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

NIOEC SP

NIOEC SPECIFICATION FOR PROCESS DESIGN OF SOLID – LIQUID SEPARATORS

SECOND EDITION

JUNE, 2016

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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 on going 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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INTRODUCTION

To satisfy the requirements of this NIOEC Specification, Iranian Petroleum Standard IPS-E-PR-895(1) (JAN 2006) with the modifications as specified herein after shall be strictly followed.

Articles 1 and 2 of this document replace entirely the related articles in the referenced IPS Standard.

1. SCOPE

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/relevant IPS and the international standards, shall be made through written consent and approval of NIOEC.

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.

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-PR-895	"Engineering Standard for Process Design of Solid – Liquid Separators"
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NIOEC-SP (NIOEC SPECIFICATIONS)

NIOEC-SP-00-10	"NIOEC Specification for Units"
NIOEC-SP-00-97	"NIOEC Specification for Process Design of Gas (Vapor) - Liquid Separators"

2.1. EQUIVALENT TO IPS STANDARDS

Substitute the following IPS Standards as referred to throughout IPS-E-PR-895 for the relevant NIOEC's Specifications as follows:

<u>IPS Standard</u>	<u>Relevant NIOEC Specification</u>
IPS-E-GN-100	NIOEC-SP-00-10
IPS-E-PR-880	NIOEC-SP-00-97

3. UNITS (Modification)

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

4. DEFINITIONS AND TERMINOLOGY (Modification)**5. SYMBOLS AND ABBREVIATIONS (Modification)****6. ADDENDUM TO IPS-E-PR-895**

This addendum revises the below listed articles of the referenced standard as follows:

6.2.1. Mechanical Separation by Gravity (Substitution)

In certain circumstances, process conditions preclude the possibility of using direct filtration as a means of separating a solid-liquid mixture. High dilution or extreme fineness of particle lead to uneconomic sizes of filter or, in some cases, make normal filtration impossible without pretreatment or concentration of the feed.

Here, gravity sedimentation, involving a difference in density between solids and liquids, is used to produce an essentially clear overflow of liquid and a concentrated underflow of the mixture. The latter may now be more readily filterable, or be in a condition suitable for disposal, e.g. in sewage handling.

Solid particles will settle out of a liquid phase if the gravitational force acting on the droplet or particle is greater than the drag force of the fluid flowing around the particle (sedimentation).

Stokes' law applies to the free settling of solid particles in liquid phase.

6.2.2 Mechanical Separation by Momentum (Substitution)

Centrifugal sedimentation is based on a density difference between solids and liquids. the particles are subjected to centrifugal forces which make them move radially through the liquid either outwards or inwards, depending on whether they are heavier or lighter than the liquid. Centrifugation may thus be regarded as an extension of gravity sedimentation to finer particle sizes and it can also separate emulsions which are normally stable in the gravity field.

Separation by centrifugal action is the most frequently technique used in this field.

6.2.3 Mechanical Separation by Filtration (Substitution)

Filtration is the separation of a fluid-solid mixture involving passage of most of the fluid through a porous barrier which retains most of the solid particulates contained in the mixture.

Filtration processes can be divided into three broad categories, cake filtration, depth filtration, and surface filtration.

7.1.2 Types of Liquid Filters (Substitution)

Considering the flow characteristics, as mentioned in Clause 6.2.3.1, three types of filtration processes exist, constant pressure, constant rate and variable pressure-variable rate. Regarding the manner of operation, filtration may be continuous or batch.

Filter presses and vacuum drum filters are well known examples for batch and continuous filters respectively. The complete spectrum of filtration equipment is shown in Table below:

Classification of Filters

Screens
Stationary
In-line strainers*
Horizontal or slightly inclined
Curved ('sieve-bend')
Vertical
Moving
Continuous (vertical or rotating drum)
Oscillating (vibrating or gyratory)
Demisters**
Scrubbers (wet and 'dry') **
Depth filters
Pads and panels (cassettes)*
Thick cartridge*
Deep bed ('sand')*
Surface/cake filters
Vacuum
Batch
Nutsche (manual or scroll discharge)
Rotary table
Tilting pan (single or rotating/indexing)
Leaf or tubular element
Continuous
Rotary drum (range of discharge mechanisms)
Rotary disc
Indexing disc
Belt (single or multiple chambers)
Gravity
Flat bed (roll)*
Centrifugal
Fixed bed (batch and semi-continuous, perforate basket)
Manual discharge
Automatic discharge (vertical, horizontal, inclined axis, inverting)
Moving bed
Conical screen (horizontal or vertical axis)
Free (tumbling) discharge
Controlled discharge
Cylindrical screen (horizontal axis – pusher)
Fluid pressure
In-line
Basket strainers
Sheets*
Capsules*
Bags, sleeves and pockets*
Cartridges (thin medium – wide range of designs)*
Other membrane filters (spiral wound, tubular, etc)*
Pressure vessel
Tubular element (bag or candle filter)*
Filter coalescers
Flat elements (sheet, plate, leaf)
Thickeners

