ENGINEERING STANDARD

FOR

PROCESS DESIGN OF FUEL SYSTEMS

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0. INTRODUCTION

"Process Design of Utility Systems for Oil, Gas & Petrochemical (OGP) Processes" are broad and contain variable subjects of paramount importance. Therefore, a group of IPS Standards are prepared to cover the subject.

The process engineering Standards of this group includes the following standards:

STANDARD CODE	STANDARD TITLE
IPS-E-PR-310	"Process Design of Water Systems"
IPS-E-PR-330	"Process Design of Production & Distribution of Compressed Air Systems"
IPS-E-PR-340	"Process Design of Fuel Systems"
IPS-E-EL-100	"Electrical System Design (Industrial & Non-Industrial)"
IPS-E-PR-450	"Process Design of Pressure Relieving Systems Inclusive Safety Relief Valves"
IPS-E-PR-460	"Process Design of Flare & Blowdown Systems"
IPS-E-SF-120	"Offshor Installations Fire Fighting and Fire Protection Systems"
IPS-E-SF-140	"Masks and Breathing System"
IPS-E-SF-160	"CO_2 Gas Fire Extinguishing Systems"
IPS-E-SF-180	"Dry Chemical Fire Extinguishing Systems"
IPS-E-SF-200	"Fire Fighting Sprinkler Systems"
IPS-E-SF-220	"Fire Water Distribution and Storage Facilities"
IPS-E-SF-340	"Fire Water Pump Systems"
IPS-E-SF-380	"Fire Protection in Buildings"

This Standard Specification covers:

"PROCESS DESIGN OF FUEL SYSTEMS"

1. SCOPE

This Process Engineering Standard Specification specifies the minimum requirement for process design of fuel systems used in OGP industries. Major design parameters and guidelines for process engineers in connection with fuel systems are covered in this Standard.

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

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in Standards and Codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/ Consultant.

BSI (BRITISH STANDARDS INSTITUTION)

BS 5351,	"Specification for Steel Ball Valves for the Petroleum, Petrochemical and Allied/Industries", 1986
BS 6843,	"Classification of Petroleum Fuels", 1988

API (AMERICAN PETROLEUM INSTITUTE)

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

IPS (IRANIAN PETROLEUM STANDARDS)

E-PR-200	"Basic Engineering Design Data"
E-PR-360	"Process Design of Liquid & Gas Transfer and Storage"
E-PR-420	"Process Design of Heat Tracing & Winterizing"
E-PR-440	"Process Design of Piping Systems (Process Piping & Pipeline Sizing)"
E-PR-450	"Process Design of Pressure Relieving Systems Inclusive Safety Relief Valves"
E-PR-740	"Process Design of Pumps"
E-PR-771	"Process Requirements of Heat Exchanging Equipment"
E-PR-810	"Process Design of Furnaces"
E-PR-830	"Process Design of Valves & Control Valves"
E-SF-860	"Air Polution Control"

3. DEFINITIONS AND TERMINOLOGY

Term used in this Standard are defined as follows:

3.1 Bunker "C" Fuel Oil

A heavy residual Fuel oil used by ships, industry, and for large-scale heating installations. In industry, it is often referred to as Grade No. 6 Fuel Oil.

3.2 Burning Line

A line conveying refinery fuel gas, as distinguished from gas intended for subsequent processing.

3.3 Fuel Gas

Any gas used for heating.

3.4 Fuel Oil

Any liquid or liquefiable petroleum product burned for the generation of heat in a furnace or firebox, or for the generation of power in an engine, exclusive of oils with flash point below 38°C (tag closedcup tester) and oils burned in cotton-or-wool-wick burners.

3.5 Heating Value of a Fuel

The caloric, thermal, or heating value of a fuel is the total amount of heat developed by the complete combustion of a unit quantity of fuel, expressed as kJ/kg for liquid fuels and MJ/Nm^3 for gas fuels.

3.6 Liquefied Petroleum Gas (LPG)

Light hydrocarbon material, gaseous at atmospheric temperature and pressure, held in the liquid state by pressure to facilitate storage, transport, handling. Commercial liquefied petroleum gas consists of propane, butane, or mixture thereof.

3.7 Manufactured Gas

All gases made artificially or as by-products, as distinguished from natural gas; applied particularly to a utility sendout.

3.8 Mazut

A Russian name for distillation residues used largely as fuel oil; also spelled "masut" or "mazout".

3.9 Natural Gas

Naturally occuring mixtures of hydrocarbon gases and vapors, the more important of which are methane, ethane, propane, butane, pentane, and hexane.

3.10 Purging

The displacement of one material with another in process equipment; frequently, displacement of hydrocarbon vapor with steam or inert gas.

3.11 Refinery Gas

Any form or mixture of gas gathered in refinery from the various Units.

