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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 standard 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 standard 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 standard 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 on going projects.

In response to the initiative of the Design Division of the Engineering and Construction 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 Division of the Engineering and Construction 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 Deputy of the Engineering and Construction Director of NIOEC for evaluation and consideration.

S. R. KASAEIZADEH



EXECUTIVE DIRECTOR

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NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) REMARKS RELATED TO EACH REVISION SHOW A BRIEF DESCRIPTION. THESE REMARKS SHALL BE INTERPRETED IN CONJUNCTION WITH THE REVISED TEXT MARKED BY REVISION NUMBERS.
- 3) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 4) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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0	JULY 2005	A. KARIMI	M.H. ZAKER	M.R. FARZAM	M.A.A. SAJEDI
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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. Where data presented on process Data Sheet conflicts with the requirements of this Specification the individual Data Sheet shall govern.

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 of ASME.

1.7 Order of Precedence

In the event of a conflict among the various documents, the order of precedence shall be as follows:

- The purchase order (including attachments) and variations thereon.
- The data sheets and drawings.
- This Specification.
- TEMA

If conflict is discovered between the items listed, it shall be the responsibility of the Vendor to call attention to the conflict.

2. REFERENCES

Throughout this Specification the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this Specification.

For undated references, the latest edition of the referenced document (including any supplements and amendments) applies. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall mutually be agreed upon by the company and the Vendor/Contractor.

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Section II	Edition 2002	"Materials"
Section V	Edition 2002	"Nondestructive Examination"
Section IX	Edition 2002	"Welding & Brazing Qualifications"

ASME B.1.1	“Unified Screw Thread”
ASME B.1.20.1	“Pipe Thread”
ASME B.16.5 Edition 1996	“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 Edition 1996	“Square and Hex Bolts and Screw”
ASME B18.2.2	“Square and Hex Nuts”
ASME B36.10 Edition 2000	“Welded and Seamless Wrought Steel Pipe”
ASME B46.1 Edition 1995	“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	Edition 1998	“Tube Dimensions for Heat Exchangers”
API RP-521	Edition 1997	Guide for Pressure-Relieving & Depressuring Systems”

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERING)

MR-0103 Edition 2003

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”

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-G-ME-220	Edition 1998	“Engineering and material standard for shell and tube heat exchanger”
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UBC (UNIFORM BUILDING CODES) UBC 1997

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

3.1 “Employer” means “National Iranian Oil Engineering & Construction Company”. (NIOEC)

3.3 “Purchaser” means “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.

3.4 “Vendor” means the manufacturer's from which the equipment is to be purchased.

3.6 “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.

3.7 “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. SYMBOLS & ABBREVIATIONS

A.W.S. American Welding Society

6. DESIGN

Note: For thermal and mechanical design [NIOEC-SP-00-50](#) shall also be considered.

6.1 Thermal Design

6.1.1 The heat transfer area and heat transfer coefficients shall be based upon the outside effective tube surface.

6.1.2 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.

6.1.3 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.

6.1.4 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.

6.1.5 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
Aluminums brass	0.9	2.4	3	8
Aluminum bronze	1.5	3.1	5	10
Cupronickel	1.5	3.1	5	10
Aluminum	0.9	3.1	3	10
Monel	1.8	3.1	6	10
Stainless steel	2.4	3.1	8	10

6.1.6 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.

6.1.7 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.

7. MECHANICAL DESIGN

7.1 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).

7.1.1 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°.

7.1.2 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 which may be 1540mm internal diameter.

7.1.3 For shell side fouling factor of $0.0004 \text{ hr.m}^2 \text{ }^\circ\text{C/kcal}$ or greater, square pitch shall be specified. For services with a fouling factor less than $0.0004 \text{ hr.m}^2 \text{ }^\circ\text{C/kcal}$, triangular pitch may be used.

Tube size and pitch shall be as per following table.

