order to make the thermal design acceptable as per HTRI software, the same will be done without any cost and delivery implications.

7.0.2 If an ACHE has to satisfy more than one process condition, separate "Equipment Data Sheet" shall be furnished for each condition. The relevant process condition number shall be given in the heading of each sheet.

7.0.3 ACHE design shall take into account operation at part load. This is important for viscous materials (>=5cP) and those with high pour points. Vendor shall consider the following:

The inside tube wall temperature shall be a minimum of 10 °C (18 °F) above the pour point. This condition shall be satisfied for the lowest part-load design case with the air entering at winter design temperature. The provision of counter or parallel flow piping arrangement, air re-circulation and/or heating coils may be necessary to achieve this.

In cases where the process fluid may solidify or become highly viscous when flow is interrupted or for systems where there is a maximum allowable cooling rate, e.g. deposition of ammonium carbonate, steam heating & control shall be incorporated for start up & shut down.

7.0.4 The varying air temperature across the rows of a single pass condenser results in unequal performance. Employing variable fins per inch in the individual rows with the lowest in the bottom row and highest in the top row should eliminate this.

7.1 Tube Bundle Design

7.1.0 (New) Vendor shall strictly follow the design information issued by the Purchaser. Any comment and/or reservations shall be resolved with the Purchaser at the bidding stage. Reservations or deviations not accepted during bidding stage shall not be reopened during job execution.

7.1.1.8 (Addition) There shall be practically no air gaps in bolted joints (plenum to beam, in between parts of plenum etc.). However, these gaps shall be limited to 0.5 mm (maximum).

7.1.1.13 (New) The bundle side frame shall have minimum 5 mm thickness for tube lengths less than 6 m and bundle width up to 2 m and shall have 8 mm thickness (minimum) for greater tube lengths or bundle widths. Only one joint is permitted in the frame. The weld, if any, shall be full penetration weld, shall be ground flush from inside and DP tested.

7.1.1.14 **Tube to tube sheet joints**

(New) Tube to tube sheet joints shall be expanded type except that the tube to tube sheet joints shall be welded for the following cases:

a) Critical service requirements such as lethal, hydrogen service with hydrogen partial pressure > 7 kg/cm^2 (g), etc.

b) For duplex and super duplex materials where reliable expanded joints are difficult to achieve.

c) When specified in Process Licensor's requirements or datasheet.

d) Tube hardness or yield strength exceeds that of tube sheet.

e) When design pressure > 50 kg/cm^2 (g) and design temperature is > 400 °C.

f) When design pressure > 70 kg/cm^2 (g) and design temperature is > 300 °C.

g) For sour service with SS tubes and tube sheet.

7.1.3. **Tube Bundle Design Temperature**

7.1.3.1 (Addition) ACHE MDMT shall be taken lower of 0 °C or the design temperature specified in the equipment drawing or Design Basis.

7.1.3.2 (Addition) Extruded fins may be used for design temperature up to 288 °C (maximum). Embedded 'G' fins may be used for design temperature up to 400 °C (maximum). Beyond 400 °C, only welded fins shall be used. For ACHEs in offshore service, extruded fins shall be preferred.

7.1.6 **Headers**

7.1.6.0 **Type of header**

(New) The type of header as specified by Purchaser shall be adopted. In general cover plate type headers shall be used when fouling resistance is greater than 0.0004 $hrm^2°C/kcal$. Plug headers shall be provided for services such as hydrogen, lethal, sour, amine, design pressure greater than 50 kg/cm^2 (g).

7.1.6.1.2 (Addition) If the operating temperature exceeds 180 °C, a split header shall be provided after first tube pass of multi pass bundle.

7.1.6.1.4 (Modified) Header shall be designed so that the inter pass cross-sectional flow area is at least 130% of the flow area in the previous tube pass.

7.1.6.1.6 (Addition) The minimum tube sheet thickness for expanded tube to tube sheet joint shall be 25mm for CS and LAS materials with 3mm CA and 22mm for SS material with no CA, to ensure two grooves for expansion. For higher CA, minimum thickness shall be increased by the additional CA (e.g. CA in excess of 3 mm for CS or LAS, etc.).

7.1.6.1.9 (New) Even number of passes are preferred for simplicity in piping layout. Process nozzles shall be at the fixed header end to minimise thermal expansion stresses. Pass partition plates shall be provided with one 6mm diameter drain hole.

7.1.6.2 **Removable Cover Plate and Removable Bonnet Headers**

7.1.6.2.2 (Modified) Removable bonnet headers shall not be used.

7.1.6.2.3 (Modified) Bolted joints shall be designed with confined gasket only. Refer figure 4 A and B for typical confined joint detail. Use stud bolts for header flange and cover plate joint.

7.1.6.3 **Plug Headers**

7.1.6.3.4 (New) For strength welded tube to tube sheet joint, if clearance between the top/bottom/side/ partition plate and tube is less than 18mm or the plug size is less than tube OD plus 9mm, then Vendor shall demonstrate his experience by giving past references and by performing mock up to prove his capability in this regard. The mock-up shall be done before the submission of design or drawings.

7.1.7 **Plugs for Tube Access**

7.1.7.6 (Addition) Plug shall not project into the header box. In case of sour and lethal service, double plug shall be used for CS and LAS materials.

7.1.8	**Gasket**
7.1.8.7 (Modified)	Metal Jacketed (3 mm thick) gaskets shall be 13mm (minimum) wide all around. CAF (2 mm thick) gaskets shall be 19 mm (minimum) wide all round. Width of the gasket at pass partition shall be equal to the pass partition plate thickness.
7.1.8.8 (c)	The weld and HAZ is not harder than the parent material and has the same corrosion (new) resistance.
7.1.8.8 (d)	The pass partition ribs of metal-jacketed gaskets may be tack welded to the inside of (new) peripheral section.
7.1.8.10 (New)	The selection of gaskets in header flanges depends on the temperature, pressure and corrosivity of the fluid to be sealed. For cover type header, the gasket shall be CAF or metal-jacketed type with the metal compatible with cover and flange material. CAF may be used only for water, air, steam (up to 150 °C) with ASME 150 Class and if permitted as per Purchaser's specifications. CAF shall be 2mm thick only. Asbestos not to be used if not specifically permitted. For plug headers, only solid soft metal gaskets are to be used.
7.1.9	**Nozzles and other connections**
7.1.9.0 (New)	Maximum nozzle size shall be limited to 12"NB and where possible shall be restricted to 8"NB by splitting large flows into multi nozzles, if necessary. Header boxes having length more than 1800mm shall have minimum two nozzles for process inlet and outlet.
7.1.9.5 (Modified)	All connections shall be flanged irrespective of flange rating.
7.1.9.7 (Addition)	Bolt holes shall straddle principal centrelines.
7.1.9.8 (Addition)	Fabricated transition pieces wherever indicated in this clause shall not be permitted. Swaged CS nozzles shall be normalised if the thickness exceeds 16mm or if they are not formed in the normalising range. Hot-formed SS nozzles to be solution annealed. Slip-on flanges shall not be used. Lap joint stub in flanges shall not be used.
7.1.9.11/14/17/20 (Modified)	Threaded connections shall not be used.
7.1.9.15 (Modified)	If specified by Purchaser, additional chemical cleaning connection shall be minimum 2"NB. The type and location shall be as specified.
7.1.9.16 (Modified)	Multi-purpose connections shall be as per Design Basis.
7.1.9.22 (New)	All process nozzles of 3" NB and above shall be provided with 3 no. stiffeners and process nozzles of 2" NB and below shall be provided with 2 no. stiffeners. Size of stiffener shall be 50 wide x 8thk.
7.1.10	**Maximum allowable moments and forces for nozzles and headers**
7.1.10.5 (New)	Nozzles shall be designed for two times the nozzle load limit given in API 661. For Air coolers of 600# nozzle flange rating and above, the same shall be 3 times API 661 limit. Structural components shall be designed considering three times nozzles loads as given in API

irrespective of flange rating. Nozzle loads in excess of these loads, if specified by purchaser, shall be considered.

7.1.11 **Tubes**

7.1.11.3 (Addition) For extruded fins (integral type) the minimum tube thickness applies to the inner tube.

7.1.11.5 (Addition) Fins serrated on the outside edge may be used only for CS fins.

7.1.11.7 (Addition) L-fins shall not be used.

7.1.11.14 (New) The mechanical bond between tube and embedded fins shall be tested as follows:

i) Cut fin to obtain a sector with a chord of approx. 12mm at the root of the fin.

ii) Pull out the fin sector by hanging weights or any other appropriate method. Acceptance criteria shall be a force of at least 3.0 kg.

iii) 1% of the total number of tubes per size, fin diameter, fin pitch shall be tested at two locations along the tube length. Tubes, which pass the test, may be used after stitching of fin portions across the cut.

iv) In the event of any tube failing to comply with pull out test requirements, a further two tubes shall be re-tested and, if the results are satisfactory, the tubes can be accepted. If, however, the further test results are unsatisfactory, the entire lot of tubes shall be rejected.

v) The pulling test shall not be carried out within 25mm from each fin connection point.

Two cross-section cutaways shall be made for inspection of tube grooving and fin bonding per each machine setting (i.e. one tube for each type of tube and fin detail and minimum one test per order).

7.1.11.15 (New) The number of fins shall not exceed 433 per meter (11 per inch).

7.2 Air side Design

7.2.1.6 (Addition) If the control of air flow is to be achieved by use of auto variable fans or variable speed drives at least 50% of the fans are to be made auto variable, unless specified otherwise. Auto variable fans or variable speed drives, if used, shall be located towards that end of the bundle where inlet nozzle(s) is/are located.

7.2.1.8 (Addition) Drivers, gear boxes, transmission components, instrumentation, louver actuator and positioner etc. shall not be installed in the hot air stream.

7.2.2 **Noise Control**

7.2.2.1 Permissible noise level of the ACHE measured shall not exceed 85 dB (A) with all fans running at full load with measurement taken at 1 m from bundle on the header access walkways and 1 m from the bay limits on the motor maintenance platform. The permissible noise levels 1 m below the motor shall be 90 dB (A) maximum. Vendor shall demonstrate these noise level limits during run-in tests. Vendor shall guarantee these sound levels.