3.12 Residual Fuel Oil

Topped crude oil or viscous residuum in refinery operations.

4. SYMBOLS AND ABBREVIATIONS

AGA	=	American Gas Association
API	=	American Petroleum Institute

BSI	=	British Standards Institution
CCR	=	Continuous Catalyst Regeneration
EPM	=	Engineering Practice Manual
FCC	=	Fluidized Catalytic Cracking
HFO	=	Heavy Fuel Oil
IPS	=	Iranian Petroleum Standards
ISO	=	International Organization for Standardization
LC	=	Level Controller
LDF	=	Light Distillate Fuel
LI	=	Level Indicator
LNG	=	Liquefied Natural Gas
LPG	=	Liquefied Petroleum Gas
NIOC	=	National Iranian Oil Company
PIC	=	Pressure Indicator Controller
Sp Gr	=	Specific Gravity (Relative Density)
THI	=	Temperature High Indicator.

5. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

6. FUEL SUPPLYING SYSTEMS

6.1 General

6.1.1 Fuel shall be used to provide heat for power generation, steam production and process requirements.

6.1.2 Fuel system shall include facilities for collection, preparation, and distribution of fuel to users.

6.1.3 Alternative fuels (as required) should be made available at all consuming points. The commonly used ones are liquid fuel and gas fuel.

6.1.4 On liquid fuel supplies at least one pump and its standby should be steam driven or available reliable other power sources. Standby pumping units shall be arranged for instantaneous start-up on the failure of the operating unit.

6.1.5 The process design of pressure safety valves and/or pressure relief valves in fuel system shall be as per IPS-E-PR-450 "Process Design of Pressure Relieving Systems Inclusive Safety Relief Valves".

6.1.6 Piping/Instrumentation configuration of fuel systems to each heater shall be according to IPS-E-PR-810, "Process Design of Furnaces".

6.2 Fuel Selection

6.2.1 The selection of fuels used in the system shall be based on the cost, availability, dependability of supply, convenience of use and storage, and environmental regulations.

6.2.2 Material which cannot be sold readily in commercial channels and has the least monetary value shall be used as fuel.

6.2.3 Liquid materials commonly diverted to refinery fuel include visbreaker tar, fluid catalytic cracking (FCC) decanted oil, vacuum tower bottoms, lube extracts and waxes. The majority of these materials would be difficult to blend to a commercial fuel of acceptable specification, because of viscosity, sulfur content, or presence of foreign matter.

6.2.4 All above materials shall be used as liquid fuel, in a manner so as to maintain the threshold limits as specified in IPS-E-SF-860, "Air Pollution Control" Standard.

6.2.5 Gaseous materials diverted to refinery fuel are those which cannot be processed to salable products economically, and frequently include, H_2, CH_4, H_2S* and C_2H_6 and shall be contained essentially of CH_4 and/or C_2H_6 (see Appendix A item 1).

Note:

*** H_2S content of fuel gas main header should not be more than 60 mg/kg as recommended, however. this figure should be subject to Company's approval.**

6.2.6 Provision(s) shall be made for using the liquefied petroleum gas (LPG) and/or natural gas to supplement the gaseous fuel.

6.3 Liquid Fuel

6.3.1 General

6.3.1.1 The ultimate aim in liquid fuel supply system design shall be to ensure that the supply of suitable fuel to each fired heater/furnace will not fluctuate with load changes.

6.3.1.2 Liquid fuel storage tanks shall be designed as per IPS-E-PR-360, "Process Design of Liquid & Gas Transfer and Storage".

6.3.1.3 The process design of piping of liquid fuel system shall be as per Standard IPS-E-PR-440 "Process Design of Piping Systems (Process Piping & Pipeline Sizing)".

6.3.1.4 The process design of liquid fuel pumps shall be as per Standard IPS-E-PR-740 "Process Design of Pumps".

6.3.1.5 All liquid fuels lighter than fuel oil should be filtered through mesh of about 0.3 mm aperture.

6.3.2 Fuel oil system

6.3.2.1 A typical system includes tankage from which the circulation pumps take suction, pumping the fuel oil through the heaters and strainers to the main circulation system. This serves all Units that are potential users of fuel oil and returns to the tank, through a back pressure controller.

6.3.2.2 The system should be designed to supply fuel oil to the furnaces at constant pressure and at the required viscosity. The required pressure depends on the type of burners used in the furnaces. The viscosity requirement should be met by means of temperature control.

6.3.2.3 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.

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

a) Circulation Pumps

To provide a reliable supply of fuel oil at least three pumps should be used. Typically, at least one pump should be turbine driven 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.

b) Line System

In the case of heavy fuel oil, measures should be taken to prevent plugging of lines. These may include heat tracing, insulation, and a separate flushing oil system (low pour point fuel). The flushing oil system will facilitate furnace starting up and shutting down operations and flushing out of lines, filters and fuel oil heaters.

c) Strainers

To prevent plugging of the burners, parallel strainers should be installed in the discharge and suction of fuel oil distribution pumps, with the mesh sizes of 0.75 and 1.5 mm respectively.

d) Instrumentation

The system should be equipped with a low pressure alarm for supply header, located in each control house.

