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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY
NATIONAL IRANIAN OIL ENGINEERING
& CONSTRUCTION COMPANY

NIOEC SP

NIOEC SPECIFICATION
FOR

SHELL & TUBE HEAT EXCHANGERS

FIRST EDITION

JULY, 2005

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IN THE NAME OF GOD**FOREWORD**

By their very nature, technical Specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such Specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international Standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant Specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design and Engineering Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design and Engineering Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design and Engineering Director of NIOEC for evaluation and approval.

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NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 3) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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1. SCOPE

This NIOEC Specification covers the general requirements for the design, fabrication, inspection and delivery of shell and tube type heat exchangers.

Deviations from this specification will only be permitted on obtaining written approval from NIOEC.

Resolution on cases not explicitly stipulated in this Specification, or on cases where conflicts may arise among the requirements of the referenced IPS and the international standards, shall be made through written consent and approval of NIOEC.

- 1.1. Any deviation from this Specification shall be explicitly indicated by the Vendor for the employer's review and acceptance.
- 1.2. Approval of Vendors' drawings shall not relieve the Vendor from responsibility with regard to performance of the equipment specified therein.
- 1.3. Process requirements for each heat exchanger will be given on the "Process Data Sheet" which will be compiled by the Purchaser and submitted to the Vendor. A blanked copy is attached in Appendix II.
- 1.4. The "Heat Exchanger Specification Sheet" shall be complied by the Vendor, including baffle pitch and cut, and be submitted to the Purchaser for review and approval.
- 1.5. Additional Provisions for heat exchangers in hydrogen service are given under Section 10.
- 1.6. The design, fabrication, test & inspection of shell & tube type heat exchangers shall conform to TEMA class "R", & section VIII, Div.1,2 of ASME.

2. REFERENCES

The following standards, codes, and specifications, to the extent specified hereinafter, shall constitute a part of this NIOEC Specification. Latest edition of the undated referenced documents and the cited edition of the dated references shall apply. The applicability of changes made to the dated references, after the cited date shall be mutually agreed upon between NIOEC and the vendor/contractor.

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Section II	"Materials"
Section V	"Nondestructive Examination"
Section IX	"Welding & Brazing Qualifications"
Section VIII	"Rules for unfired Pressure Vessels"
ASME B.1.1	"Unified Screw Thread"
ASME B.1.20.1	"Pipe Thread"
ASME B.16.5	"Steel Pipe Flanges and Flanged Fittings"
ASME B.16.20	"Metallic Gaskets for Pipe Flanges"
ASME B.16.47	"Large Diameter Steel Flanges"
ASME B18.2.1	"Square and Hex Bolts and Screw"
ASME B18.2.2	"Square and Hex Nuts"
ASME B36.10	"Welded and Seamless Wrought Steel Pipe"
ASME B46.1	"Surface Texture, Surface Roughness, Waviness and Lay"

TEMA (TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION)**ASTM (AMERICAN STANDARDS FOR TESTING AND MATERIALS)****API (AMERICAN PETROLEUM INSTITUTE)**

API 640	“Tube Dimensions for Heat Exchangers”
API RP-521	“Guide for Pressure-Relieving & Depressuring Systems”

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERING)

MR-0103
MR-0175

NIOEC SP (NIOEC SPECIFICATION)

NIOEC-SP-80-02	“NIOEC Specification for Painting”
NIOEC-SP-50-04	“NIOEC Specification for Piping Material Specification”
NIOEC-SP-90-02	“NIOEC Specification for Welding Shop and/or Field Fabricated Piping”
NIOEC-SP-00-50	“NIOEC Specification for Design Criteria for Process & Mechanic”
NIOEC-SP-00-01	“NIOEC Specification for Civil Design Criteria”
NIOEC-SP-00-10	“NIOEC Specification for Units”
NIOEC-SP-00-11	“NIOEC Specification for Site Conditions”

NIOEC SIP (NIOEC SHOP INSPECTION PROCEDURE)

NIOEC-SIP-44-01	“Shop Inspection Procedure for Shell and Tube Heat Exchangers”
NIOEC-SP-00-01	

Standard Drawings

Applicable Standard Drawings as compiled in the list of Appendix I.

3. UNITS

International System of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

4. DEFINITIONS & TERMINOLOGY

This section contains definitions for the terms as they are used in this document.