Rotary (drum, submerged drum, Fest, etc)
 Filter press
 Simple plate and frame
 Chamber press diaphragm plate, plate press)
 Tower press (continuous medium)
 Variable volume (tube press)
 Mechanical pressure
 Band press
 Horizontal
 Vertical
 Screw press
 Other force fields
 Magnetic
 Electrically aided

Notes:

This list is mainly of equipment used for liquid phase separations, except for those items marked:

** gas filtration only or mainly

* Versions for gas and liquid filtration

Table above is organized primarily by the type of filtration used in each filter. Relatively pure surface filtration comes first, exemplified by screens, followed by depth filtration. The bulk of the table is taken up with those filters that work initially by surface screening, but which move quickly into the formation of a cake of accumulated solids on the surface of the filter medium. Once a thin cake is formed, the remaining filtration occurs through this cake, which grows in thickness until the pressure differential across it becomes too great.

The cake filters are divided by the driving force that causes the filtration: vacuum (i.e. a negative pressure at the filter medium), gravity alone (i.e. the hydrostatic head of the liquid above the medium), centrifugal force (i.e. an amplified gravity effect), fluid pressure (imposed by the suspension feed pump), mechanical pressure (a squeezing effect), and the use of other force fields. The large number of types of pressure filter is obvious – for most people the pressure filter, from simple cartridge to the complex fully automated filter press, typifies filtration.

7.1.3 Filter Media (Substitution)

A filter medium is any material that, under the operating conditions of the filter, is permeable to one or more components of a mixture, solution or suspension, and is impermeable to the remaining components.

There are many different types of filter media available and all have an important role in filtration. The range includes: paper, natural and synthetic fibres, powders, felt, plastic sheet and film, ceramic, carbon, cotton yarn, cloth, woven wire, woven fabric, organic and inorganic membranes, perforated metal, sintered metals and many other materials. Types of Filter Media by material are shown in Table below:

Types of Filter Media by Material

Material	Format
Natural fibre: wool, cotton, etc.	Felt: loose, bonded, needled
Natural filament: silk	Woven yarn, filament
	Knitted yarn, filament
	Wound yarn
Processed natural fibre: cellulose	Wet-laid (paper, filter sheets)
Man-made organic: regenerated cellulose	Granules: loose, bonded, sintered
synthetic polymers	Fibres and Filaments: felted, woven, dry-laid (spun), wet-laid (paper), rigidized, sintered
	Foam
	Extruded mesh ('Netlon')
	Sheet: perforated, stretched (fibrillated), porous, membrane
	Tubular: rigid porous, hollow fibre
Metals: ferrous and non-ferrous	Rod or bar structures
	Granules or powder: loose, sintered
	Fibres: loose, sintered
	Sheets: perforated (punched, etched)
	Wire: wound cartridge, woven mesh, sintered mesh
	Expanded mesh ('Expamet')
	Foam
Glass	Fibre: wet-laid (paper)
	Porous tube
Carbon: natural	Granules or powder: loose, bonded, embedded
activated	Fibres: loose, felted, woven, embedded
	Porous block
Ceramics: metal oxides	Granules or powder: loose, sintered
others	Formed blocks, with tubular holes
	Fibres: loose, sintered
	Foam
Other minerals: mineral wools	Fibres: wet-laid (filter sheets), pads
sand, anthracite, garnet	Granules
Various materials (metal, paper, plastic)	Solid fabrications: stacked discs, edge filters,

	wedge wire, wire wound
Paper-like materials	Pleated sheet
Inert granules of all kinds	Packed beds (deep bed filters)
Mixtures of inert and active materials	Combination media
These may be generally divided into four groups, General media, Membrane type media, Woven wire, and Expanded sheet media.	