6.3.2.5 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.

6.3.2.6 To obtain the required fuel oil supply temperature adequate (at least two) heat exchangers (fuel oil heaters) heated by 2000 kPa (ga) [20 bar (ga)] 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".

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

6.3.2.8 By using fuel oil at each Unit, provision shall be made for a fuel oil return valve.

6.3.2.9 A fuel oil return meter shall be provided on each Unit that consumes fuel oil. To avoid excessive fuel oil circulation this flow should be kept as less as possible.

6.3.2.10 The recirculating 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.

6.3.2.11 The fuel oil lines shall be steam traced according to IPS-E-PR-420, "Process Design of Heat Tracing & Winterizing".

6.3.2.12 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. The size of the return header shall be the same as the size of the supply header.

6.3.2.13 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.

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

6.3.2.15 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.

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

6.3.3 Refinery gasoline fuel

6.3.3.1 Refinery gasoline fuel (visbreaker gasoline) may be considered as an alternative liquid fuel in steam boilers.

6.3.3.2 Gasoline fuel system shall have its own facilities for storage, pumping and filters.

6.3.3.3 To accommodate variations in gasoline fuel demand, pressure control spillbacks shall be considered to allow excess fuel returned to the storage tanks as required.

6.3.3.4 Following instruments shall be provided in boiler house control room:

a) Visbreaker gasoline storage tank low level alarm.
b) Visbreaker gasoline supply header, pressure indication and low pressure alarm.

6.4 Gaseous Fuel

6.4.1 General

6.4.1.1 The fuel gas supply system shall be designed to provide the consumers with liquid-free gas at constant pressure [about 350 kPa (ga) or 3.5 bar (ga)] and reasonably constant heating value.

6.4.1.2 The system shall include, collecting piping, mixing drum controls, and distribution piping. A typical refinery fuel gas system is shown in Fig. B.2 in Appendix B.

6.4.1.3 All fuel gas stream shall be routed to mixing drum where entrained liquid is separated from the gas and where good mixing is ensured before distribution.

6.4.1.4 Location of fuel gas mixing drum should minimize collection and distribution piping.

6.4.1.5 Liquid from the knockout drum and mixing drum shall be drained to a closed recovery system or flare header.

6.4.1.6 The main source of fuel gas shall be the gas produced in process Units. In order to enable the balancing of gas production and gas consumption, necessary provisions for installation of LPG vaporizer and natural gas supplying systems to fuel gas mixing drum shall be considered.

6.4.1.7 If main fuel gas header pressure, drops to its preset value, LPG and/or natural gas shall be used to supplement the make-up gas.

6.4.1.8 A liquid knockout drum near the gas consuming furnace (or group of furnaces) shall be provided to prevent liquid slugs from entering the burners.

6.4.1.9 The mains and all fuel gas lines shall be steam traced and insulated to hold a temperature of at least 50°C to prevent condensation and hydrate formation.

6.4.1.10 To counteract the tendency of butane to recondense in mixing drum, a steam coil in its base shall be provided. Provision for installation of relief valve to flare header shall also be considered.

6.4.1.11 The fuel gas supply system should be equipped with enough controls and alarms, such as low system pressure and high knockout drum liquid level alarms, to assure a safe fuel gas supply.

6.4.1.12 The pressure controlling system shall be provided to fuel gas mixing drum, which actuates from fuel gas main header and responses to steam control valve of LPG vaporizer and/or natural gas control valve to supply required pressure.

6.4.1.13 In the event of high pressure in mixing drum (abnormal condition), the excess gas shall be released to the flare on pressure control.

6.4.1.14 Alarms should be fitted to the pilot gas system to warn of low pressure /low flow.

6.5 LPG Vaporizer

6.5.1 General

6.5.1.1 Liquefied petroleum gases (LPG) shall be used as a fuel in gaseous form. Vaporizer system shall be provided for this purpose.

6.5.1.2 The system shall consist of the following:

a) one LPG surge drum;
b) two LPG fuel pumps, one in operation (motor driven) and one stand-by (turbine driven);
c) one LPG vaporizer;
d) all necessary controllers.

6.5.1.3 Various streams of LPG and butane shall be received in the LPG surge drum and will be pumped into the fuel gas vaporizer.

6.5.1.4 Pressure in the LPG surge drum should be uncontrolled and will fluctuate with composition and temperature.

6.5.1.5 Level in LPG surge drum should be controlled. Surge drum level shall be recorded and provisions for high and low liquid level alarms shall be installed.

