

FURNACES**JGS 210-120-1-26E**

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DWG. NO. D-10-1225-101 Crude Furnace Section	
DWG. NO. D-10-1225-102 Furnace Firing Section	
DWG. NO. D-10-1225-103 Combustion Air Section	
DWG. NO. D-10-1225-104 Furnace Decoking Section	

1. SCOPE

- (1) This standard practice covers the basic design of furnace for petroleum refineries and similar plants, including the procedure for P&ID preparation. Also, it discusses the design philosophy with reference to furnace design requirements.
- (2) This standard practice shall not be applied the following type of furnaces :
 - (a) Steam reformers and steam boilers
 - (b) Reaction furnace, incinerator and line burners for sulfur recovery unit
 - (c) Inert gas generators

2. WORK PROCEDURE**2.1 Format**

Data sheets for furnaces shall be prepared in the latest JGC standard form 1908-1~9 unless otherwise specified, and the design requirements shall be indicated clearly therein. If the furnace is intended for several cases of operation, the design conditions and operating conditions in each case shall be shown. Conditions in special cases such as regeneration conditions in HDS unit shall be shown together with the operating conditions. However, decoking operation conditions for furnace tube need not be indicated.

2.2 Input Data

The required data for furnace design are as follows.

- (1) Service Name
- (2) Fluid Name
- (3) Heat Absorption (MMKcal/Hr)
- (4) Flow Rate (kg/Hr)
- (5) Allowable Press. Drop (kg/cm²)
- (6) Fouling Factor (Hr.m².°C/Kcal)
- (7) Corrosion or Erosion Characteristics, if any
- (8) Inlet Condition
 - Temperature (°C)
 - Pressure (kg/cm²A)
 - Liq. Flow (kg/Hr)
 - Vap. Flow (kg/Hr)
 - Liq. SpGr at 15°C
 - Vap. Molecular Weight
 - Liq./Vap. Viscosity (CP)
 - Liq./Vap. Specific Heat (Kcal/kg.°C)
 - Liq./Vap. Thermal Cond. (Kcal/m.Hr.°C)
- (9) Outlet Condition *1
 - Temperature (°C)
 - Pressure (kg/cm²A)
 - Liq. Flow (kg/Hr)
 - Vap. Flow (kg/Hr)
 - Liq. SPGR @15°C
 - Vap. Molecular Weight
 - Liq./Vap. Viscosity (CP)
 - Liq./Vap. Specific Heat (Kcal/kg.°C)
 - Liq./Vap. Thermal Cond. (Kcal/m.Hr.°C)
- (10) Heating Curve

*1 At flash zone or tower inlet.

3. DESIGN REQUIREMENTS OF FURNACE

3.1 Design Conditions

The design conditions of furnace shall be determined according to the following procedure.

- (1) The duty of furnace should be determined based on the highest duty in each operation case.
- (2) 110% of the highest duty should be considered for the design duty of furnace.
- (3) The following additional conditions should be considered for the furnace design.
 - (a) If the operation case of the highest duty is extremely rare, the design duty shall be 100% of the highest or 110% of normal, whichever is greater.
 - (b) In the reboiler furnace, the charge (circulation) flow rate should be determined based on the following under the tower inlet conditions.
 - The minimum target of V/F should be 50 wt %.
 - If the furnace outlet temperature exceeds 370°C at V/F = 50 wt %, the V/F must be controlled to less than 50 wt % so that the furnace outlet temperature is maintained at 370°C or less to avoid thermal cracking.
 - There are several cases where the process has been designed at V/F = 75 wt %, under the condition that the charge oil is light and clean as in the case of the paraxylene and gasoline rerun process. If charge flow rate reduction proves to result in marked cost advantages, the V/F may be increased to max. 75 wt %, after carefully studying the effect of V/F = 75 wt % on thermal cracking, furnace coil dry section formation, and duty control.
- (4) If the furnace charge stream contains such corrosive materials as sulfur compounds, naphthenic acid and etc., those contents should be indicated in the data sheet.
- (5) For the design of furnace in Hydrodesulfurization and Reforming Units, refer to JGS 210-126-10-01.

3.2 Furnace Turndown

The turndown ratio should be indicated in the data sheet according to the project specification. Unless otherwise specified, it shall be 50% of the normal duty.

Generally, 30% of design duty depending on the burner's performance is allowed for the minimum turndown ratio of furnace.

3.3 Furnace Outlet Temperature

- (1) In cases where the thermal decomposition temperature of fluid is known, it shall be indicated together with the location (flash zone or furnace outlet) in the data sheet to prevent decomposition.
- (2) The allowable maximum outlet temperature of furnace should be determined based on the charge oil decomposition and discoloration conditions. The maximum temperature in the flash zones of crude distillation units and gas oil reboilers shall be as indicated below unless otherwise specified.

