

NIOEC-SP-00-65(1)							
DOCUMENT CODE							NO. OF PAGES: 9
PLAN/PRJ/SUB	UNIT	PHASE	DISCIPLINE	DOCUMENT TYPE	SERIAL NO.	REV. NO.	DATE
NIOEC	000	EG	PR	SP	0065	A1	JUNE 2015



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

NIOEC SP

NIOEC SPECIFICATION FOR PROCESS DESIGN OF FUEL SYSTEMS

SECONED EDITION

JUNE 2015

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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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REV.	DATE	PREPARED	CHECKED	APPROVED	AUTHORIZED

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INTRODUCTION

To satisfy the requirements of this NIOEC Specification, Iranian Petroleum Standard [IPS-E-PR-340](#) Dec. 2012 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

NIOEC specifications cover the general requirements for detailed engineering, procurements, testing, inspection & construction of refinery/ oil plant, distribution depots, pump stations and pipelines.

This Specification specifies the minimum requirement for process design of fuel systems used in the above-mentioned industries.

This Specification covers only gaseous and liquid fuel systems, and shall not be applied for solid fuel system.

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

BSI (BRITISH STANDARDS INSTITUTION)

BS 5351, "Specification for Steel Ball Valves for the Petroleum, Petrochemical and Allied Industries", 2010

BS ISO 8216-99, Petroleum products. Fuels (class F). Classification. General, July 2002

API (AMERICAN PETROLEUM INSTITUTE)

API-RP-550 "Manual on Installation of Refinery Instruments and Control Systems", 4th. Ed., July 1985

API STD 616 "Gas Turbines for the Petroleum, Chemical and Gas Industry Services", Ed., 5th Ed 2011

IPS (IRANIAN PETROLEUM STANDARDS)

[IPS-E-PR-340](#) "Engineering Standard for Process Design of Fuel Systems"

NIOEC-SP (NIOEC SPECIFICATIONS)

[NIOEC-SP-00-10](#) "NIOEC Specification for Units"

NIOEC-SP-00-50	"NIOEC Specification for Design Criteria"
NIOEC-SP-70-01	"NIOEC Specification for Instrumentation"
NIOEC-SP-00-71	"NIOEC Specification for Process Design of Cooling Water Circuits"
NIOEC-SP-47-01	"NIOEC Specification for Process Design of Vacuum Equipment (Vacuum Pumps and Steam Jet Ejectors)"
NIOEC-SP-00-97	"NIOEC Specification for Process Design of Gas (Vapor)-Solid Separators"
NIOEC-SP-46-08	"NIOEC Specification for Centrifugal Compressors in General Refinery Services"
NIOEC-SP-46-09	"NIOEC Specification for Reciprocating Compressors for General Refinery Services"

EQUIVALENT TO IPS STANDARDS

Substitute the following IPS Standards as referred to throughout [IPS-E-PR-340](#) 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-G-IN-200	NIOEC-SP-70-01
IPS-E-PR-400	NIOEC-SP-00-71
IPS-E-PR-440	NIOEC-SP-00-50
IPS-E-PR-745	NIOEC-SP-47-01
IPS-E-PR-880	NIOEC-SP-00-97
IPS-E-PR-750	NIOEC-SP-46-08
IPS-M-PM-170	NIOEC-SP-46-08
IPS-G-PM-200	NIOEC-SP-46-09

3. UNITS (Modification)

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

4. ADDENDUM TO IPS-E-PR-340

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

DEFINITIONS AND TERMINOLOGY

3. 12 Higher Heating Value (HHV)-(addition)

The theoretical gross heat available from the combustion of fuel, assuming condensation of the water that is produced. HHV is usually expressed as KJ/Kg (Btu/lb)

4. 13 Lower Heating Value (LHV)- (addition)

The net heat available from the combustion of fuel, assuming that the water formed by the combustion remains in the vapor state. LHV is usually expressed as KJ/Kg (Btu/lb). Fuel balances are typically done on a LHV basis.