6.5.1.6 In the event of high liquid level in the LPG surge drum, provision shall be made to pump LPG directly into the flare header.*

6.5.1.7 LPG fuel pump shall take LPG from surge drum and will pump it into the fuel gas vaporizer through flow recorder by level controller in fuel gas vaporizer.

Note:

*** This situation may occur temporarily due to low gas consumption.**

6.5.1.8 By-pass line for LPG fuel pumps shall be provided to transfer LPG from LPG surge drum to fuel gas vaporizer, in the event of high pressure in LPG surge drum.

6.5.1.9 LPG fuel pumps shall have minimum flow by-pass line to protect them at times of low consumption of LPG.

Instrumentation shall be provided to start automatically spare LPG fuel pump in case of failure of the main pump.

6.5.1.10 Size of the vaporizer, i.e., heat exchanger required depends upon the following factors:

a) maximum gas demand;
b) size and location of LPG surge drum;
c) minimum amount of gas carried in LPG surge drum;
d) climatic conditions;
e) gas pressure to be supplied by plant.

6.5.1.11 Location of the safety valve on the fuel gas vaporizer shall be in vapor portion of that to avoid the problem of having liquid LPG going into the flare header.

6.5.1.12 A vaporizer should be equipped with an automatic means of preventing liquid passing from vaporizer to gas discharge piping. Normally this shall be done by a liquid level controller and positive shut-off liquid inlet line or by a temperature control unit for shutting-off the liquid line at low temperature conditions within vaporizer.

6.6 Minimum Data Required for Basic Design

6.6.1 Following data shall be provided as a minimum requirement for basic design calculation of liquid fuel to be used for normal operation or alternative operations, including tartup. For further information see IPS-E-PR-200, "Basic Engineering Design Data".

- Net Heating Value, in (kJ/kg)
- Gross Heating Value, in (kJ/kg)
- Sulfur, in mass, in (mg/kg)
- Vanadium, in mass, in (mg/kg)
- Sodium, in mass, in (mg/kg)
- Nickel, in mass, in (mg/kg)
- Iron,in mass, in (mg/kg)
- Conradson Carbon, in (mass %)
- Ash, in (mass %)
- Other Impurities in (mass %) or mass, (mg/kg)
- °API
- Viscosity: dynamic in (Pa.s) at 100°C or at specified temperature °C
- Vapor pressure, in (Pa) at specified temperature °C
- Flash Point, in (°C)
- Pour Point, in (°C)
- Supply header operating pressure, in [kPa (ga)] or [bar (ga)] (max., normal, min.),
- Return header operating pressure, in [kPa (ga)] or [bar (ga)] (max., normal, Min.),
- Supply header operating temperature, in (°C) (max., normal, min.),
- System mechanical design pressure & temperature, in [kPa- (bar)] & °C.

6.6.2 Following data shall be provided as a minimum requirement for basic design calculation of fuel gas to be used for normal operation and for alternate operations, including startup, if pilot gas is not supplied from the fuel gas header, its properties shall be provided.

For further information see IPS-E-PR-200, "Basic Engineering Design Data".

- Relative density (specific gravity) at 15°C
- Net heating value, in (MJ/Nm^3) or [kJ/kg]
- Gross heating value, in (MJ/Nm^3) or [kJ/kg]
- Flowing temperature, in (°C) (max., normal, min.)
- Header operating pressure, in [kPa (ga)] or [bar (ga)] (max., normal, min.)
- System mechanical design pressure & temperature, in [k Pa (ga)] or [bar (ga)] & °C
- Total sulfur, in mass, (mg/kg)
- Chloride, in mass, (mg/kg)
- Other impurities, in (volume %) or mass, (mg/kg)
- Flow rate available, in (Nm^3/h).

7. FIRED HEATERS FUEL SYSTEM-DESIGN

7.1 General

The fuel system shall be in accordance with the following requirements. A typical configuration is shown in Fig. C.1 of Appendix C.

7.1.1 The pilot gas, where practicable, shall be taken from a sweet gas supply, independent of the main burner gas, or from a separate off-take on the fuel gas main, with its own block valve and spade-off position. Unless otherwise approved by Company, the pilot gas pressure shall be controlled at 35 kPa (0.35 bar) and the pressure regulating valve shall be the self-operating type.

7.1.2 Fuel manifolds around heaters shall be sized such that the maximum pressure difference between individual burner off-takes shall not exceed 2% of the manifold pressure at any time. In addition, account shall be taken of the effect to individual burner pipework sizes and arrangements on the distribution of fuel flow to each burner.

7.1.3 Individual burner isolation valves for the main fuels and steam shall be located under the heater. The burner isolation valves, excluding pilots, shall be located within an arm's length of the peep-holes giving a view of the flames from those burners. Where possible, a standard disposition of valves for each burner shall be used; namely: from left to right, gas, oil and steam.