<u>Use of Furnace</u>	<u>Maximum Temperature at Flash Zone</u>
Crude Distillation Unit	388°C (730°F)
Gas Oil Reboilers	371°C (700°F)

- (3) There is a strict limitation on the outlet temperature of the furnace in Vacuum Unit to prevent the coking problem in furnace tubes, which is described in JGS 210-231-1-02.
Furnaces in which coking is expected to occur, shall be provided with a permanent decoking system. Also, for furnaces whose outlet temperatures are 315°C (600°F) or lower, and gas heaters, it is not necessary to provide a decoking system.

3.4 Types of Fuel

When the fuel conditions are entered in the data sheets, attention shall be paid to the following points :

3.4.1 Fuel Gas

- (1) The fuel gas compositions for start-up, normal and backup shall be made clear.
- (2) If the burners to be used are of the usual type, the fuel pressure at the burners is normally planned to be around 1.5 kg/cm²G.
The pilot gas burner pressure is normally planned to be around 0.3 to 0.5 kg/cm²G at the burner.
- (3) In cases where offgas is burnt in the furnace (as in the case of offgas from a vacuum distillation unit), the offgas compositions and operation conditions shall be made clear.
In such cases, special type burners will be required and the offgas pressure will need to be 0.1 kg/cm²G minimum at the burners.
- (4) The required pressure at burner shall be confirmed to furnace engineer, when vendor's information are available.

3.4.2 Fuel Oil

- (1) The fuel oil properties shall be made clear. In cases where there are restrictions on NO_x and/or SO_x emissions with respect to air pollution, the sulfur and nitrogen contents of fuel shall be shown. The vanadium, sodium and con carbon residue contents of the fuel shall be shown.
- (2) The fuel oil viscosity shall be maximum 200 SSU (42 cst) at the burner. The fuel oil preheat temperature shall be determined with consideration given to be required viscosity at the burner. Appendix-1 is a chart showing the relationships between temperature and viscosity of fuel oil.
- (3) The fuel oil pressure for steam atomizing type burner shall be Min. 5.0 kg/cm²G at the burner and the steam pressure shall be Min. 6.5 kg/cm²G at the burner.
- (4) Net fuel consumption/return flow ratio at the fuel oil burner shall be as follows :

<u>Heat Duty</u> <u>(MMBTU / hr)</u>	<u>Net Fuel Consumption</u> <u>/ Return Flow ratio</u>
0 - 20	1.0 / 2.0
20 - 100	1.0 / 1.0
100 - over	1.0 / 0.2

3.5 Fouling Factor

The standard fouling factor for furnace is shown in Appendix-2.

3.6 Pressure Drop

- (1) The guideline to estimate the pressure drop across furnace is shown as follows.
Since the pressure drop across furnace is closely related to the structure of furnace, it should be determined in cooperation with the furnace engineers.

<u>Service</u>	<u>Expected Press. Drop (kg/cm²)</u>
Crude Charge Furnace	7.0 ~ 14.0
Vacuum Charge Furnace	5.5 ~ 8.5
Reboiler Furnace	3.5 ~ 5.0

- (2) In the case of services where vaporization will occur in the furnace tubes, the flash curve and fluid temperature - physical property data (for instance, °API and MW) shall be prepared.
- (3) With respect to the size and pass of the furnace in Crude Distillation Unit, Appendix-3 can be used as a reference.

4. PROCEDURE FOR P&ID PREPARATION AROUND FURNACE

The role of the refinery furnaces is to supply the required heat to the process fluid by burning fuels. This is usually done by regulating the fuel flow to the burners in accordance with the temperature at or near the heated fluid outlet.

In general, P&ID's for a furnace should cover or comprise the following four sections:

- (1) Process Fluid Heating Section
- (2) Fuel Supply and Burner Control Section
- (3) Combustion Air Supply Section, where forced air supply or air preheater (APH) is installed
- (4) Decoking or Descaling Facility Section, if applicable

The typical P&ID's for each section are illustrated in the attached drawings (D-10-1225-101, 102, 103 and 104). They are applicable to the individual project in addition to the modification based on the specific requirements to the respective project.

4.1 Process Fluid Heating Section

4.1.1 Flow Control on Each Stream-Pass

If the furnace charge is divided into two or more streams, design consideration to ensure even flow distribution to each stream is important since furnace tubes will be over-heated in the lagging flow, which will eventually lead to tube coking and rupture. The following provision should be considered to multi-stream pass furnaces:

- (1) Flow Rate Control on Each Stream-Pass

Provide a control valve with a flow controller on each stream so as to keep the split flow constant. This should be applied basically to multi-stream pass furnaces where the process fluid is partially vaporizing, such as fractionator charge furnaces and reboiler furnaces.