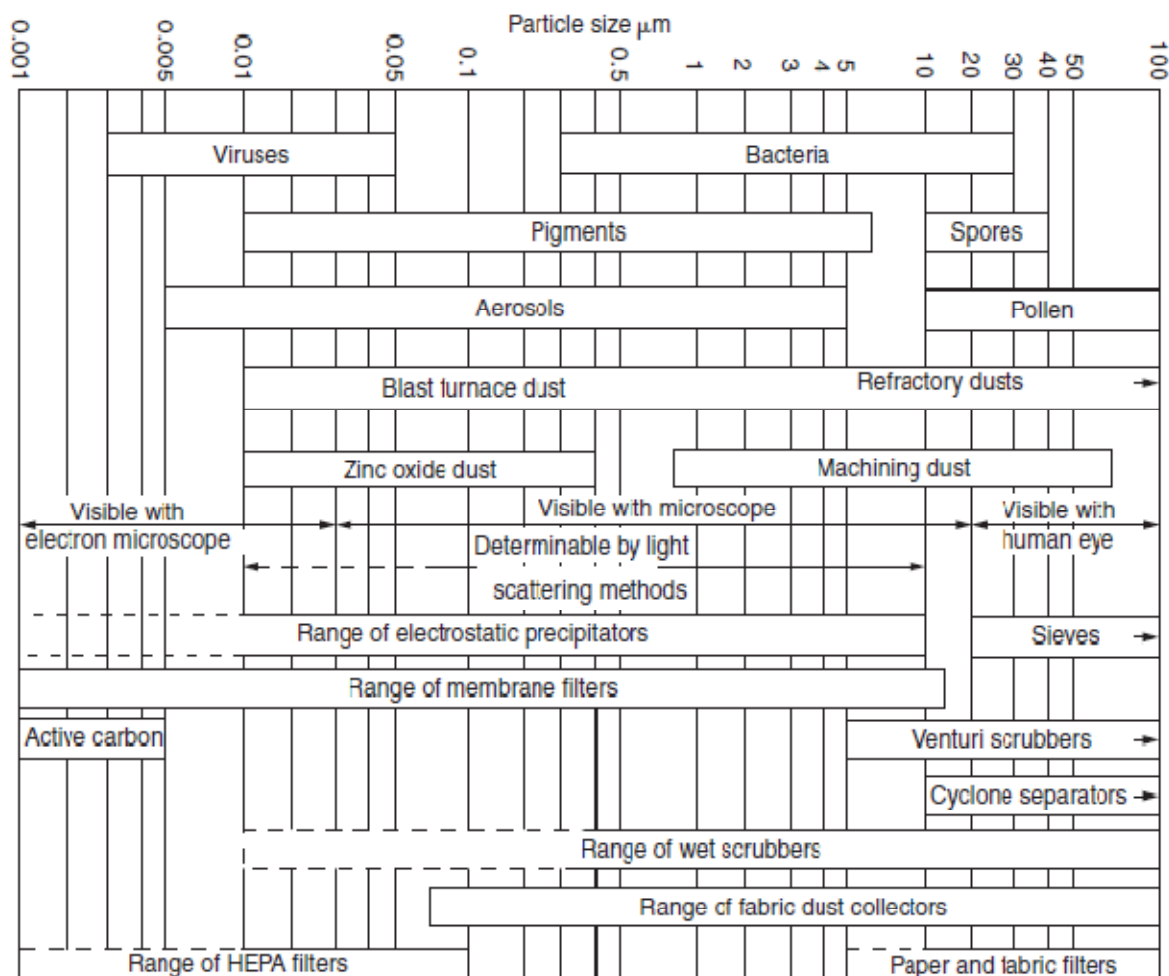
7.1.3.1 Cartridge Filters (Modification)

The following paragraph add to the beginning of 7.1.3.1:

Cartridge filters are one of the most widely used types and have the advantage of being simple, with minimal installation cost. Cartridges have had many improvements in manufacturing and pore size control. Some media used in making cartridges, such as porous ceramics, sintered metals, felts and papers, are dealt with separately as we proceed.

7.2.2.1 Selection of Filter Type (Modification)

Table 5 replaced by:



Contaminant sizes and separators

8.1.1 Sedimentation Centrifuges (Substitution)

Sedimentation centrifuge remove or concentrate particles of solids in a liquid by causing the particles to migrate through the fluid radially toward or away from the axis of rotation, depending on the density difference between particles and liquid.

Five main types of industrial sedimenting centrifuges may be distinguished according to the design of the bowl and of the solids discharge mechanism. Figure below shows a schematic classification of the equipment; the mode of discharge and operation is quoted for each type of equipment.

8.1.1.1 Sedimentation by Centrifugal Force

A solid particle settling through a liquid in a centrifugal-force field is subjected to a constantly increasing force as it travels away from the axis of rotation. It therefore never reaches a true "terminal" velocity.

However, at any given radial distance r the settling velocity of a sufficiently small particle is very nearly given by the Stokes-law relation.

If Stokes settling of a dilute suspension of uniform particles occurs in a tubular bowl of radius r , containing a thin layer of liquid of thickness s , with a given flow rate Q , the critical diameter D_{pc} of centrifuge is given by:

$$D_{pc} = \sqrt{\frac{9Q\mu s}{(\rho_p - \rho_l)V\omega^2 r}}$$

Most particles with diameters larger than D_{pc} will be eliminated by the centrifuge, most particles with smaller diameters will appear in the effluent, and particle with diameter D_{pc} will be divided equally between effluent stream and settled solids phase.

ENGINEERING STANDARD

FOR

PROCESS DESIGN

OF

SOLID-LIQUID SEPARATORS

ORIGINAL EDITION

JULY 1997

This standard specification is reviewed and updated by the relevant technical committee on Jan. 2006. The approved modifications are included in the present issue of IPS.

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