All burners and pilot isolation valves shall be of the ball valve type to BS 5351 or equivalent, subject to the operating temperature and pressure, including any purge steam, being within the rating of the valve seat. All burner isolation valves shall have some readily recognisable indication of the valve position.

7.1.4 Each burner isolation valve for pilot gas shall be positioned safely away from the burner and so that an electrical portable ignitor, when inserted in the lighting port, can be remotely operated from the burner valve position. In the case of floor-fired heaters, the pilot burner valves shall not be located under the heater and shall be operable from grade.

7.1.5 The valves for controlling the flow of foul or waste gases to the individual nozzles shall not be located underneath floor-fired heaters but shall be positioned near the pilot gas valves.

A flame trap of an approved type shall be fitted in the main foul or waste gas lines leading to a furnace, with a high temperature alarm actuator installed immediately downstream of the trap. Cleaning of the traps shall be provided for.

7.1.6 Irrespective of any purging arrangements within the burners, steam purging of the oil lines between the burner valves and the burners shall be fitted.

The gas lines between the burner isolation valves and the burners shall be fitted with a purge connection.

The steam and purge valves shall be located adjacent to the burner isolation valves.

7.1.7 Each fuel supply header to a heater and all individual pilot gas supply to each burner, excluding waste or foul gases, shall be fitted with two filters in parallel or with dual filters. Where the latter incorporate two filter elements in one housing, individual elements shall be removable whilst in service without interruption of fuel flow. There shall be no leakage from the operating compartment to the open compartment when one element removed.

The filter mesh sizes shall be as specified by the burner supplier and approved by Company. The mesh material on main gas and pilot gas shall be Monel. For the pilot gas filter the mesh size should be approximately 0.5 mm. In the case of the pilot gas supply, the pipework between the filters and the pilots shall be in 18/8 stainless steel.

7.1.8 Piping shall be in accordance with IPS-E-PR-440 "Process Design of Piping Systems "Process Piping & Pipeline Sizing", except that where fuel atomizers or gas nozzles require positional adjustment within the burner for optimum combustion, flexible piping for all fuels and steam connections to individual burners shall be provided. This flexible piping shall be of the fireproof continuously-formed stainless steel bellows type, protected by metal braiding and approved by Company.

7.1.9 The fuel oil, atomizing steam and gas piping to the burners shall be arranged so that the oil, main gas or pilot nozzles can be removed without isolating the other fuel supply to that burner.

7.1.10 Individual gas and oil burner off-takes shall be from the top of headers. The ends of oil and fuel gas headers shall be flanged to allow access for cleaning.

7.1.11 Each main fuel control valve shall be in accordance with IPS-E-PR-830, "Process Design of Valves & Control Valves". The control scheme of the fuel supply system to each heater shall be as indicated in IPS-E-PR-810, "Process Design of Furnaces".

7.1.12 Pilot gas pressure reducing valve shall be of the selfoperated type and in accordance with API PR 550. They shall be provided with isolation and hand operated bypass valves.

7.1.13 All fuel control valves and meters shall be conveniently located at grade and a safe distance from the furnace.

7.2 Shut-Off Systems

7.2.1 To ensure the effective isolation of furnaces form remote control positions. solenoid initiated shut-off valve shall be installed in each main furnace fuel line additional to the control valve, and in each waste or foul gas line. They should be installed next to the control valves. These valves will normally be shut by remote manual or automatic initiation, e.g., by "Heat-Off Switch" but opened only by local manual operation. These valves should additionally be shut automatically when the main fuel pressure upstream of the control valves falls below the stable burning limit of the main burners, or the atomizing steam falls below a predetermined pressure.

7.2.2 Consideration should also be given to having the shut-off valve close automatically in the case of high liquid level in the fuel gas knockout drum.

7.2.3 The shut-off valve should be operable from the control room.

7.2.4 In addition solenoid initiated shut-off valve shall be installed in the pilot gas line to be operated only by the "Emergency Shutdown Switch".

7.2.5 Operation of Heat-off and emergency shutdown switches are categorized in Appendix D.

7.2.6 All systems shall fail safe, i.e., in normal operating conditions sensor contacts shall be closed, relays and solenoid valves shall be energised, and in the trip conditions, air-operated valves shall vent.

7.3 Atomizing Steam and Tracing

7.3.1 The atomizing steam supply shall be run from the main separately from the steam tracing supply and shall not be used as steam tracing. Additionally, where light distillate fuel (LDF) firing is specified, the atomizing steam lines shall be lagged separately from the fuel lines to prevent vapor locking.

7.3.2 Atomizing steam off-takes to the burners shall be from the top of the header and adequate trapping arrangements shall be provided to prevent the admission of condensate to the burners, including steam traps at the end of manifolds.