5. 14 Wobbe index-(addition)

A measure of Joule/Sec (Btu/Sec) that can pass a given orifice. In addition to the heating value of the Fuel, it also considers the effects of specific gravity and temperature. Therefore, it is a better indication of heat input to combustion equipment than heating value alone. Acceptable variation in Wobbe Index should be obtained from the equipment vendors (for boilers, gas turbines, etc)

$$Wobbe = \frac{LHV}{\sqrt{SG \times Temp}}$$

6.3.2.3(addition)

The fuel oil storage temperature is dependent on the pour point and viscosity of the fuel oil and may be above the flash point. If the Storage temperature is at least 10°C below the flash point, tank blanketing is not necessary, but if not, storage tank shall be blanketed with steam, nitrogen or fuel gas. If steam blanketing is applied, an atmospheric vent shall be provided. If nitrogen or fuel gas is used, the gas shall be vented to flare or otherwise incinerated.

6.3.2.4 The system shall be designed so that from the fuel oil tanks, one supply and return header serves the processing Units while a separate supply and return header serves the boiler plant.

6.3.2.5 In the system design, particular attention should be paid to the following:

a) Circulation Pumps.(Substitution)

To provide a reliable supply of fuel oil at least three pumps should be used. Typically, at least one pump should be turbine driven (upon availability of steam) and the others motor driven.

Automatic cut-in of the standby pump should be provided on low pressure in the fuel system. Loss of one pump may nevertheless result in a considerable pressure transient in the fuel oil supply system, which may cause furnaces to trip. By having three pumps each of about 70% capacity this effect is reduced considerably.

When handling high viscosity oils such as heavy oil or a wide range of oil types ranging from low to high viscosity, i.e., wider pressure ranges are covered by the different type of pumps.

In screw type pump, high rotating speed and head are available. Covering viscosity, 30 to 4000 cSt and temperature up to 95° C.

In gear pump, medium and low head are available in gear pumps; covering viscosity 40 to 1000 cSt and temperatures up to 95°C.

In centrifugal pump, pump suction permanent strainer and safety valve for discharge control are not required. This pump cover wider range viscosity; higher efficiency than that of rotary pumps can be obtained in 30 cSt or lower

Fuel oil pumps are usually designed to handle more than one type of liquid fuel. Alternate fluid properties at operating temperatures must be specified to insure that the pump will be capable of meeting its design requirements under all fluid conditions. Consider the design impacts of handling heavier fuels in the future.

e) Storage tank (addition)

- (i) Storage tank type shall be aboveground cone or dome roof structure.
- (ii) API-650 "Welded oil storage tank is generally applied.
- (iii) The tank shall cover fuel consumption for one to two days consumption in a plant.
- (iv) Two tanks (min) shall be installed, considering tank maintenance, if the fuel oil is continuously used.
- (v) When heavy oil is stored, the temperature shall be maintained at 50 to 60 °C, using tank heaters.

When return oil temperature exceeds 100°C, water in the service tank may boil over and cause a serious accident; thus measures to prevent rain or other water from getting into tank shall be taken (nitrogen or gas blanketing), or the return oil shall not be returned to the service tank, but to the pump suction line instead.

6.3.2.6 Heaters on each fuel oil tank shall be able to keep the content at about 65°C. This temperature should be limited to a maximum of 115°C to minimize possibility of boil-over due to vaporization of water in tanks. The fuel oil supply header temperature shall be maintained at a temperature consistent with burner supply viscosity requirements.

6.3.2.7 To obtain the required fuel oil supply temperature adequate heat exchangers (fuel oil heaters) heated by 2000 kPa (g) [20 bar (g)] medium pressure steam shall be provided. These heaters shall be installed in parallel arrangement, and all will be required to be in service when maximum fuel oil consumption is experienced. The process design of fuel oil heaters shall be as per IPS-E-PR-771, "Process Requirements of Heat Exchanging Equipment".

6.3.2.8 Fuel oil supply temperature shall be regulated by controlling steam flow to the heaters.

6.3.2.9 By using fuel oil at each Unit, provision shall be made for a fuel oil return line with block valve.

6.3.2.10 A fuel oil return meter shall be provided on each Unit that consumes fuel oil.

6.3.2.11 The recirculation fuel oil shall be returned at substantially temperature difference with respect to the exchanger effluent, it may be directed back to the tank through the small vapor disengaging drum. Smoother operation will result, if it shall be always directed into the pump suction while the tanks are only heated to about 65°C.

6.3.2.12 The fuel oil lines shall be steam traced according to [IPS-E-PR-420](#), "Process Design of Heat Tracing & Winterizing".