7.2.3 **Fans and Fans Hubs**

7.2.3.1 (Modified) Two or more fans aligned in the direction of tube length shall be provided for each bay. All fans in a bay shall be arranged for independent operation. Common fans cooling more than one process duty shall be used only on approval from Purchaser.

7.2.3.5 (Addition) Fans shall be designed for a noise level of maximum 80dB(A), keeping in mind the overall limits as per 7.2.2.1. Fan tip speed shall be suitably selected. Fan manufacturer shall furnish noise level datasheet for fans.

7.2.3.11(b) (Modified) Pneumatic actuator shall be equipped with a positioner. Each actuator shall have an integral positioner mechanism and mechanical maximum and minimum stops, adjustable over the full range. Exposed actuator shafts shall be chrome protected. Each actuator shall be provided with flexible hose (s), terminating in a 1/4" NPT screwed female connection.

The actuators shall be suitable for an air supply pressure of 9.5 kg/cm2(g) design, 7 kg/cm2(g) normal and 2.5 kg/cm2(g) minimum. Purchaser will specify the exact air supply pressure. Any pressure reduction system on the supply air, if required, shall be in Vendor's scope.

In general, an actuator operating range of 0.2 to 1.0 kg/cm²g is preferred.

7.2.3.11(c) (Addition) In case of loss of air pressure or control signal, the blades shall lock at maximum air flow position unless specified otherwise. In the event that the fan fails to respond in in this manner, means shall be included by the Vendor to physically lock the blades in high pitch position. Auto variable fans to be shop adjusted for variation between zero performance and design pitch required. Positioner to be supplied and set for full signal pressure range. Signal pressure for auto variable fan shall be 0.2 to 1.0 kg/cm2-(g) for zero flow to design flow unless specified otherwise. HP of motor to be selected based on the airflow at design pitch. Provide one I/P converter per item, unless specified otherwise. One volume booster shall be provided for each auto-variable fan.

I/P converter shall be of electronic feedback type unless specified otherwise and shall be yoke mounted. It shall have an integral terminal housing. I/P converter with flying leads shall not be acceptable. Unless otherwise mentioned, it shall be intrinsically safe. Pneumatic connections shall be 1/4" NPT (F). The electrical connections shall be 1/2" NPT (F). If they are different, suitable adapters shall be provided. The overall accuracy of the I/P converter shall be better than ±0.3%.

7.2.3.17 (New) Fan shall be selected so that the design under fouled condition satisfies the following requirements with reference to fan performance curves:

a) The design point shall lie on the performance curve for which fan blade angle is at least 5 degrees and preferably 10 degrees less than the largest blade angle at which fans operate satisfactorily.

b) The design point shall not lie on the performance curve in proximity to the stall region which the manufacturer shall indicate in the fan curves.

7.2.3.18 Air Cooler fans shall be procured from EIL approved suppliers list attached elsewhere (New) in the Package/Material Requisition.

7.2.3.19 (New) Fan datasheet shall be forwarded to motor supplier and frame size shall be able to take all torque/ loads/ thrust imposed by fan. Vendor shall submit necessary calculation after order.

Vendor shall obtain and furnish the fan details from fan supplier as per the fan specification sheet including fan GD^2value, torque vs speed curves, fan rpm etc. Vendor shall also furnish the drive make, motor make and frame size. Based on this data, the drive details shall be developed by vendor and submitted to EIL. Vendor shall furnish these drive details to the drive supplier and get the confirmation from him on the adequacy of the drive to transmit the required power. Vendor shall furnish to the motor supplier the requirements of GD^2, torque vs speed characteristics of fan and loads on motor from the drive affecting the selection of motor bearing, rating & frame size etc. Vendor shall ensure that the motor supplier has selected suitable motor as per motor specifications and datasheets for the conditions specified. Vendor shall obtain EIL approval for drive selection before procurement of the same.

Vendor shall furnish design calculation for fan shaft and motor shaft to EIL along with fan characteristic curves & motor datasheet for review/information. EIL comments, if any shall be fully complied with, and if required shaft size to be revised as per calculations without any cost and time implications.

7.2.3.20 Fan blades and assembly shall be balanced as per requirements of API 661 para (New) 7.2.3.7 and Balancing shall be according to ISO 21940 with balance quality grade G 6.3 or better

7.2.4 **Fan Shafts and Bearings**

7.2.4.0 (New) Fans shall be provided with QD bushes (minimum 10mm thickness) for attachment to fan shaft. Fan assemblies shall be fitted with their own thrust bearing situated at the drive end and a steady bearing at the outer end. The thrust bearing shall be capable of carrying any thrust loads transmitted by the driver. The thrust bearing inner race shall be mechanically locked by means of split rings to prevent accidental downward movement of shaft.

7.2.6 **Fan Guards**

7.2.6.1 (Modified) Removable galvanised steel fan guard shall be provided on each fan for forced as well as induced draft units. A hinged door shall be provided on the fan guard of fan diameter greater than 2m, to attend to problems without removing entire fan guard.

7.2.7.2 **Electric Motor Drivers**

7.2.7.2.1 (Addition) All electrical equipment shall be selected to suit the specified hazardous area classification, and the environment in which these have to operate. Area classification shall be as specified in the enquiry documents.

Vendor shall provide plate guards made from galvanized steel plates on the motor assemblies to avoid ingress of rainwater and capable of withstanding washing down by water hose. Details of the guards shall be developed by the vendor and submitted for information.

7.2.7.2.10 (New) Start and stop switches shall be provided for ACHE motors. Emergency stop switch shall also be provided at the grade. Supply of switches shall be as per requisition/ bid document.

7.2.8 **Couplings and Power Transmissions**

7.2.8.2 **Belt Drives**

7.2.8.2.1 Belt drives shall be high torque type, positive drive belts and shall be procured from (Modified) EIL approved suppliers list attached elsewhere in the Package/Material requisition.

7.2.8.2.4 (Addition) Belt drive tensioning means shall be adjustable without the need to remove the guard and without losing the alignment of the pulleys.

7.2.8.2.14 Pulley wheel shall be of cast iron or steel. All pulleys shall be dynamically balanced.

(New) Pulleys shall be thoroughly cleaned of rust, grease, and dirt and shall be shop coated. Belt drive pulleys shall be supplied by Vendors approved by belt supplier indicated in Para 7.2.8.2.1 and shall be certified accordingly.

7.2.8.2.15 (New) Belts shall be heavy duty, oil resistant, antistatic, fire resistant and have neutral twist and shall be selected to suit the specified hazardous area classification. Belt drives shall not be used for offshore applications where only gear box shall be used.

7.2.9 (Modified) **Vibration Sensors / Probes & Transmitters / Vibration Cut-out Switches**

Vibration Sensors / Probes & Transmitters shall be provided by vendor for vibration measurement and automatically stop fans at high vibration, unless specified otherwise. Vibration Sensors / Probes & Transmitters shall have the features as mentioned under point-(A) below and Vibration switches shall meet requirements given under point (B) below.

(A) Vibration Sensors / Probes & Transmitters (as applicable):

a) Fans to be provided with Vibration Sensors / Probes & Transmitters for trip and alarm to Purchaser's PLC. Start and stop push button at operating platforms shall be provided. Stop push button shall be provided at grade also.

b) Vibration Sensors / Probes shall be inertia sensitive type with the vibration range suitable for the offered fan. Alarm and Trip Value shall be provided by vendor.

c) The Vibration transmitters shall be two wired system, loop powered with 24V DC, 4-20 mA output, load driving capacity of 500 ohm (minimum).

d) Vibration Sensors / Probes & Transmitters shall be weatherproof to IP65, Intrinsically Safe suitable for specified area classification (IEC Zone 1, Gas Group-IIC). In addition to the certification from authorized agencies like CIMFR, FM, UL etc., the Probes/ Transmitters shall have the valid approval from statutory authorities of place of installation which is PESO/ CCE in case of Indian installations.

e) Vibration Sensors / Probes & Transmitters assembly shall have two cable entries as a minimum, each of ½" NPT size. In case vendor standard model does not support two entries, the Transmitter housing shall be supplied with integrally mounted 3-way junction box. The junction box shall be certified for specified area classification. Flying Lead wires are not acceptable. Additional openings shall be plugged with metallic blind plug.

f) Vibration Sensors / Probes & Transmitters shall be located at motor suspension beams as close to the motor as possible. Probes/ Transmitters shall be readily accessible for maintenance from platform without any interference.

g) Cable between Vibration Sensor/Probe & Vibration transmitter shall also be supplied by the vendor (consider cable distance of 30m for each Vibration Sensor / Vibration transmitter) along with junction box for termination of purchaser 12/6 (shall be informed during detailed engineering) pair signal cable. Junction box shall be weather proof to IP-65. Cable shall be armoured type only. Further cabling from Junction box to purchaser's PLC/DCS shall be in Purchaser's scope.

h) All cable glands from sensor to transmitter and from transmitter to junction box shall be supplied by vendor. Cable glands shall be with PVC cover suitable for armoured cable. All Cable entry to sensor/ transmitter & junction box to transmitter shall be ½ inch NPT. Vendor shall also provide cable gland for purchaser cable from junction box of 1.5 inch NPT. All unused entry ports in the junction box shall be provided with weather proof metallic plugs.

i) Vibration Sensors / Probes & Transmitters shall be supplied from manufacturer of repute and model shall have proven references of operating for a period of minimum 6 months, in the similar type of application. Vibration Sensors / Probes & Transmitters of prototype design or not having proven references shall not be supplied.