Unless otherwise specified by the burner Vendor, the atomizing steam pressure shall be controlled by a steam/oil differential pressure controller capable of operating over the specified firing range, or by a steam pressure controller.

7.3.3 Tracing of the fuel lines shall be separated from other tracing systems. The heavy fuel oil (HFO) system including instrument legs is to be traced right through to the burner, but that section of the fuel line common to both low flash and heavy fuel oils shall be traced separately from the rest of the HFO system. Tracing may be by steam or electricity.

Arrangements shall be made to ensure that traced lines and associated instrumentation are not over-pressured due to overheating if the fuel oil becomes stationary in the lines for extended periods.

7.3.4 Unless otherwise approved by Company, fuel gas lines upstream of the burner isolating valves shall be traced.

7.3.5 The process design of tracing of fuel lines shall be as per IPS-E-PR-420 "Process Design of Heat Tracing & Winterizing".

8. GAS TURBINE FUEL ALTERNATIVES

8.1 Gaseous Fuels

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

8.1.2 For natural gas/LNG boiloff, the inlet gas temperature shall be above dew point of liquid hydrocarbons.

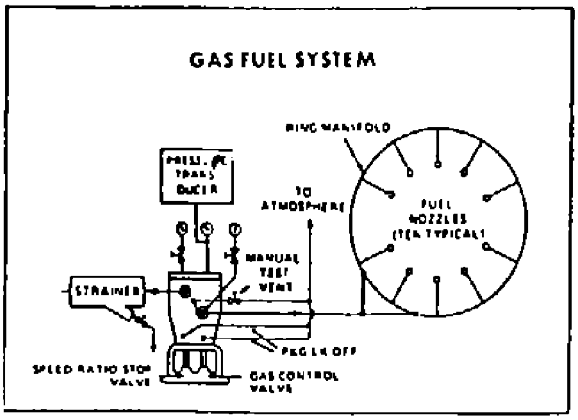
8.1.3 For sour gas the following consideration shall be applied:

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

8.1.4 For process gas, due to wide variation in composition they shall be considered on a case-by-case basis.

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

8.1.6 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.



GAS FUEL SYSTEM
Fig. 1

8.1.7 The liquid hydrocarbon content of natural gas shall be reduced to a maximum of 12 liters per Nm^3 "dry gas" before using in gas turbine.

8.1.8 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. (see note below). In some cases, it may be burned directly in the gas turbine if the proper selection is made of materials and components in the gas turbine end fuel system.

Note:

Based on Iranian Sources the H_2S content of treated natural gas ranges between trace and 60 max. mg/kg.

8.1.9 Filters should be according to Clause 7.1.7 herein.

8.2 Liquid Fuels

8.2.1 Gas turbine liquid fuels have a wide range of properties, but for gas turbine application they shall be divided into two broad classes:

1) True distillate fuels which normally can be used without any change and as it is.
2) Ash-forming fuels which generally require heating, fuel treating, and periodic cleaning.

8.2.2 Ash-forming fuels shall require on-site fuel treatment to modify or remove harmful constituents. In addition, there shall be provisions for cleaning ash deposits from the turbine periodically.

8.2.3 Liquid fuels ranging from naphtha to residual fuels should be successfully used in heavy-duty gas turbines.

8.2.4 True distillate fuels do not usually require heating for proper atomization, except for the heavy distillates and some light distillate used in cold regions. Heavy fuels shall always require heating for proper fuel atomization, the temperature required being related to the type of fuel atomization.

8.2.5 For heavy residual fuels it shall be necessary to heat the fuel to lower the viscosity to the operating range of the fuel transfer and filter system. It should also be necessary to heat some crudes and heavy distillates to keep wax dissolved.

8.2.6 A secondary and start-up/shut-down fuel should be considered for naphtha for safety reasons. A secondary fuel should be ready for heavy fuels both for fuel system flushing and to provide fuel lightoff.

8.2.7 Explosion proofing of the gas turbine system shall be required with low flash point fuels such as naphthas and some crude oils.

8.2.8 Gas turbines for heavy-fuel application shall require a combustion liner designed for a more radiant flame.

APPENDICES

APPENDIX A
CLASSIFICATION OF PETROLEUM FUELS AS INDICATED IN BS 6843 (SEE CLAUSE 2.2)

1) GASEOUS FUELS

Gaseous fuels of petroleum origin consisting essentially of methane and/or ethane.

2) LIQUEFIED GASEOUS FUELS

Goseous fuels of petroleum origin consisting predominantly of propane-propane and/or butanes-butenes.

3) DISTILLATE FUELS*

Fuels of petroleum origin excluding liquefied petroleum gases. These include gasoline, kerosenes, gas-oils and diesel fuels. Heavy distillates may contain small quantities of residues.