Shell side fouling ($\text{hr.m}^2 \text{ }^\circ\text{C/kcal}$)	Tube side fouling ($\text{hr.m}^2 \text{ }^\circ\text{C/kcal}$)	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	11/4 Triangular
over 0.0004	up to 0.0006	3/4	1 Square
over 0.0004	over 0.0006	1	11/4 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 square pitch if turbulence required.

7.1.4 When tube side medium is clean, or when the fouling factor on the tube side is equal to or less than $0.0004 \text{ hr m}^2 \text{ }^\circ\text{C /kcal}$, or when required by the process fluid on the shell side, or number of joint closures should be restricted, U – tube construction is permitted. and normally, for non – fouling service on the shell side, fixed tube sheet or U – tube exchangers with triangular pitch layouts shall be used. For fouling services 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.

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

7.1.6 Unless otherwise specified, channels shall be removable and shall be provided with removable covers.

7.1.7 All exchangers, with the exception of kettle type reboilers and those containing U-tube, shall be equipped with removable shell covers.

7.1.8 Where “U” tube construction is utilized, each U – tube shall be formed from a single length of tubing.

7.1.9 The use of Stay Bolts as a means to stiffen tube sheets, channel covers and flange heads is not permitted.

7.1.10 In addition to normal design loads, exchangers shall be designed to withstand a horizontal pulling load of 133% of the bundle weight. 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.

7.1.11 For Isomax H.P. exchangers Vendor is to submit constructional details of tube sheet and seal baffle design.

7.1.12 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.

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

7.2.1 Design Pressures

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

7.2.1.1 Any abnormal operating conditions, maintenance conditions e.g. steam out, should be taken into consideration.

7.2.1.2 When the design pressure of the low pressure side is less than 10/13 of the design pressure of the high pressure side, special attention shall be made to the consideration of tube failure. The criteria shall be set taking into account requirements outlined in section 3.15 of API-RP 521. Tube plates may be required to withstand differential pressure in high pressure exchanger when specified on the Data Sheet.

7.2.1.3 Vendor shall provide visible warning plate adjacent to, or part of, the name plate outlining test pressure regulations, when differential pressure design is used.

7.2.2 Design Temperature

7.2.2.1 Design temperature shall be indicated on the individual Process Data Sheet.

7.2.2.2 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.

7.2.2.3 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.

7.2.2.4 The fluid design temperature shall be assumed as design temperature for insulated flanges. In case of naked flanges the design temperature shall be assumed as corresponding to 90% of the fluid design temperature. If flanges are designed on basis of naked flanges, a warning shall be given on the nameplate, "Not to insulate flanges."

7.3 Corrosion Allowance and Minimum Wall Thickness

7.3.1 Corrosion allowance shall be per TEMA standard, Section RCB – 1.5. For materials other than carbon steel corrosion allowance shall be specified on the exchanger specification sheet.

7.3.2 No corrosion allowance shall be added to tubes.

7.3.3 Minimum admissible wall thickness shall be per TEMA and ASME Codes, except for tubes to be as per table 7.7.3

7.4 Alloy Protective Lining

7.4.1 When the Process Data Sheet indicates materials other than carbon steel for tube sheets without specifying "solid", Vendor may quote the more economical alternative between "solid" and "cladded" material.

7.4.2 Lining for exchanger shells, tube sheets, channels and other parts shall be of integrally clad plate or build up and machined weld deposit.

7.4.3 The minimum thickness of applied liners shall be 3mm and the thickness of alloy cladding shall be to 3mm minimum as closely as standard mill practices will permit.

7.4.4 Pass partition grooves in lined tubesheets and channel covers shall have the specified minimum lining thickness on all surfaces.

7.4.5 Applied alloy liners shall be considered as corrosion allowance only, not as part of the base metal, when calculating the thickness of pressure parts.

7.4.6 If the base metal is carbon steel, then if other carbon steel components in contact with the same process flow are specified to be of fully killed carbon steel, the base metal of the cladding shall also be of the same material.