Employer: National Iranian Oil Engineering & Construction Company. (NIOEC)

Purchaser: National Iranian Oil Engineering & Construction Company. When quoted in this Specification as part of a direct purchase order by NIOEC and “Contractor” where this Specification is part of Contract Documents.

Vendor: The manufacturer's from which the equipment is to be purchased.

Contractor: The party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility.

Inspector: The inspector or engineer by the Purchaser and acting as the Purchaser's representative, the inspector's or engineer's respective assistants properly authorized and limited to the particular duties assigned to them, or the Purchaser acting as the inspector.

5. DESIGN

For thermal and mechanical design NIOEC-SP-00-50 shall also be considered.

5.1. Thermal Design

- 5.1.1.** The heat transfer area and heat transfer coefficients shall be based upon the outside effective tube surface.
- 5.1.2.** Calculated fouling resistances shall not be less than the fouling resistances given in the process Data Sheet. If the process Data Sheet omits these data, fouling resistances per TEMA shall apply. The tube side fouling resistance per TEMA shall be applied and increased by the outside/inside surface ratio as per TEMA, Section T – 2.4.
- 5.1.3.** When the physical properties of fluids (Specific heat, density, viscosity etc.) are to be taken from available literature, preference shall be given to Maxwell's handbook and TEMA standards.
- 5.1.4.** Maximum acceptable pressure drops indicated in the process Data Sheet shall be understood for fouled exchangers and as inclusive of the pressure drops through inlet and outlet nozzles. In cases of alternate conditions these shall be applied to the worst operating condition.
- 5.1.5.** Design velocities in tubes for cooling water shall be kept within the operating range of 0.9 to 1.8 m/s for carbon steel or admiralty brass and 1.8 to 3.1 m/s for monel or stainless steel tube materials. Velocities for fluids other than water in the tubes shall be such to create a turbulent flow but in no case shall exceed 3 meters per second (10 FPS).

Tube Materials	Average Speed			
	m/ sec.		ft./ sec.	
	Min.	Max.	Min.	Max.
Carbon steel	0.9	1.8	3	6
Admiralty	0.9	1.8	3	6
Aluminium brass	0.9	2.4	3	8
Aluminium bronze	1.5	3.1	5	10
Cupronickel	1.5	3.1	5	10
Aluminium	0.9	3.1	3	10
Monel	1.8	3.1	6	10
Stainless steel	2.4	3.1	8	10

- 5.1.6.** The thermodynamic designer shall follow the process Data Sheet as to fluid position in the shell and tubes; unless it is explicitly stated that circulation may be inverted if advisable for technical or economical reasons.
- 5.1.7.** For Kettle Type Steam Generators no weir is required. The clearance above the maximum level of water shall be such as to minimize liquid entrainments by steam. Such entrainments shall anyway not exceed 5% by weight of the steam when the boiler will produce 125% of design steam rate.

6. MECHANICAL DESIGN

6.1. General

All exchangers shall be designed for horizontal erection unless otherwise explicitly specified. Earthquake load, wind load and snow load shall be as follows:

- 1) Earthquake load shall be in accordance with civil design criteria NIOEC-SP-00-01 (Clause 2.10)
- 2) Wind load shall be in accordance with chapter 16 of UBC as following:
 - a) Basic wind speed and exposure coefficient at site as per NIOEC-SP-00-11.
 - b) Design wind pressure shall be in accordance with the chapter 16 of Vol 2, Div. III.
- 3) Snow load shall be considered as per NIOEC-SP-00-11 (Site Conditions).

6.1.1. All exchangers of the same size type and material shall maximize interchangeability of parts where practical. The highest practical number of exchangers shall have interchangeable tube bundles. Whenever possible tube bundles shall be designed to permit rotation though 180°.

6.1.2. For all exchangers a maximum nominal diameter of the tube bundle of 1140mm is allowed. For special cases, higher diameters may be permitted only by the Purchaser approval. For kettle type reboilers maximum 1540mm internal diameter is acceptable.

6.1.3. For shell side fouling factor of 0.0004 hr.m² °C/kcal or greater, square pitch shall be specified. For services with a fouling factor less than 0.0004 hr.m² °C/kcal, triangular pitch may be used.