4) RESIDUE FUELS

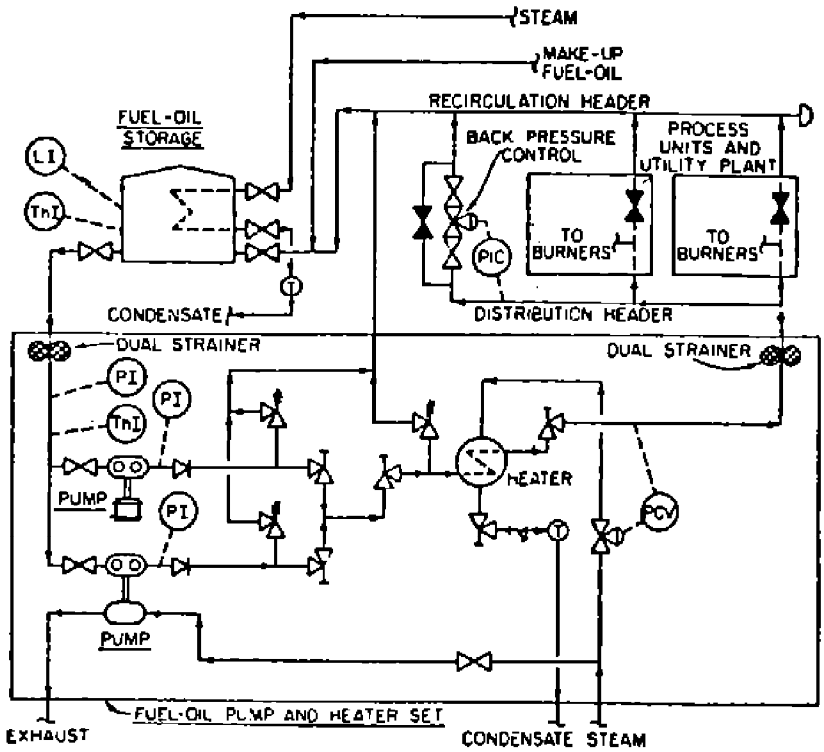
Petroleum fuels containing residues of distallation processes.

5) PETROLEUM COKES

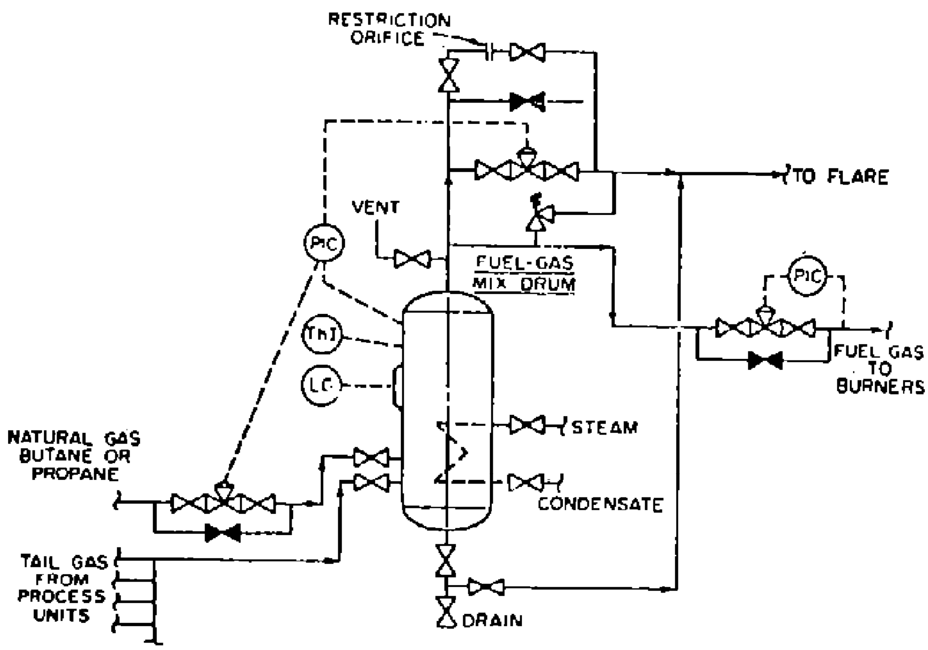
Solid fuels of petroleum origin consisting essentially of carbon, mostly obtained by cracking processes.