(B) Vibration Cut-out Switches:

a) Vibration switch shall have 2 nos. independent contacts for further wiring by Purchaser, one for alarm in DCS & other for tripping in MCC. Vibration high high alarm and tripping of fan shall be simultaneous. Start and stop push button at operating platforms shall be provided. Stop push button shall be provided at grade also.

b) Vibration switch shall be inertia sensitive type with the vibration range suitable for the offered fan. Set point shall be adjustable throughout the range i.e. 0 to 100%, and shall be adjustable externally without opening the switch housing. Switch shall have local as well as remote reset facility.

c) Unless specified otherwise, switch shall be hermetically sealed type and provide two independent gold-plated contacts i.e. either by one DPDT (preferable) or two SPDT type each rated for 240V AC, 5A and 110V DC, 0.5A.

d) Switch enclosure shall be weatherproof to IP65. Unless otherwise specified, the housing shall also be certified flameproof and explosion proof suitable for specified area classification (IEC Zone 1, Gas Group IIC). In addition to the certification from authorised agencies like CIMFR, FM, UL etc., the switch shall have the valid approval from statutory authorities of place of installation, which is PESO/CCE in case of Indian installations.

e) The switch assembly shall have two cable entries as a minimum, each of 1/2" NPT size. In case vendor standard model does not support two entries, the switch housing shall be supplied with integrally mounted 3-way junction box. The junction box shall be certified flameproof/explosion proof meeting above requirements.

f) Vibration switch shall be located at motor suspension beams as close to the motor as possible. Switches shall be readily accessible for re-setting from maintenance platform without any interference.

g) Vibration cut-out switches shall be supplied from manufacturer of repute and the proposed model shall have proven references of operating for a period of minimum 6 months, in the similar type of application. Switches of prototype design or not having proven references shall not be supplied.

7.2.10 **Louvers**

7.2.10.15 (Addition) Requirements for each pneumatic actuator: -

(a) The positioner shall have mechanical pneumatic louver position feedback. For electrical or electronic control signals, a I/P converter located at grade or local platform shall be used.

I/P converter shall be of electronic feedback type unless specified otherwise and shall be yoke mounted. It shall have an integral terminal housing. I/P converter with flying leads shall not be acceptable. Unless otherwise mentioned, it shall be intrinsically safe. Pneumatic connections shall be 1/4" NPT (F). The electrical connections shall be 1/2" NPT (F). If they are different, suitable adapters shall be provided. The overall accuracy of the I/P converter shall be better than ±0.3%.

b) Each change in signal shall give a proportional change in louver angle from fully closed to fully open repeatable to within 5 degrees for the same instrument air pressure signal, increasing or decreasing.

c) There shall be a minimum of one actuator per bay, a minimum of one actuator per unit and minimum of one actuator per 15 m2 of louver surface area.

d) The actuators shall be suitable for an air supply pressure of 10.5 kg/cm2 (g) design, 4 to7 kg/cm2 (g) normal and 2.5 kg/cm2 (g) minimum. Purchaser will specify the exact air

supply pressure. Any pressure reduction system on the supply air shall be in Vendor's scope.

e) The signal to actuator shall be 0.2 to 1.0 kg/cm^2 (g) for fully closed to fully open position unless specified otherwise.

7.2.10.17 (Modified) Where a single controller operates more than one actuator, isolation valves or other means shall be provided by Vendor to allow maintenance.

7.2.10.19 (Modified) With loss of control air pressure the louver shall lock in at 'fully open position' unless specified otherwise.

7.2.10.20 (Addition) Provision shall be kept for manual operation of all louvers.

7.2.10.21 (Addition) Provide legible indicator that indicates "angles of louver blade" and "open" or "closed" position.

7.2.10.26 Louvers shall be procured from EIL approved suppliers list attached elsewhere in the (New) Package/Material Requisition.

7.3 Structural Design

7.3.1.1 (Addition) For ACHE to be installed in India, the Codes for structural design shall be Indian Standard unless specified otherwise.

7.3.1.5 (Modified) For induced draft units, tube bundles shall be removable without requiring removal of the platforms. For forced draft units, the bundles shall be removable without separately supporting or dismantling of the fan, plenum, or platforms and without requiring disturbance of the structure or adjacent bays.

7.3.1.7 (New) The structural design shall be done on a reputed software package based on stiffness method of analysis e.g. STAAD PRO. Beams of length 6 m and below shall not have a splice joint, however for length above 6 m one splice joint may be permitted subject to the following:

i) It is not located at the point of maximum bending moment or shear.
ii) It shall be full penetration weld duly DP tested.
iii) Suitable size of connecting plate shall be welded on both sides of the web and preferably inside of flange.

7.3.1.8 (New) In order to meet the vibration requirements it is preferred that the drive assembly shall not be suspended from plenum but supported on the main column.

7.3.1.9 (New) The structural assembly shall be done by bolting only so that the same can be easily dismantled. However, structural modules like platforms and brackets may be pre-welded and bolted to columns at site. Steel structure shall be shop assembled.

7.3.1.10 (New) Piping support loads on structure, if specified by Purchaser, during detailed engineering shall be considered by Vendor.

7.3.2 **Vibration Testing**

7.3.2.2 (Addition) Vibration check shall be made on each motor (both driving and non-driving ends). This shall be done at shop. Motor base plate, fan or motor supporting beams, main structure columns with all machines running individually and also with all machines running together at their full load. Motor and bearing blocks shall also be checked for any abnormal heating by running all the machines for sufficient time. Vendor shall arrange necessary instrumentation for carrying out the vibration check and shall carry out modifications, if required.

7.3.3 **Structural Design Loads and Forces**

7.3.3.5 (Addition) Thermal force reaction shall be based upon an effective coefficient of friction equal to 0.3.

7.3.3.7 (Modified) For ACHE to be installed in India, Wind load shall be in accordance with IS-875, unless stated otherwise.

7.3.3.8 (Modified) For ACHE to be installed in India, Earthquake forces shall be in accordance with IS-1893, unless stated otherwise.

7.3.4 **Plenums**

7.3.4.6 (Modified) Minimum thickness of steel sheet material used in construction of plenums shall be be 2.8 mm (12 gauge) minimum, if the construction is transition type or straight box type. If it is inclined panel type as in case of induced draft then the minimum thickness shall be 3 mm for fan diameter up to 1.2 m (i.e. 4 feet) and 4 mm for larger size of fans.

7.3.5 **Mechanical Access Facilities**

7.3.5.1 (Modified) Access platform shall be provided on all four sides of a continuous bank of bundles. Stair shall be provided on one side and ladder on the other side.

7.3.5.2 (Modified) Maintenance platform shall be provided, unless specified otherwise, beneath each drive assembly to provide access for removal and replacement of all drive components. An unobstructed platform area extending at least 900 mm in any plan dimension on all sides of the driver and drive components shall be provided. However, such platforms shall not extend beyond the bay plan limits. Ladders shall be provided for access to induced fan for maintenance.

Fan and motor assemblies shall be designed for remote lubrication from maintenance platform without shutting down the equipment. Suitable SS tubing (¼"diameter) shall be provided outside the fan and motor guards to permit lubrication of fan shaft bearing and motor shaft bearing without shutting down the fans and/or motors. These connections shall be accessible from maintenance platform and terminated at one point. Vendor to develop detailed drawing.

7.3.5.3 (Addition) Platform for header access shall have minimum clear width of 900 mm.

7.3.5.4 (Addition) Grating shall be provided. These shall be anti-skid type, removable with maximum length of 1.5 m.

7.3.5.9 (New) Headroom clearance of 2200mm below motor suspension shall be maintained.

7.3.6 **Lifting Devices**

7.3.6.1 (Addition) Positioning of lifting lugs shall be such that horizontal balance of bundles is obtained.

7.4 **Roofing**
(New) Roofing shall be provided if specified by Purchaser and covering shall be of asbestos sheet unless specified otherwise.

8. **MATERIALS**

8.1.1 All materials shall be new. Material of construction may be specified in the

(Addition) requisition or data sheets in the general terms. Materials shall conform to relevant ASME specifications, or equivalent thereof.

MDMT shall be taken as 0°C or the design temperature specified in drawing or datasheet whichever is lower, unless specified otherwise in design basis or datasheets or drawings. For low temperature service (0°C and colder), unless exempted by ASME Section VIII, Div. 1, Paragraph UG-20 (f) and Paragraph UCS-66, all Carbon & Low alloy Steel materials (for pressure parts and attachments to pressure parts) shall be impact tested at the MDMT or colder and meet requirements of ASME, Section VIII, Division 1, Paragraph UG-84.

8.1.2 (Modified) Cast iron including nodular ductile iron shall not be used for pressure components in any service.

8.1.3/5 (Modified) For painting and hot dip galvanizing refer clause 11.2

8.1.7 (New) Pressure part plates having thickness 16 mm to 50 mm (both inclusive) shall be UST as per ASTM A-435.
Pressure part plates having thickness above 50 mm and all plates to be used for tube sheet and plug sheet shall be UST as per ASTM A-578 Level B. No laminations or inclusions shall be permitted.

8.1.8 (New) **Tubes**

i. All the tubes shall be seamless and cold drawn.

ii. Product analysis of tubes shall be carried out and reported.

iii. CS tubes shall be in annealed condition.

iv. SS tubes shall be in solution-annealed condition.

v. Actual yield strength and maximum hardness of tubes should be checked at the time of procurement and it should be ensured that these are lower than those of tube sheet, in order to achieve a sound expanded tube-to-tube sheet joint.

vi. Tubes shall be eddy current tested in addition to hydro test at the mill. For eddy current testing entire metal column of the tube shall be used.

vii. Hydro test pressure shall be higher of actual exchanger pressure or as required as per ASME Section II.

8.1.9 (New) All pipes shall be seamless and hot finished. dimensions and tolerances shall be in accordance with ASME 36.10 or 36.19 as applicable per material specification.