6.3.2.13 The fuel oil system shall be designed such that at least 2 parts shall be supplied to the heater, one part burned, and one part returned. Unless otherwise specified the size of the return header shall be the same as the size of the supply header.

6.3.2.14 Separate nozzles should be provided on storage tanks for make-up of fuel oil, recirculation, and withdrawal of oil. The arrangement of nozzles should minimize short circuiting of recirculated oil.

6.3.2.15 Fuel oil supply header shall be controlled at a minimum pressure of 1000 kPa (g) [10 bar(g)], unless otherwise is specified for process requirements.

6.3.2.16 Relief valves shall be located on the discharge of the pumps and on the fuel oil heaters. Relief valve discharges should be piped back to the fuel oil storage tank.

6.3.2.17 Typical refinery fuel oil system is shown in Fig. B.1 in Appendix B.

6.5.1.3(modification)

Various stream of LPG and LPG off spec shall be received in the LPG surge drum and will be pumped into the vaporizer.

6.6.1(addition)

- Fuel blending components

6.6.2(addition)

- H₂S content

7.3.6(addition)

Fuel oil with viscosity of 15 to 30 cst (180 SSU) is suitable in the steam atomizing method. Thus, when using a fuel oil over the above viscosity at room temperature, viscosity needs to be reduced, heating with steam or electricity.

If high viscosity fuel oil is used; it shall be heated over 100 ° C.

The mechanical atomizing method is needed for viscosity less than 20 cst (150SSU).

8.1 design consideration(addition)

The fuel system design will vary according to the type and source of the fuel gas supplied.

The principal parameters and design considerations are:

- Gas composition (mixing) and supply control – attention shall be given to the suitability and reliability of supply
- Achieving required supply pressure (expansion or compression) – attention shall be given to expansion cooling and compression heating effects. Reliability of compression equipment shall be taken into account particularly with respect to required response time for back –up fuel supply and mixing / buffering capacity.
- Primary liquid knock – out (KO) facilities after compression or mixing – if compression may produce liquids, KO facilities shall be provided immediately downstream of the compressor (or aftercooler if applied). Any liquid drop – out shall be removed from the fuel gas, never re – vaporized in the gas by heating.
- Gas buffering / mixing – in order to maintain sufficient supply of fuel gas within the Wobbe index variation limits during supply upsets, particularly during change- over to back – up fuel supply , gas mixing and buffering equipment shall be provided to maintain base load operation , unless stated otherwise by the principal.
- Dual gas manifold – to cater for gas of variable composition and Wobbe Index , some gas turbines may be designed with a dual manifold and automatic control for switching the second manifold into service as required to maintain a constant a constant heat input. However, when the dual gas manifold is used, the option for liquid fuel firing is no longer available.
- Inert gas addition for Wobbe index control or NO_x control – if inert gas such as nitrogen or carbon dioxide is available on a continuous basis at sufficient pressure, this may be mixed into the fuel gas at the buffer/ mixing vessel. However, this technique shall be applied only after careful examination of the consequences of loss (trip) of inert gas on Wobbe index of

the gas and after verification by the gas turbine Manufacturer of the suitability of the gas composition , with or without inert gas , for firing in the proposed gas turbine.

- Gas heating for density /Wobbe index control – if gas composition changes produce wobbe index variations greater than the acceptable range advised by the gas turbine Manufacturer, sufficient compensation may be possible by heating the fuel gas to produce a gas of lower density. This may find application, for example, where vaporized LPG is used as a back –up fuel, in which case a higher vaporization pressure lower than the gas to avoid contamination of the gas in the event of cross – leakage. In addition, the safety aspects of cross – leakage of gas into the heating medium shall be evaluated.
- Fast response back-up fuel system – unless otherwise advised by the principal, the system shall allow a fuel change- over whilst maintaining base load operation of the gas turbine. As well as ensuring adequate gas buffering, attention shall be given to the design of LPG vaporizers with respect to response time when used as the back –up system. When heating by steam, the design shall ensure that condensate does not accumulate in the heating coil and thereby inhibit heat transfer when a demand occurs. An alternative design of vaporizer(e. g. compact heat exchanger) may be applied to achieve the required response subject to approval by the Principal of the design type.