However, the process fluid must be liquid phase, not vaporized, just upstream of the flow control valves. If the process fluid is vapor-liquid mixed phase at heater inlet, some method other than flow controllers should be considered.

- (2) Symmetrical Piping Layout

Symmetrical piping arrangement may be employed at the inlet and outlet of furnace, when omitting the flow control valve on each stream pass.

This should be applied to a system composed of not more than four stream passes, and the process fluid should be liquid or gas single phase over the entire passage in all the intended operating modes.

Clearly indicate "Symmetrical Piping" on the P&ID if applied. Supplementary design notes should be also indicated such as envisaged piping arrangement, requirement for flow regime in vapor-liquid two phase application, etc., if required.

- (3) Distributing and Collecting Manifold Headers

Where the process fluid is vapor or liquid single phase, distributing and collecting manifold headers may be employed at inlet and outlet of the furnace without control valve on each stream pass. Especially in processing liquid fluid, ensure that no operational problems exist in all the operating modes including precommissioning, start-up and shut-down operation.

Even though the fluid is vaporized, this manifold header system is often applied to steam generation coils installed in the furnace convection section. Care should be taken in sizing and arrangement of the manifold headers to ensure uniform flow distribution.

- (4) Supplements

- (a) As for hydrotreating units processing kerosene or heavier oils, where the process fluid is vapor-liquid mixed phase at furnace inlet, independent flow control for each of liquid feed oil and recycle gas stream is usually employed upstream of combined feed exchanger. In this case, the number of stream-passes is designated for the furnace to be the same as that of the heat exchanger. The number of the streams shall be determined, considering the total system including the furnace.
- (b) If it is technically and economically justified, separate furnace for each of the feed oil and the recycle gas stream may be considered.

4.1.2 Utilization of Convection Section

Furnaces are usually provided with a convection section to recover heat of combustion flue gas discharged from radiant section to achieve higher furnace efficiency. Convection section can be utilized not only for heating up process fluids but also for heat recovery with utilities at lower temperatures such as preheating boiler feed water (BFW), steam generation, steam superheating. However, when utilizing the convection section, it shall be noted that duty control on the hot side (flue gas) is impossible. Configuration of the convection section is detailed by furnace vendor based on the process duty specifications, including kind of utilities to be heated, requirement for minimum furnace efficiency, etc.

4.1.3 Auxiliary Facilities**(1) Purge steam Connections**

Purge steam connections are to be supplied to the combustion chamber (or radiant section) of the furnace. MP steam should be used as the purge stream.

The number of connections depends on the volume of the combustion chamber, which is determined by furnace vendor.

Purge connections may also be used as snuffing steam connections, if required.

(2) Sootblowers (Option)

In order to keep outer surface of the furnace convection tubes which are likely to be fouled with soot, clean, sootblowers are equipped. Requirement and/or criteria regarding provision of the sootblowers are normally specified by the client, and detailed by furnace vendor.

As a guide, sootblowers are to be normally provided when liquid fuel is contemplated and convection section incorporates extended surface tubes (finned or studded tubes).

A steam pressure of approximately 10 Kg/cm².G or higher is normally required at sootblower. MP steam should be used accordingly.

(3) MP Steam Connections for Emergency Blow Out (Option)

In most of the charge furnaces of crude and vacuum distillation units, MP steam purge connection on each stream pass is provided at furnace inlet. MP steam is introduced to blow out the fluid remaining in the furnace tubes in an emergency case.

Steam supply piping for decoking operation may be utilized, if possible.

4.1.4 Instrumentation

Basic engineering concept regarding instrumentation for main process streams relating to furnaces should be as follows:

(1) Pressure Instrument

Field mounted pressure indicators should be supplied to inlet of each stream, and one indicator on the common outlet header for detecting signs of in-tube fouling/coking, where the fouling is expected.

Where the process fluid is clean, and even flow distribution to each stream-pass is not critical, one indicator at each of inlet and outlet common headers is sufficient.

Where the pressure is an important operational variable, it should be indicated on the panel of the central control room (CCR).

(2) Temperature Instrument**(a) Charge and Transfer Temperatures**

A panel-mounted temperature indicator should be installed on the outlet header. One should also be supplied to the inlet header if it is essential to monitor the furnace duty.

In installation of flow controller on each stream pass, a panel-mounted temperature indicator should be provided to the outlet of each stream pass for monitoring uniform heating and even flow distribution over the split streams.