8.1.10 (New) **CS or LTCS MATERIALS (Pressure Parts or Non-pressure parts welded to pressure parts or parts wetted by the fluid in tube side)**

a) Carbon content shall not exceed 0.23%.

b) Plates shall be in normalised condition.

c) Use of SA 515 is not permitted.

d) CS plates above 50 mm thickness shall also meet the following additional requirements of SA-20:

i) Vacuum treatment as per the supplementary requirement S1. If vacuum degassing is not reported in the test certificates, through thickness test as per SA 770 shall be conducted and minimum reduction in area of 35 % shall be ensured.

ii) Charpy V-notch test as per supplementary requirement S5 of specification SA-20. Material meant to be used for design temperatures warmer than 0°C, impact test shall be carried out at 0°C or MDMT whichever is lower and acceptance criteria for energy absorption shall be as per Table A2.15 of SA-20. In case acceptance criteria is not available in SA-20, then applicable design code shall be referred unless otherwise specified in requisition. Orientation of test bar shall be transverse to rolling direction.

e) Unless specified otherwise in requisition or bid document, all CS materials specified as HIC tested shall meet the requirements of specification: 6-79-0012 or 6-79-0013 (as applicable).

f) CS pipes shall be SA-106 Gr. B for MDMT greater than – 29 °C, unless otherwise specified. For MDMT less than and equal to – 29 °C, CS pipes shall be SA 333 Gr. 1 or 6.

8.1.11 (New) **LAS MATERIALS (Pressure Parts or Non-pressure parts welded to pressure parts or parts wetted by the fluid in tube side)**

a) All LAS plates, pipes and forgings except C-½Mo materials shall be in normalised and tempered conditions.

b) Accelerated cooling from an austenitizing temperature by liquid quenching followed by tempering (N + ACC. + T) is also acceptable for plates. Irrespective of thickness, LAS plates shall meet the requirements of API RP 934 (part as applicable).

c) For 1¼Cr- ½Mo materials the maximum room temperature tensile strength of all pressure containing components, materials and welds shall be 100000 psi.

d) For LAS tubes (SA 209 and 213) hardness test shall be performed on outside of the tubes as per ASTM A-450.

e) For LAS plates above 50 mm thickness, following supplementary requirements of SA-20 shall also apply.

i) Vacuum treatment as per supplementary requirement S1. If vacuum degassing is not reported in the test certificates, through thickness test as per SA 770 shall be conducted and minimum reduction in area of 35 % shall be ensured.

ii) Charpy V-notch impact test as per supplementary requirement S5 with:

Test temperature:	Minus 18 °C or MDMT whichever is lower. For 5Cr-0.5Mo materials, test temperature shall be 0 °C.
Acceptance Criteria:	As per Code
Orientation of test bar:	Transverse to the direction of rolling.

8.1.12 (New) **SS MATERIALS (Pressure Parts or Non-pressure parts welded to pressure parts or parts wetted by the fluid in tube side)**

a) All SS material (300 series) shall be in the solution annealed and pickled condition. All stabilised grades of SS (i.e. SS 321, SS 347 etc.) shall be given stabilisation treatment in addition to solution annealing. For all stabilized grades of stainless-steel materials, soaking temperatures for stabilization heat treatment shall be 915°C ± 10°C and soaking period shall be minimum of 4 hours (2 hours for thickness ≤ 3.5mm).

b) All SS (300 series) plates shall be hot finished with No. 1 finish on both sides. Cold rolled plates, if permitted by requisition, shall have No. 2B finish.

c) SS (300 series) materials shall be procured with the IGC test as per ASTM-A 262 (test shall be carried out, after the specified heat treatment and sensitisation per specification) with acceptable corrosion rate and practices as under:

i) All services except nitric acid service - Practice E shall be followed. Specimen after exposure shall be bent as per mentioned in A 262 Practice E and shall be examined at a magnification of 200 X. The bent specimen shall be free of any cracks or grain droppings. The microscopic examination result shall be submitted to AI for approval

ii) Nitric acid service - Practice C corrosion rate <635 micro-m per annum.

d) All Duplex and Super Stainless steel materials shall meet the requirements of 6-79-0015.

8.1.13 (New) All forgings except nozzle flanges less than 10"NB shall be 100% UST as per ASTM A-388. Acceptance standard shall be as per AM 3.3.4 of ASME Sec VIII Div. 2.

8.1.14 (New) All steel sections, plates and other miscellaneous structural steel materials shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings.

The materials, construction specifications such as dimensions, shape, weight, tolerances, testing etc. for all structural materials shall conform to IS 2062 Grade A or equivalent, unless specified otherwise.

8.4 Louvers

8.4.2 (Addition) Louver bearings shall be guaranteed for life and shall never require lubrication.

8.4.3 (Modified) Louver blades shall be made of corrosion-resistant material like aluminium. Louver frame shall be made of aluminium or steel. Steel louver frames shall be hot dip galvanized.

8.5 Other Components

8.5.1 (Addition) Aluminium fin material shall not be less than 99.5% pure (SB 209 Alloy 1060). For offshore applications fin shall be to SB 209 Alloy 3003 Temper O.

8.5.2 (Modified) **Fan blade material**
Fan blades shall be of aluminium alloy. Aluminium alloys for fan blades shall be selected to be resistant to stress corrosion cracking. Fan hub and blade material shall be non-sparking type. Copper content in aluminium blade should not exceed 0.4%.

If specifically indicated by Purchaser, FRP blades may be used. FRP blades shall be used only for forced draft units. FRP blade fans shall meet all the requirements of EIL specification 6-15-0072.

8.5.6 (Modified) Solid metal gaskets for shoulder plugs shall be dead soft annealed. It is recommended that Soft Iron and Soft SS gaskets for plugs shall have hardness of minimum 15 BHN less than the material of plug and plug sheet. Hardness of Soft Iron gaskets shall not exceed 90 BHN and that of Soft SS gaskets shall not exceed 140 BHN. This shall be a hold point for AI.

8.5.7 (New) Fan shaft shall be to either SA 105 or EN 24 (hardened and tempered and UST). CS pipes may be used for shaft housing. Bearing housing shall be to SA 105.

8.5.8 Material for instrumentation valves and tubing shall be SS. All instrumentation shall

(New) be suitable for the hazardous area classification for electrical safety.

8.6 (New) In case fire proofing of air cooler structure is required, structure columns and beams shall be provided with welded nuts as per EIL standard.

9. FABRICATION

9.1.1.1 (Addition) All welding procedures shall be submitted to AI for approval. All welding shall be done with electrodes, fillers and fluxes of reputed make with proven reproducibility of results. Brand names shall be specifically approved by AI. Only low hydrogen electrodes shall be used for all CS pressure parts welds.

9.1.1.3 (Addition) Backing strips shall not be used.

9.1.1.5 (Addition) Hardness limitations for base metal, HAZ and welds shall be as per 6-15-0091.

9.1.1.6 (New) Repairs to base material and welds shall not be made without the approval of the Purchaser or AI.

9.1.1.7 (New) Requirements of 6-79-0016 shall be complied with for welding of Duplex and Super Duplex materials.

9.1.1.8 (New) Non-pressure attachments, such as lugs or structural steel supports, shall be attached to the pressure parts with a continuous weld. All double fillet welds in contact with hydrogen stream shall be vented. All LAS weld attachment to pressure retaining component shall be full penetration weld and ground to a smooth concave contour.

9.1.2 **Plug Headers**

9.1.2.1 (Modified) Partition plates and stiffening plates to plugsheet and tubesheet welding shall be full penetration welds.

9.1.3 **Removable Cover Plate and Removable Bonnet Headers**

9.1.3.3 (New) Stiffener plates 6 mm thickness shall be provided to stiffen the flanges of all flanged headers at a spacing of approximately 250 mm. These shall be spaced as not to interfere with the bolts and nozzles.

9.2 Post Weld Heat Treatment

9.2.3 (Addition) For hydrogen, sour, amine and caustic service, minimum stress relieving temperature for Carbon Steel. For Alloy steel, the minimum stress relieving temperature shall be as per Code.

9.3 Tube-to-tube sheet Joints

9.3.3 **Expanded tube-to-tube sheet joints**

9.3.3.0 (New) Expanded tube-to-tube sheet joints shall be in accordance with EIL specification no. 6-15-0004.

9.3.4 **Welded tube-to-tube sheet joints**

9.3.4.0 (New) Welded tube-to-tube sheet joints shall be in accordance with EIL specification no. 6-15-0003 for ferritic and austenitic materials. Seal welded joints are not acceptable.

9.6 Alignment and Tolerances

9.6.1 (Addition) Gasket flange faces on stacked units shall not be out of parallel by more than 0.8 mm (1/32 inches).

9.6.5 (New) The face of each gasket contact surface shall lie between two parallel planes 0.8 mm (1/32 inches) apart.

9.6.6 (New) Tolerance on tube length after fining shall be –0mm, +3.0mm
Tolerance on fin OD shall be –0mm, +0.8mm

9.8 Finishing

(New) All welds in the area 250 mm from the ends in the bottom of header (where the header is resting on frame channel) shall be ground flush. In a split header all welds in bottom plate of top header and top plate of bottom header shall be ground flush. Inside corners of openings for nozzles to be rounded off to 3 mm radius.

10. INSPECTION, EXAMINATION AND TESTING

10.0 (New) All materials for pressure parts and non-pressure parts welded to pressure parts shall be accompanied by mill test certificates duly certified by reputed third party agency or by the representative of the Purchaser. In absence of mill test certificates the material shall be got tested and certified from a reputed third-party agency like EIL, Lloyds, BV, DNV, etc. and the test results shall be submitted in lieu of mill test certificates. All cost towards such testing and inspection shall be borne by Vendor. All material shall be inspected at Vendor's or sub vendor's shop for verification prior to use on the job. The decision of AI to accept or reject materials on the basis of such testing shall be final.

All structural material shall be accompanied by quality certificates. In case the certificates are not available, or are incomplete or when the material quality differs from standard specification, such materials shall not be used. However, Vendor shall get all appropriate tests conducted in approved test houses for such materials as directed by AI without claim to extra cost and submit the same to the Inspector for his approval. AI may approve the use of such materials entirely at his discretion.

All flame proof electrical equipment manufactured in the country shall have CCE approval certificates along with a valid BIS license. Electrical equipment with area classification as Type 'e' or Type 'n' shall have CCE approval. All imported electrical equipment shall have a similar certificate from the country of origin.

10.1 Quality Control

10.1.2 (Modified) **Radiography**
Minimum radiography shall be spot. Radiography shall be 100% if the thickness of weld exceeds 30mm for CS and for all thickness of LAS plates. For hydrogen, lethal, sour, amine and caustic service 100% radiography shall be done irrespective of thickness.