As an alternative to gaseous fuel back-up , diesel (distillate) fuel may be used provided that the gas turbine is equipped for dual fuel. Diesel fuel back-up systems are standard systems from the gas turbine Suppliers and incorporate a skid- mounted fuel forwarding system.

- Final knock-out , filtration and firing control- this final section is normally part of the gas turbine package specification and is basically the gas turbine manufacturer`s protection for his equipment. The gas supplied in accordance with the fuel gas system requirements will not contain any liquid and this final KO facility should never experience liquids during operation. Only at start-up , when gas is vented to flare immediately upstream the gas turbine (line warm-up) will there be any likelihood of liquid. This vent connection shall be as close as possible to the fuel control valve. If particulate contamination of the gas is considered to be a possibility, e.g. corrosion deposits in pipelines, parallel 100% capacity filters shall be installed. These filters shall be switchable, have facilities for isolation and cleaning and be equipped with pressure drop monitoring / alarm facilities.

8.2 Gaseous Fuels

8.2.1 For liquefied petroleum gas (LPG) liquid phase formation in combustor shall be avoided.

8.2.2..(Sub.)

For natural gas/LNG boil off, the inlet gas temperature shall be above dew point of liquid hydrocarbons. It is essential that no liquid entrainment (either water or hydrocarbons) can occur and so efficient liquid knock-out followed by gas superheating to a minimum of 20°C above the gas dew point is required

8.2.3 For sour gas the following consideration shall be applied:

- a) corrosion resistant gas supply hardware;
- b) any heat recovery equipment should have cold end protection.

8.2.4. (Sub.)

For process gas, due to wide variation in composition they shall be considered on a case-by-case basis. Particularly where some variation in fuel gas composition/ temperature is possible, or where more than one fuel gas type may be supplied to the gas turbine(e.g. a different fuel as back-up), due attention shall be given to the manufacturer's limitation on the Wobbe Index(WI) of the fuel.

8.2.5 Practically all types of gaseous fuels should be burned in heavy-duty gas turbines, but not necessarily interchangeable in the same machine.

8.2.6 The standard gas turbine should be designed for natural gas specification. A fuel falling outside these requirements should be accommodated by suitable modifications to the turbine control system, gas-fuel components, rating, and fuel handling equipment. Fig. 1 represents the gas fuel system of standard turbine.

8.2.7 (addition) In order to maintain stable operation and maximize lifetime of the combustors, it is also necessary to minimise variations in combustion dynamics by supplying a fuel which provides a constant release of heat at a given pressure drop over the combustor fuel nozzle and, also, which produces a constant flame type. Therefore, it is preferable to use a fuel at a constant composition and temperature which will thus produce a consistent flame characteristic. When fuel gas composition does vary, temperature adjustment of the gas

supply offers a degree of density adjustment to maintain a constant combustor pressure drop/heat release relationship, but this does not necessarily maintain the same combustion characteristics. The fuel shall also be free of contaminants which could prejudice the lifetime of the gas turbine blades by either corrosion or erosion. Allowable contaminants shall be verified with the gas turbine manufacturer. Natural gas is a fuel which satisfies these requirements and is the gas most commonly used in industrial gas turbines. It is also

the gaseous fuel upon which gas turbine design is most commonly based. However, other gaseous fuels can be used provided that the variations in calorific value, density and composition are restricted and that the gas turbine combustor design is suitably matched to the fuel type. Particularly where some variation in fuel gas composition/temperature is possible, or where more than one fuel gas type may be supplied to the gas turbine (e.g. a different fuel as back-up), due attention shall be given to the manufacturer's limitations on the Wobbe Index (WI) of the fuel.

Note that a constant Wobbe Index provides a constant heat input for a given burner pressure but does not necessarily provide a constant flame type. The latter is dependent on the gas composition. In particular, the proportion of hydrogen will affect the resulting flame characteristics. Therefore, the gas turbine Manufacturer/Supplier shall always be consulted as to the suitability of the machine for the range of fuel gas compositions envisaged.

8.2.8 The liquid hydrocarbon content of natural gas shall be reduced to a maximum of 12 liters per Nm³ "dry gas" before using in gas turbine.

8.2.9 Natural gas may have appreciable levels of hydrogen sulfide as a significant contaminant, which is known as sour gas. This hydrogen sulfide should be removed by fuel treatment. In