*** The products belonging to distillate fuels can be obtained not only by distillation but also for example, by cracking, alkylation, etc.**

APPENDIX B
TYPICAL REFINERY FUEL-OIL & FUEL-GAS SYSTEMS

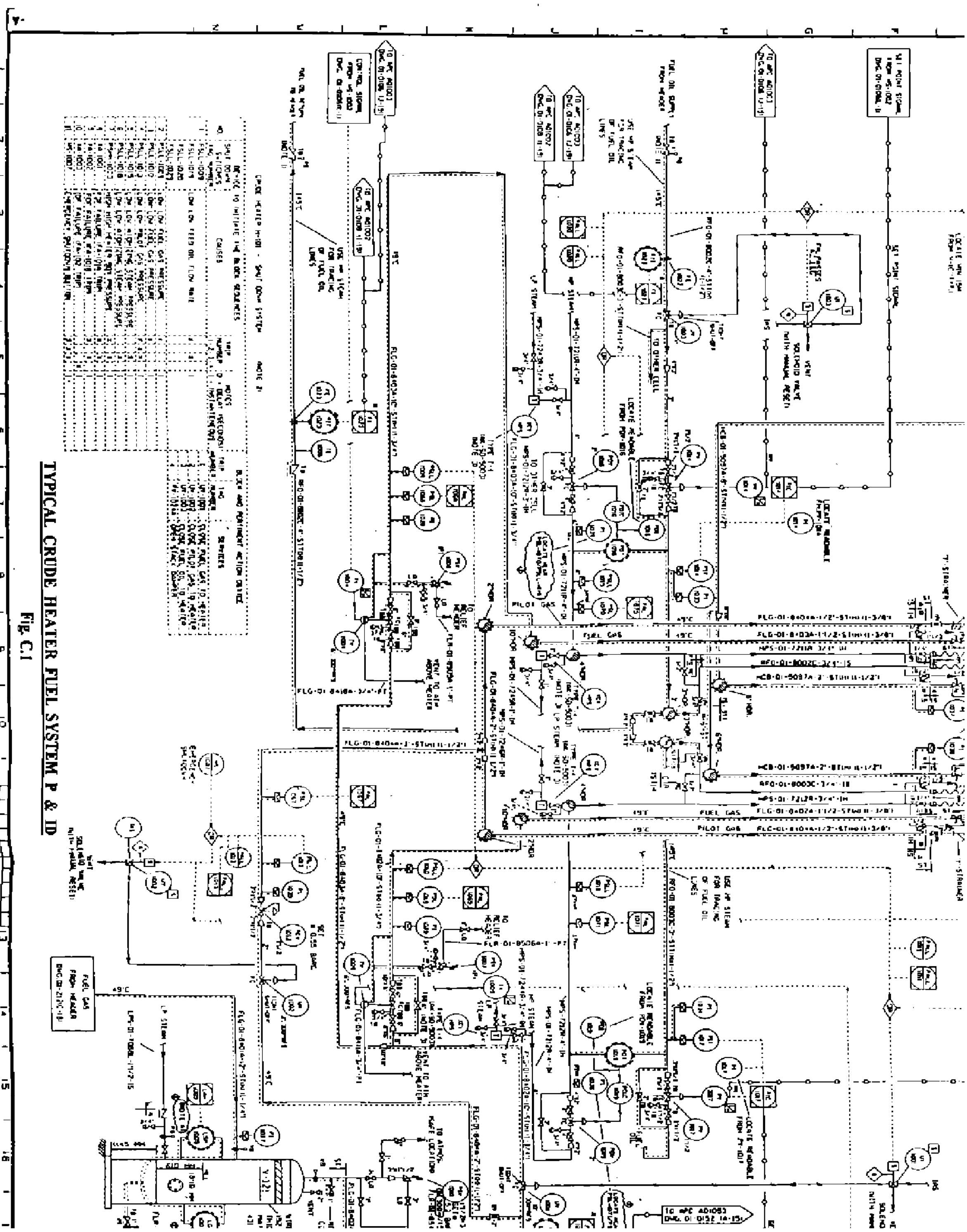


TYPICAL REFINERY FUEL - OIL SYSTEM
Fig. B.1



TYPICAL REFINERY FUEL - GAS SYSTEM
Fig. B.2

APPENDIX C
TYPICAL CRUDE HEATER FUEL SYSTEM P & ID



TYPICAL ARRANGEMENT OF FUEL SYSTEM OF FIRED HEATERS - MULTIPLE FUELS
Fig. C.1

APPENDIX D
OPERATION OF HEAT - OFF AND EMERGENCY SHUTDOWN SWITCHES

D.1 Heat-Off Switch

Heat-off switch operation shall include either one or more of the following:

1) shut-off all fuel supplies, with the exception of pilot gas supplies, to all fired process heaters;
2) shut-off heat to reboilers and feed pre-heater;
3) in certain cases stop the Unit charge pumps. In such cases these shall be agreed with the Company.

D.2 Emergency Shutdown Switch

Emergency shutdown switch operation shall include either one or more of the following:

1) perform all the operations listed in heat-off (D.1);
2) initiate appropriate automatic devices;
3) shut-off all nominated feeds to the Unit;
4) fail safe critical control valves, a list of which is to be submitted to the Company;
5) shut-off pilots for gas supplied to heaters.