Radiography can be substituted by 100 % UST provided either a print out is submitted or AI witnesses the examination. If radiography is being substituted by UST, magnetic particle examination shall be carried out in addition to UST.

However, when supplemental requirements as per Para 12 are applicable or if required by Code, substitution is not permitted and 100% radiography only shall be done.

Wherever radiography is indicated as full all long and circumferential seams including flange to neck, pipe to pipe and pipe to fitting shall be 100% radiographed.

10.1.4 (Modified) When spot radiography is indicated, it shall mean 10% of weld length (minimum one shot) for each weld configuration to be radiographed with a minimum of six radiographs of at least 250 mm length each in one header box as detailed below:

a) One shot each of the four long seams between top/bottom plate and tube sheet/plug sheet.
b) One shot for any one of the welds of side plate to top and bottom plates.
c) One shot for any one of the welds of side plate to tube sheets and plug sheet.

10.1.6 (Addition) When set-on connections are used, the header plates shall be UST in the area of attachment for a radial distance equal to twice the thickness of plate and no laminations shall be permitted.

10.1.7(d) (Modified) Weld hardness shall be as per Table 12. However, additional hardness limitations for materials, welds and HAZ wherever specified on drawings or datasheets or specifications and for LAS materials shall be as per 6-15-0091. Hardness for Duplex and Super duplex materials, welds and HAZ shall be as per 6-79-0015 and 6-79-0016. Hardness limitation for tube-to-tube sheet welding shall be established on a mock up.

10.1.8/9 (Modified) Tubes shall be manufactured full length without any circumferential welds.

10.1.15 (New) All nozzle attachment welds and pass partition plate to header plate attachment welds shall be examined by MP or LP test for crack detection. Examination shall apply to root pass after back chipping or flame gauging (where applicable) and to the complete weld.

10.1.16 (New) When impact tests are required on material as per Code or specification the welds shall also be qualified for impact test. In such case following special requirements shall apply to the welding procedure qualification:

i) Qualification tests shall be made on plates of the ASME specification as specified for the ACHE using welding electrodes of AWS/SFA specification and wire & flux of the specification and brand as are to be used on the job.

ii) Welding current and travel speed shall be considered essential variables in order to ensure that production welding is substantially equivalent to the procedure qualification.

iii) Welded test plates shall be subjected to a total thermal history expected of the finished ACHE. Additionally, one extra stress relieving cycle shall be considered for site repair.

iv) Charpy V-notch impact tests shall be made on the weld and heat affected zone of the test plate for each welding procedure to be qualified. Test procedure shall be in accordance with UG 84 of Code. Test temperature shall be MDMT. Impact energy requirements shall be as per Table 2.15 of SA 20 of ASME Sec. II Part A or UG 84 of Code whichever is stringent.

10.1.17 (New) MP or DP test of finished welds shall apply also to all header materials greater than 38 mm thickness.

10.1.18 (New) It shall be ensured that all LAS and SS materials are finally check tested by a PMI analyser before despatch of the equipment. All LAS weld joints shall be UT examined from accessible side after PWHT.

10.1.19 (New) In addition to stamping the specification and manufacturers' symbol as specified in ASME, on one of the ends the size of the studs shall be clearly punch marked. Similarly, the nuts shall have the size punch marked on one of the faces. In case of tapped hole, the size shall be punch marked near the hole without disturbing the gasket seating area. Further, for all alloy and SS bolts & nuts shall also be identified by distinct colour marking at the stud end and bolt side face.

10.2 **Pressure Test**

10.2.3 (Modified) Potable water with chlorides less than 25 ppm by weight shall be used in hydrostatic testing of units with SS or monel materials exposed to the test medium.

10.3 **Shop Run-In Tests**

(Modified) Vibration test, noise level test, etc. those are necessary to ensure smooth running of ACHEs shall be conducted by Vendor at shop or site. If the site erection is not in Vendor's scope, Vendor shall provide site supervision and supply all necessary material and instrumentation.

11. PREPARATION FOR SHIPMENT

11.1 **General**

11.1.1 (Modified) All units shall be dry, thoroughly cleaned and free from loose scale and other foreign matters before shipment.

11.1.2 (Addition) Tube bundles shall be completely dried by passing hot air for sufficient time until no increase in relative humidity of outgoing air is observed. Alternatively, vacuum drying is also acceptable. After drying all CS and LAS bundles shall be purged with dry nitrogen at 0.25 kg/cm^2. The bundle shall be provided with pressure gage to monitor nitrogen pressure and 1/2" non-return valve.

11.1.3 (Modified) All connections not provided with blind shall be provided with gasketed steel covers fastened by four bolts or 50% of the required flange bolting whichever is greater.

11.1.6 (New) Fin tubes shall be protected with heavy-duty wire mesh duly stiffened to prevent damage by personnel walking on top during shipping, handling, erection etc. The protective cover including the heavy-duty wire mesh shall be hot dip galvanised.

11.1.7 (New) During transport and storage, a maximum of two bundles may be stacked provided sufficient precaution is taken to prevent damage.

11.1.8 (New) Complete Packing list with Box numbers, Part nos., Part Name, weight of Boxes shall be furnished along with consignment/documentation to site/ warehouse in sufficient copies. Storage Instructions shall be furnished along with consignment and necessary cautions to be mentioned on the parts and components while packing.

11.2 **Surfaces and finishes**

11.2.3 (Addition) The primer shall be inorganic zinc silicate (65-75 microns dry film thickness) for design temperatures up to 400°C and Heat Resistant Silicone Aluminium Paint (20 microns dry film thickness) for design temperatures above 400°C, unless stated otherwise. The header shall also be given final coat of paint as specified by Purchaser. The air side face of tube sheet shall be painted after stress relieving (in case of CS or LAS) and before drilling of tube holes. The paint shall be suitable for corrosive industrial and coastal environment as applicable.

11.2.5 (New) All structural steel not galvanised shall be prepared to near white sandblast finish to ISO 8501-1, grade Sa $2^1/_2$ and then given an inorganic zinc silicate primer coat of 0.075mm DFT.

11.2.6 (New) All structural parts of tube bundle frame, plenum chamber, motor suspension assembly, shaft housing, gratings for stairs and platform, all guards etc. shall be hot dip galvanised. Bolting shall be electro galvanised.

12. SUPPLEMENTAL REQUIREMENTS

12.1 General

(Modified) The supplemental requirements shall apply if the design pressure exceeds 70 kg/cm^2(g) or when the plate thickness of a box type header exceeds 50 mm or when the exchanger is in lethal or critical service. Whether the service is lethal or critical shall be defined by Purchaser.

12.2 Design

12.2.1 (Addition) Top/bottom plate to tubesheet/plugsheet joints shall be butt welds with tube sheet/plug sheet having a hub meeting the requirements of Fig UW 13.3 (a) or (b) of Code.

12.2.2 (Modified) All tubes shall be strength welded to tube sheet. Seal welding is not permitted.

12.3 Examination

12.3.15 (New) PTCs are required for all butt welds if the weld thickness exceeds 50mm for CS and 25mm for LAS, or when required by the specifications or Code. The following shall apply: -

a) Two PTCs representative of the weld between top/bottom plate and tube sheet/ plug sheet shall be provided for each procedure, position and thickness. One of the test plates shall be provided for the closing joint of the plug type header.

b) PTC shall be from material of the same heat and thickness as of parent metal. During and after welding PTC shall be subjected to same heat treatment as and together with the course they represent, extra PTC shall be preserved to take care of eventuality of retests.

c) Following tests shall be carried out as per methods of testing given in Code:

i) One transverse tension test. (Ultimate Tensile Strength, Yield Strength and percentage elongation shall not be less than those specified for base material)

ii) Two side bend tests with weld located in the center of bend.

iii) One hardness test on PTC weld and HAZ

iv) Micro and macro examination of welds.

v) For CS material charpy V notch tests on weld and HAZ shall be carried out as follows:

a. For low temperature service (MDMT < 0 °C) the test temperature shall be MDMT.

b. For service with MDMT > or equal to 0 °C, the test temperature shall be 0 °C.

c. The acceptance criteria for energy absorption shall be as per table A 2.15 of SA 20 of ASME Sec. II part A or UG-84 of Code whichever is more stringent. -

vi) For LAS material charpy V notch tests on weld and HAZ shall be carried out. Test temperature and acceptance criteria shall be as indicated in Para 8.1.11 (d)(ii) above.

13. SPARES

(New)

Mandatory and 2 years maintenance spares including spares for electrical and instrumentation parts shall be as indicated in the ***enquiry documents***. Vendor shall include the mandatory spares in his item rate and indicate unit rate for 2 years maintenance spares, unless specified otherwise.

स्टैटिक ईक्विपमेन्ट (प्रैशर वैसल्स हीट एक्सचेन्जर्स) के आवश्यक कठोरता के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR HARDNESS REQUIREMENT OF STATIC EQUIPMENTS (PRESSURE VESSELS, HEAT EXCHANGER)

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	27.12.19	REAFFIRMED & REISSUED AS STD SPEC	PKP	NSK	KJM	RKT
3	05 11 14	REVISED & REISSUED AS STD. SPEC.	TK	KA	RKT	SC
2	29 06 09	REAFFIRMED & REISSUED AS STD SPEC.	VB	RKG	AKM	N DUARI
1	26 03.04	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	NSK	PK	SSA	SKG
0	15 03 96	ISSUED AS STANDARD SPECIFICATION	RV	SSA	RKA	AS

Abbreviations:

ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
HAZ	:	Heat Affected Zone
PWHT	:	Post Weld Heat Treatment

Convenor: Mr. KJ Harinarayanan

Members:
Mr. Sanjay Mazumdar
Mr. K Anjaneyulu
Mr. Arun Kumar
Mr. Inder Kumar
Mr. Tarun Kumar
Mr. Anish Trehan
Mr. Srikanth Karanam
Mr. Neeraj Agarwal (Projects)
Mr. S Ghosal (Process)
Mr. T Kamalakannan (SCM)

CONTENTS

1.0 SCOPE

This specification covers general requirement of hardness of base metal, weld and heat-affected-zone (HAZ) and is applicable to all C-½ Mo, Cr-Mo steels and other materials whenever asked for in drawings/ specifications/standards. All testing shall be done after PWHT.