Tube size and pitch shall be as per following table as a minimum.

Shell side fouling (hr.m ² °C/kcal)	Tube side fouling (hr.m ² °C/kcal)	Tube O.D. (inch)	Pitch (inch)
up to 0.0004	up to 0.0006	3/4	1 Triangular
up to 0.0004	over 0.0006	1	1-1/4 Triangular
over 0.0004	up to 0.0006	3/4	1 Square
over 0.0004	over 0.0006	1	1-1/4 Square

Exceptions:

- Use square pitch if shell side available pressure drop is low.
- Use square pitch if vapor/liquid separation is required.
- Use triangular or rotated square pitch if more turbulence is required.

6.1.4. When tube side medium is clean, or when the fouling factor on the tube side is equal to or less than 0.0004 hr m² °C /kcal, or number of joint closures should be restricted, U – tube construction is permitted. For non – fouling service on the shell side, fixed tube sheet or U – tube exchangers with triangular pitch layouts could be used. For fouling services on the shell side and cooling water services, except for surface condenser of steam turbines, floating head or U – tube exchangers with square pitch layouts shall be used. This applied both to low – fin or bare tubes. The use of fixed tube sheet exchangers is restricted to those indicated in the individual process Data Sheet.

6.1.5. Water cooled units shall be designed for the cooling water to flow through the tubes unless specified otherwise on the process data sheet.

6.1.6. Unless otherwise specified by NIOEC, channels shall be removable and front head channels shall be provided with removable covers.

- 6.1.7.** All exchangers, with the exception of kettle type reboilers and those containing U-tube, shall be equipped with removable shell covers.
- 6.1.8.** Where “U” tube construction is utilized, each U – tube shall be formed from a single length of tubing.
- 6.1.9.** The use of Stay Bolts as a means to stiffen tube sheets, channel covers and flange heads is not permitted.
- 6.1.10.** In addition to normal design loads, for units with removable tube bundles, supports should be designed to withstand a pulling force equal to 1-1/2 times the weight of the tube bundle.
All combinations of loads shall be considered to determine the maximum design stress conditions for design except for maintenance loads combined with wind, earthquake loads. Erection loads shall also be taken into consideration.
- 6.1.11.** For Hydrocracking units H.P. exchangers Vendor is to submit constructional details of tube sheet and seal baffle design.
- 6.1.12.** Where the shell may become over – pressured in the event of a burst tube the Vendor shall submit proposals for limiting the pressure in the shell.

Code Stamp:

The official code symbol stamp per the applicable code will not be required, unless otherwise specified.

6.2. Design Pressure and Temperatures (See item 5.1 of NIOEC-SP-00-50)

6.2.1. Design Pressures

Design Pressures shall be as shown on the individual Process Data Sheet. When alternate operating is specified, the exchanger unit shall be designed to handle either condition without exceeding the allowable pressure drop.

- 6.2.1.1.** Any abnormal operating conditions, maintenance conditions e.g. steam-out, should be taken into consideration.
- 6.2.1.2.** The design pressure of the low pressure side shall not be less than 10/13 of the design pressure of the high pressure side, unless otherwise specified by NIOEC..
- 6.2.1.3.** Vendor shall provide visible warning plate adjacent to, or part of, the name plate outlining test pressure regulations, when differential pressure design is used.

6.2.2. Design Temperature

- 6.2.2.1.** Design temperature shall be indicated on the individual Process Data Sheet.
- 6.2.2.2.** When, due to the possible loss of flow of the cooling medium, the tubes, tube-sheets and floating heads may be subject to the full inlet temperature, it shall be indicated on the individual Process Data Sheet and these components shall be designed for the maximum anticipated operating temperature of the hotter medium.
- 6.2.2.3.** The design temperatures for multiple exchangers in series shall be selected in accordance with the maximum temperatures likely to occur on each exchanger in both clean and fouled condition. The design temperature indicated on the Process Data Sheet is the temperature of the hottest exchanger. Intermediate design temperatures shall be calculated assuming the highest heat transfer coefficient with fouled surface and the lowest heat transfer coefficient with fouled surface for the colder and hotter sections respectively. If irregular heat profiles are indicated on the Process Data Sheet, design data will be supplied on which the Vendor shall base all calculations, which shall be submitted to the Purchaser for approval.