2.0 HARDNESS REQUIREMENTS

Hardness in base metals, weld and heat affected zone as per ASTM E10 shall not exceed the following:

For P1 materials	- 200 BHN
For P3 & P4 materials	- 225 BHN
For P5 & P6 materials	- 235 BHN

3.0 WELDING QUALIFICATION TEST

3.1. For each welding procedure qualification six tests shall be made, three in weld metal and three in HAZ. Hardness requirements shall be as per cl. 2.0 above.

3.2. In addition to the requirement of 3.1 above, Vickers Micro hardness test shall be made on a full cross-section at 25 mm intervals beginning at 3 mm from the top surface with 5 kg load or with a load approved by the authorized inspector. Tests shall be made at each level for each of the following locations as per ASTM E 92:

Three tests shall be made in the weld metals, two tests in HAZ and one test in the base metal in accordance with Fig.1 and the hardness shall not exceed the following in base metal, weld metal and HAZ.

For P1 materials	- 210 VHN
For P3 & P4 materials	- 237 VHN
For P5 & P6 materials	- 247 VHN

4.0 PRODUCTION TEST

4.1 All pressure containing weld metals are to be checked for hardness of weld and HAZ after PWHT but before hydro-test. The hardness shall not exceed the value stipulated.

4.2 Each longitudinal seam shall be checked both internally and externally near the center and at one end.

4.3 Each circumferential weld shall be checked at four locations approximately 90°apart, both internally and externally.

4.4 Each nozzle weldments shall be checked at two locations, 180° apart, both internally and externally.

5.0 APPROVAL

In case the hardness as obtained on production test is more than the limit specified in 2.0 above, the vendor shall submit the corrective procedure to lower the hardness in writing to EIL and/or authorized inspection agency for review/approval.

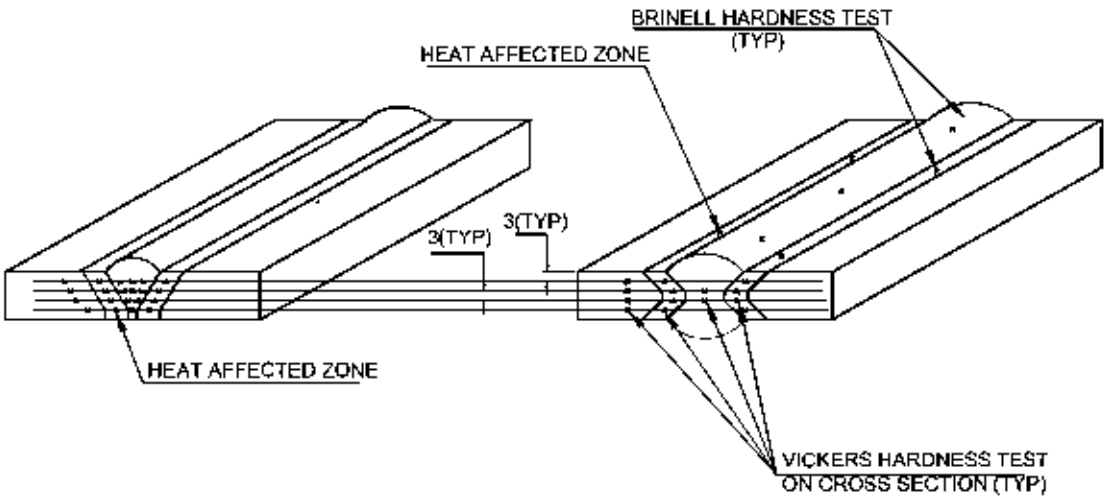

FIG.1- HARDNESS REQUIREMENT ON TEST COUPONS

डैम्पर और शट् ऑफ ब्लेड के डिजाईन एवं आपूर्ति हेतू मानक विनिर्देश

STANDARD SPECIFICATION FOR DESIGN & SUPPLY OF DAMPERS / SHUT OFF BLADES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	11.04.2023	REVISED AND REISSUED AS STANDARD SPECIFICATION	AS/PG	AP	PG	SM
1	08.05.2019	REVISED AND REISSUED AS STANDARD SPECIFICATION	AV	PG	MK	RKT
0	26.03.2014	ISSUED AS STANDARD SPECIFICATION	AS	AP/KJHN	AP	SC

Abbreviations:

ANSI	:	American National Standards Institute
API	:	American Petroleum Institute.
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
BASEEFA	:	British Approval Service for Electrical Equipment in Flammable Atmospheres
BQC	:	Bidder's Qualification Criteria
CIMFR	:	Central Institute of Mines and Fuel Research
CSA	:	Canadian Standards Association
CRCA	:	Cold Rolled Close Annealed
ERTL	:	Electronics Regional Testing Laboratory
FM	:	Factory Mutual
GA	:	General Arrangement
IEC	:	International Electrotechnical Commission
IS	:	Indian Standard
LCIE	:	Laboratoire Central des Industries Electriques
MOC	:	Material of Construction
PESO	:	Petroleum and Explosive Safety Organization
PTB	:	Physikalisch-Technische Bundesanstalt
SOB	:	Shut-Off Blade
SOV	:	Solenoid Valve
TQ	:	Technical Questionnaire
UL	:	Underwriter's Laboratories
UON	:	Unless Otherwise Noted
VDR	:	Vendor Data Requirement

Fired Equipment Standards Committee

Convener : Prag Goel

Members : Amit Prakash
Rajesh Patel
Dhiman Deb
Navneet Agarwal
Prasenjit Saha
Siddhartha Chakravarty
Pankaj Kumar Rai

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1.0 GENERAL

1.1 This specification outlines the minimum requirements for the design, materials, fabrication, testing, inspection, packing & forwarding of dampers and shall be supplemented by the supplier to ensure that the supplied dampers are of proven quality. This document shall be read in conjunction with tender specifications along with its attachments.

1.2 Dampers are required for isolating, regulating gas / air streams in the waste heat recovery / air preheating schemes in furnaces, gas turbines / boilers etc. These dampers shall be installed in ducts / stacks which may be internally or externally insulated. The damper assembly shall comprise of both the damper and its control facility. The dampers (Louvre and Guillotine Dampers) covered under this specification are required to be supplied completely shop assembled and tested, ready for bolting / welding into the duct work.

1.3 All isolating louvre dampers may have parallel blade motion while all control dampers shall be precision control devices with opposed blade arrangement. Dampers located at the fan suction shall have blades with parallel closing movements opposite to the fan rotation.

1.4 The expected design life for the Damper is 15 years. Dampers should be suitable for outdoor operation under ambient dusty conditions.

1.5 The guillotine dampers (also called shut-off blades) shall be only ON/OFF type. No regulation shall be performed by these dampers. It is extremely important to ensure either complete retraction or complete insertion of the blade in or out of the duct work. Guillotine dampers shall be designed to provide 100% sealing across the duct and 99.5% sealing (based on normal flow) w.r.t. atmosphere, unless otherwise given elsewhere in procurement specification.

2.0 SCOPE OF SERVICES & SUPPLY (DAMPERS & SHUT OFF BLADES)

2.1 Scope of Supply

Supply shall include the following as a minimum:

i) All steel work including stainless steel materials for various components like seals etc.

ii) Shaft, shaft block, shaft bearing, blades.

iii) Cylinder, linkages, eyebolts.

iv) Winch-Pulleys and cable with position indicator shall be provided at damper operating platform level and if specified in datasheet at grade level.

v) Pneumatic / electrical / manual actuating system including actuators

vi) Electric geared motor as applicable, chain and sprocket

vii) Gearbox with hand wheel or chain with pulley for manual operation of SOB's

viii) Refractory, its anchors (type and tie back MOC shall be as per mating duct), if required

ix) Control panel with electrics and instrumentation, as required

x) Cabling from panel to individual Dampers / Shut off blades

xi) Counter weight / volume tank (if required).

xii) Supply of any loose instrument duly tagged

xiii) Supply of mandatory spares.

xiv) Supply of Recommended spares (if ordered by Client)

xv) Stainless steel name plate and flow direction arrow

xvi) Necessary lifting arrangement

xvii) Painting & Packing

xviii) Any item not specifically mentioned here but required for completing the Job

It shall be Supplier's responsibility to procure above items and assemble / install them at his workshop. The complete system shall be assembled, tested at shop by the Supplier, prior to dispatch to site.

2.2 Scope of Services

Supplier shall include the supply of following services as a minimum, in their scope:

- Sizing & complete mechanical design including actuation system ensuring that Damper cater to all the fail-safe / interlock actuation requirements, as specified in datasheets
- Preparation of relevant drawings and documents as per VDR
- Inspection Services
- To carry out necessary leakage and functional testing at shop
- Supervision of site erection & certification for correct installation and operation.
- Guarantees

3.0 DESIGN AND CONSTRUCTION (FOR LOUVRE AND GUILLOTINE DAMPERS)

The design of dampers shall meet the performance requirements as outlined in data sheets enclosed with the Tender / Requisition. In addition to the requirements given below, Design of Damper shall also comply to the requirements of API-560.

3.1 Frame

3.1.1 All dampers shall be suitable to be bolted in duct work through necessary flanges, bolting / gasket. Wherever, welded interface is required (like in stacks etc.) the frame shall be supplied in suitably beveled condition, UON.

3.1.2 Dampers shall be considered structural members and as such shall meet all structural design criteria of API Standard 560 / IS 800. Damper frames shall be channel type either rolled structural shapes or formed from plates. Frames shall be formed from min. 10 mm thick plate or plate thickness of interfacing element whichever is maximum with face-to-face dimensions to suit datasheets / functional requirements. The flanges on damper frames with flanged connections shall be 3.2 mm (1/8 in.) thicker than any ducting mating flange and

include a flatness requirement of +/- 1.5 mm (1/16 in.) for every 914 mm (36 in.) of flange perimeter. Sections of the frames shall be determined on the basis of external loading coming on the dampers. In any case damper frame shall be capable of taking minimum 3 tons dead load for damper handling air service and minimum 6 tons of dead loads for dampers handling flue gas service.

Guillotine dampers shall normally have open frame construction. For positive pressure or high temperature systems (i.e. Hot Air Ducts and Flue Gas Ducts), a fully enclosed bonnet shall be used.

3.1.3 For inside lined dampers with sealing requirement of ≥ 99.5%, the dampers shall have a floating inner frame (dual frame construction) so that no temperature differential stresses are imposed on the outer frame and the required sealing efficiency is achieved during operation. Enough clearance shall be kept between blade and frame to allow for expansion, so that blades do not get stuck while operating at high temperature. As a minimum an expansion gap around the perimeter of the damper blade equal to 1.5 times the calculated thermal expansion (based on the blade materials at design temperature) or 12.5 mm (½ in.) gap, whichever is greater.

3.1.4 Unnecessary reduction in frame size leading to permanent blockage of flow area and reduced blade sizes, is not acceptable unless required as per the process requirement.

3.1.5 For Guillotine dampers stay bars shall be provided in the duct work depending on the gas pressure and temperature. These stay bars shall support the blade and add to the stiffening of the blade. Material for stay bars shall be same as that of blade.

3.1.6 Lifting lugs shall be provided on the frame. Lifting lugs be designed to support the weight of the fully assembled damper and its auxiliary components with a jerk factor of 2.0.

3.2 Blades

3.2.1 Louvre blades shall be aerodynamically shaped with aerofoil construction of two plates around a central shaft to minimize both pressure drop and deflection. For blade of aerofoil design, the central shaft may consist of a structural member as a Central axial support of the blade. At each end, round stub shafts are spliced into the axial structural member with suitable clearances to prevent buckling of the shafts, as it thermally expands. The stub shaft pass through the bearings mounted on the damper frame. The damper design pressure and design differential pressure shall be used for structural design considerations with the damper blade in the closed position. To reduce the potential for blade deflection and warping or developing thermal stress across the shaft, for structural design calculations the design differential pressure shall be maximum of 10-inch (254mm) WC or pressure specified in datasheet and maximum design temperature shall be as per the datasheet. Blades shall be all welded construction with no hardware which might vibrate loose within the duct. Blades shall be assembled to frame in such a manner that easy removal of blade is possible.

3.2.2 Blade deflection shall be less than 1/360 of the blade span. Stress of each blade assembly, based on maximum system design loading determined by the moment of inertia through the cross-section of the blade assembly, shall not exceed levels specified in API 560.

3.2.3 Multi-blade Louvre dampers shall have maximum blade width 762 mm. Each blade shall have approximate equal surface area. Single blade damper shall be limited to 1.2 m2 of duct internal cross-sectional area.

3.2.4 Control dampers shall be multi-blade type with even number of blades. However, if damper size is too small (upto 500 mm * 500 mm) control shall be achieved by one blade only.

3.2.5 For guillotine dampers the blade construction shall be such that it gives required sealing for the operating conditions as specified in data sheets with blade in both close and open position. To achieve required sealing single blade, double blade, flex seal type or any other proven construction may be used. For single blade construction, the blade shall extend beyond the seals on all four sides into atmosphere, ensuring required sealing efficiency,

3.2.6 The option of seal air fan shall be provided only if specifically called for in the Job specification. The seal air fan shall provide seal air barrier in the inner space between two blades / inner space between blade frame and flexible metal seal may be provided. Seal air fan shall be sized with enough margins as to supply a seal air barrier pressure of minimum 75 mmWC more than that of duct pressure.

3.2.7 For high temperature gases, Supplier to ensure against blade distortion / warping while blade is retracting.

3.2.8 Material of construction of Blade shall be based on design temperature / composition of medium in contact and as per specific requirements of data sheets. In case of C.S. blades, a corrosion allowance of minimum 1.5 mm to be considered on each exposed surface of blade thickness.

3.2.9 The min. single blade thickness shall be 6 mm. In case of aerofoil blades the min. thickness shall be 3 mm, however the overall stiffness of blade shall be equivalent to min. 6 mm thick plate

3.2.10 Damper blade attachment hardware shall, as a minimum, be the same material as the blades.

3.3 Seals

3.3.1 All seals will be permanent type which requires no adjustment or replacement. Deforming seals which may fatigue, crack, warp or take permanent set are not permitted. Gaskets that may erode, abrade or deteriorate are not permitted. The seals shall be of min. SS-316 metallurgy, which allows for frequent cyclic operations and sustain the design gas pressure, temperature. In addition seals on control dampers should be capable of withstanding high localized gas velocities without erosion or ripping off. These should preferably be held positively on both sides of the blade landing bar as the case may be.

3.3.2 In case of louvre dampers, shaft seals shall be provided on outside of the frame, wherever shaft is coming out of the frame. These shaft seals shall be suitable for the gas pressure and temperature conditions given in the data sheet and shall be replaceable from outside.

3.3.3 For guillotine dampers flexible metallic sealing system shall be provided to achieve required sealing. The seals provided shall be easily replaceable from outside and shall have a removable weather protection on all four sides. The metallic seals shall be mounted on steel posts outside the duct flow passage. This shall ensure no tearing away of the seals when the gas flow is occurring with the blade retracted. The seals shall ensure sealing of the duct cut out when blade is retracted. The blades shall rest against support angles and rods and tightly held to ensure specified sealing. All Guillotine damper's seals shall have protection from weather.

3.4 Shafts

3.4.1 Material of construction of shaft shall be suitable for process conditions and flue gas composition as given in Tender specifications / data sheets.

3.4.2 The Damper shaft shall be of SS-304 or higher metallurgy. This shall avoid corrosion and consequently jamming of damper blade after sometime has elapsed from installation. Bolt

holes in blade plate and/or seal strips shall be slightly larger or elongated to permit high and low side temperature difference. Shafts shall normally be attached to the blade through shaft blocks or other suitable member. The block shall be preferably welded to the blade to avoid any blade loosening / vibration during operation.

3.4.3 Damper and Guillotine Shafts shall be capable of transmitting full operating loads and torque and stresses to be limited as per API 560.

3.4.3 Guillotine shaft / screw are to be provided with gaiters, if these parts are exposed to the atmosphere. The minimum material of construction shall be EN24 / AISI 4140.

3.5 Linkage

3.5.1 Thermal expansion shall be controlled and must not cause interference, binding or malfunction. For Multi-louvre dampers, damper blades shall be linked exterior to the damper frame by a suitable linkage system. Linkage shall consist of structural bar hinged with shoulder / eye bolts, lock nuts. Individual blade link bars shall be fixed to each blade through set collars welded to the link bar and fastened to the shaft with shear pins / keys. Linkage shall be tight, vibration free and shall permit no independent action of any blade except in case of pressure relief blade. Complete linkage shall be tested and fixed in position at the damper manufacturer's facility and shall not require field adjustment. Linkage shall be drilled and pinned to damper blade shafts. All linkage joints and cylinder mounting joints must feature a self-lubricating material running on SS pins or sealed for life grease packed.

The loss of motion in the linkage for each blade shall not exceed 0.5 % of drive link total travel. Linkage shall be designed to prevent dead center lockage.

3.5.2 For guillotine dampers blades shall be moved in and out through a reliable mechanism (actuated through electric, pneumatic and manual as the case may be) ensuring no possibility of 'blade-dropping' while operation. This may be achieved through chain-sprocket / rack & pin / screw jack or any other suitable arrangement. If chains are used, a minimum of two chains should be used and arranged to drive evenly on each side of the blade to prevent binding. In the event of chain failure, the remaining chain or chains must support the entire blade load. The guillotine damper linkage system shall ensure that even after long periods of inactivity the damper shall function properly and all critical components of linkage / operating system such as motor, gear box, chain-sprocket / drive screws etc. shall be accessible to inspect and service all the time. Operator or drive system sizing shall incorporate a 300% dead load safety factor as a minimum and other loads as per API 560. Designs where the blade shaft / screw / driving stem travels along with the blade and projects outside the SOB frame during blade open condition, are not permitted. Also, blade driving arrangement should not be in the duct open area in the blade open condition.

3.5.3 Damper bearings shall be of proven type and selected on the combined basis of:

(a) Bearing shall be self-lubricating metalized carbon flanged or pillow block sleeve type

(b) The ambient conditions at the job site

(c) The temperature transmission from the shaft to the bearing

(d) The self-alignment required on the bearings due to pressure, temperature and the deflection of the blades

3.5.4 Bearings and linkage cranks shall be of removable type. Do not weld linkage cranks to shaft. Proven type of eye bolt / pillow ball rod end bearing shall be used for hinged connection of linkage with SS pins with weather proof (Anti rust).

3.5.5 Actuators and all drive system components including linkage shall be sized to provide adequate safety margin over the allowable range and to withstand the full stall torque of the chosen drive actuator without failure (guidelines of API 560 shall be followed as a minimum for design load).

3.5.6 Supplier shall ensure suitability of MOC of Bush / bearing housing and eye bolt with respect to service conditions.

3.6 In case of Shut off Blades, the maximum time taken, from fully closed to fully open blade position or vice-versa, shall be in 5 minutes. For large size SOBs opening time of 10 minute can be accepted with prior approval of EIL.

4.0 PNEUMATIC ACTUATION SYSTEM

4.1 Damper Supplier shall provide pneumatic actuators and associated control instrumentation to meet all the requirements as per the specification.

4.2 Cylinder / Tubing / Hoses

Pneumatic cylinders shall be of minimum 4-inch dia. bore and feature adjustable cushion control at each end of the stroke. Cylinder shall be capable of delivering 150% of the maximum required operating force used with the minimum available air pressure at panel location i.e. after considering various losses. All cylinders shall be double acting type, which shall be designed to sustain a pressure of 10.5 kg/cm^{2}g and temperature of 70 °C. Cylinder barrel shall be of seamless steel honed and hard chrome plated. Piston rod shall be of stainless steel 304 with fluoro-elastomer seals. The cylinder should be painted with corrosion resistant epoxy-based resin. All connectors shall be of SS. Tubing to and from the cylinder shall be SS corrugated tubes with SS over braid with end couplers. Minimum length for hoses shall be 3.0 m and in case of dampers with double cylinder one of the hoses to be minimum 4.0 m length.

4.3 Damper Control System

The Pneumatic control and instrumentation system consists of Cylinder, Instruments, Tubing, cables with the instrumentation control as required. The minimum requirements are elaborated in the individual suggested control scheme given in relevant damper data sheet. It shall be Damper Supplier's responsibility to provide all controls / instrumentation for normal, fail-safe and other operational requirements of the dampers as per damper datasheet attached. The specification lists out briefly some of the major requirements over and above all the other requirements that Supplier shall specify.

4.3.1 All instrumentation supplied shall be from Suppliers who are on the approved list of EIL. In case for any instrument name of the Supplier is not available in the Tender, then Supplier shall obtain prior approval before order placement.

4.3.2 Equipment / Instruments / Junction boxes etc., located in electrically hazardous area shall be certified by statutory authorities as below:

4.3.2.1 Approval from local statutory authority, as applicable such as PESO, Nagpur, India etc. for the electronic instruments installed in electrically hazardous area along with:

(i) Test certificate from recognised test house like CIMFR / ERTL etc. for flameproof enclosure / intrinsic safety, as specified hazardous protection class, in the data sheet, as per relevant standard for all Indian manufactured equipment.

(ii) Certificate of conformity from agencies like LCIE, BASEEFA, PTB, CSA, FM, UL International Electrotechnical Commission System for Certification to Standards

Relating to Equipment for Use in Explosive Atmospheres (IECEx System) etc. for compliance to ATEX directives or other equivalent standards for all equipment manufactured outside India.

4.3.2.2 Equipment / Instruments specified Weather proof, Flame proof housing shall comply with the following requirements as a minimum:

Weather proof housing : IP-65 as per IS / IEC-60529

Flameproof housing : Ex (d) as per IS / IEC 60079 for flame proof construction.

Flameproof housing shall also be made weather proof.

The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC 61000-4.

4.3.3 **Positioner / Positioner Transmitter**

Positioner shall be SMART type. Separate AFR shall be used with each Positioner. Positioner shall be provided with control damper and as specified in data sheets. The Positioner shall be weather proof to IP 65. Positioner shall meet all the requirements of the data sheets including fail safe conditions. Following accessories shall be provided as a minimum:

- Positioner Transmitter (if applicable, Weather proof and intrinsically safe)
- Volume tank / boosters (if applicable)
- Air Lock relay - SS Body (as applicable)
- Attachment kit for rotary movement complete with feedback mechanism and cam lever
- All required mounting accessories including compression type fittings for all pneumatic connections
- Any other specific requirements indicated in the data sheets
- All pneumatic connections shall be grouped in a connection manifold with pressure gauge for input signal air and output air (2 Nos.).

4.3.4 **Limit Switch**

Limit switches shall be inductive proximity type, 2 wire shall meet NAMUR DIN-19234 requirement. Limit switch shall be intrinsically safe weather proof to IP65 unless stated otherwise in damper datasheets. Separate Limit switch shall be provided for open and close position. Conduit connection shall be ½" NPT (F) two numbers with plugs (cable glands IP 65 in Supplier scope).

4.3.5 **Local Control Panel**

All control instrumentation shall be housed in a closed control panel provided with doors and a lock. The panel shall be weather proof to IP 55 with instruments, instruments items, junction boxes, terminal blocks, Pushbutton, switches etc. shall be certified Flame proof Ex(d). The push buttons / switches connected to MCC / PCC / substations shall also be certified flame proof. The Panel shall be complete with interconnecting cabling, tubing. The cable connection shall be provided from bottom. The panel shall be either self- standing floor mounted type or mounted on a channel / angle frame complete in all respects ready for erection and fixing on foundations. The cabinet internal shall be laid out properly to allow for unhindered maintenance and provide an aesthetic look. A canopy or rain-shed shall be provided. The tubing shall be bent with rollers such that no flattening / crimping occur. Bulk head connector shall be provided for Pneumatic connection.

4.3.6 **Solenoid Valve**

4.3.6.1 Solenoid valve shall be intrinsically safe / Flame proof as specified in the Job Specification.

4.3.6.2 The solenoid valves shall be direct operated type, in general. Where intrinsically safe Solenoid valve specified, the coil shall be rated at 24V DC low power consumption type, suitable for voltage available as per safety certification 3-port isolation type active IS Barrier and considering cable resistance of 12.3 ohms/km @ 20°C for 1.5mm² conductors. Where 110V DC Flame proof Solenoid valve specified, the coil rating shall be 0.5A and the housing shall be Flame proof Ex(d). Solenoid valves housing shall be Weather proof to IP 65. For IS solenoid valve, Bidder shall provide Entity parameters for selected SOV along with list of compatible barriers.

4.3.6.3 The Solenoid valve shall be 3-way and universal design type. Solenoid valves shall be of failsafe design such that in the event of power failure, mechanical spring shall always assist it to return it to the safe state. The material of construction of solenoid valves shall be SS316 with the trim material of SS316, as a minimum. All solenoid valves shall be of pack less type. The Solenoid valves shall be provided with Auto reset facility. The location of Reset Push button shall be as per the P&ID. All solenoid valves shall be of tight shutoff type. Vent port shall be provided with bug screen. Valve sizing shall be governed by the cylinder size and actuation time specified in data sheets, however solenoid valves shall be full port type and solenoid valve orifice shall be approximately equal to the inlet air tubing size to facilitate quick opening.

4.3.6.4 **Coil & Housing**

Solenoid coils shall be of the moulded type design meant for continuous duty. Coil insulation shall be minimum class H suitable for high temperature as per IS / IEC-60085 unless otherwise specified. The solenoid coil shall operate the valve even when the supply voltage drops down by 15% or goes up by 10%. Vendor to ensure that for intrinsically safe solenoid valves, maximum voltage level reached after considering tolerance levels shall meet the safety requirements specified in hazardous area certification. The coil shall be wired to a terminal block located inside the housing.

4.3.7 Reset Pushbutton, Auto / Manual Selector Switches, on field shall be weather proof to IP 65 and flameproof type.

4.3.8 The Manual loader (HIC) shall be provided if indicated in P&ID/Damper datasheet and the same shall be intrinsically safe, suitable for two wire electronic loop, without requiring a separate power supply. The HIC shall be loose supplied and shall be fitted in a weather proof (IP-65) CRCA sheet enclosure for mounting at grade by purchaser. The mounting accessories like clamp, screw etc. shall be provided by vendor.

4.3.9 The selector switch shall be two position, flameproof Ex(d) supplied as loose, the same shall be mounted at grade by purchaser.

4.3.10 **Junction Box and Cable Gland**

4.3.10.1 Separate Junction box shall be provided for DCS and ESD signal and locate in the control panel. Junction boxes shall be flameproof (Exd), certified suitable for the specified hazardous area. Junction boxes shall be suitable for connecting 12 pair signal / control / alarm cable. The cable entry for 12 pair cable shall be 1½" NPTF. Each JB shall be provided with 3 multi cable entries with one entry plugged as a minimum. JB shall be suitable for 12 Nos. of single pair cable entries, single pair entry shall be of ½" NPTF. Supplier shall keep spare entries plugged. JB shall be suitable for constructed out of die-cast Aluminum LM-6 alloy. The

junction boxes shall be provided with sufficient number of terminals to terminate all the pairs of multicable and shield of individual pair's as applicable.

4.3.10.2 Cable glands shall be provided for all instruments (viz Limit switches, SOV, etc.), control panel, Terminal block & junction boxes. These shall be double compression type, Nickel plated Brass and shall be provided with PVC sleeves (shroud). All cable glands shall be weatherproof to IP65, and shall be additionally flameproof (EExd) for the specified electrical area classification, Plugs shall be provided wherever required. They shall be of nickel-plated brass. Plugs shall be certified flameproof.

4.3.11 For all electrical connections, flying Leads are not acceptable. Suitable terminal blocks shall be provided for cable termination. SOV and limit switches connected with interlock and shutdown shall be terminated in the same junction boxes.

4.3.12 **Tube and Tube Fittings**

4.3.12.1 All main line and purchaser connection pneumatic tubing shall be minimum ½" OD x 0.065" thick and internal pneumatic tubing shall be ¼" x 0.049" thick, ASTM A269 TP 316L, SS fully annealed, seamless and cold drawn. Molybdenum content shall be 2.5% minimum and carbon content of ≤ 0.03%. Maximum working pressure shall be 102 kg/cm^2(g). SS flexible tubing with SS over-braid corrugated tubing shall be used to connect cylinder and positioner to the panel.

4.3.12.2 All Tube Fittings shall be of flare less compression type having four-piece (for double compression type) construction consisting of two ferrules, nut and body or three piece (compression type) construction consisting of single ferrule, nut and body suitable for use on tubes of specified material for example stainless steel tubes conforming to ASTM A269 TP 316L with hardness in the range of HRB 70 to 79. All parts of the tube fittings shall be of 316 Stainless Steel. Threaded ends of fittings shall be NPT as per ANSI B 1.20.1.

4.3.13 All interlock and shutdown operations shall be implemented in purchaser's PLC located in control room.

4.3.14 All contacts in the intrinsically safe service shall be suitable for the applications. Switches shall be hermetically sealed type.

4.3.15 All filter regulators used for air supply to pneumatic instruments shall be supplied with 5micron filter.

4.3.16 Inspection of items shall be carried out as per Tender requirement. However, as a minimum the following tests / certificate shall be submitted by Supplier / sub vendor.

a) Material test certificate for all instruments
b) Calibration / test certificate for all instruments
c) Conformity certificate from sub-vendor
d) Pneumatic Test (1.5 times max working pressure): Body, Seat leakage testing (As applicable)

5.0 ELECTRIC ACTUATION SYSTEM

Electric actuation system for guillotine dampers shall be provided wherever applicable along with manual override as per the electrical specifications attached in the Tender. Supplier to note that distribution of all power from SOB's to Local Control Push button stations is in