ENGINEERING STANDARD

FOR

PROCESS DESIGN OF HOT OIL

AND

TEMPERED WATER CIRCUITS

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0. INTRODUCTION

The primary purpose of IPS standard specifications on "Process Design of General Heating & Cooling Systems" is to establish minimum requirements and design criteria needed in process design of the following standards:

STANDARD CODE	STANDARD TITLE
IPS-E-PR-400	"Process Design of Cooling Water Circuits"
IPS-E-PR-410	"Process Design of Hot Oil & Tempered Water Circuits"
IPS-E-PR-420	"Process Design of Heat Tracing and Winterizing"

This Engineering Standard Specification covers:

"PROCESS DESIGN OF HOT OIL & TEMPERED WATER CIRCUITS"

Thermal liquids are used for process heating and cooling in the form of liquid, vapor or a combination of both. In addition to steam, thermal liquid include, hot and tempered water, mercury, Na, K, Dowtherms A and E, molten salt mixtures, hot oils and many others, each of which can be used for a specified field of application and can operate in different temperature ranges.

1. SCOPE

This Standard Specification is intended to cover the minimum requirements and recommendations deem necessary to be considered in process design of "Hot Oil" and "Tempered Water" systems.

The scope is covered in two parts as:

Part I	"Process Design of Hot Oil System"
Part II	"Process Design of Tempered Water 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 change(s) in standards and codes that occur after the date of this standard shall be mutually agreed upon by the Company and the Vendor/Consultant:

GPSA (GAS PROCESSORS SUPPLIERS ASSOCIATION)

"Engineering Data Book"-Volume 1, 10 th. Ed., 1987

IPS (IRANIAN PETROLEUM STANDARDS)

E-PR-190	"Layout and Spacing"
E-PR-440	"Process Design of Piping Systems (Process Piping & Pipeline Sizing)"
E-PR-740	"Process Design of Pumps"
E-PR-771	"Process Requirements of Heat Exchanging Equipment"
E-PR-785	"Process Design of Air Cooled Heat Exchangers (Air Coolers)"
E-PR-810	"Process Design of Furnaces"
E-PR-850	"Process Requirements of Vessels, Reactors and Separators"

ASME (THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

"ASME Code", Section VIII, Division 1

3. DEFINITIONS AND TERMINOLOGY

Not particular definition is implemented.

4. SYMBOLS AND ABBREVIATIONS

ASME	=	The American Society of Mechanical Engineers
CWS	=	Cooling Water Supply
CWR	=	Cooling Water Return
DP	=	Differential Pressure
DT	=	Differential Temperature
FCV	=	Flow Control Valve
LHV	=	Low Heat Value
LIC	=	Level Indicator Controller
LG	=	Level Gage
OGP	=	Oil, Gas and Petrochemical

OD	=	Outside Diameter
PI	=	Pressure Indicator
TCV	=	Temperature Control Valve
TEMA	=	Tubular Exchanger Manufacturers Association, Inc
TI	=	Temperature Indicator
TIC	=	Temperature Indicator Controller
TT	=	Temperature Transmitter

5. UNITS

This Standard is based on International System of Units (SI), except where otherwise is specified. However, some non-preferred SI units such as bar = 100 kPa, for pressure, and liter = 1 dm^3 for volume, and minute/hour (min/h) for time can also be used.

PART I
PROCESS DESIGN OF HOT OIL SYSTEM

6. PROCESS DESIGN OF HOT OIL SYSTEM

6.1 General

6.1.1 A simplified schematic of major components of a hot oil system is given in Fig. 1. The heat transfer medium is pumped through a fired heater to the heat exchanger and returns to the pump suction surge tank. In some cases a fired heater may be replaced by a waste heat source, such as the exhaust stack of a gas turbine.

6.1.2 While the system is ordered and designed as a packaged system, all necessary equipment such as ladders, and platforms, guards for moving parts, etc., shall be supplied as part of the package.

6.1.3 Indoor equipment shall be suitably protected against damage by infiltration of moisture and dust during plant operation, shutdown, washdown, and the use of fire protection equipment.

6.1.4 Outdoor equipment shall be similarly protected, and in addition, it shall be suitable for continuous operation when exposed to rain, snow or ice, high wind, humidity, dust, temperature extremes, and other severe weather conditions.

6.1.5 The system shall be laid out such that to make all equipment readily accessible for cleaning, removal of burners, replacement of filters, controls and other working parts and for adjustment and lubrication of parts requiring such attention. For similar reasons, the heater front and rear doors shall be hinged or davitted.

6.1.6 Maintenance tools specially designed for the equipment shall be furnished with the system.

6.1.7 Spare parts must be readily available. If a stock of parts is not maintained by the manufacturer, critical spare items shall be furnished with the system.

6.2 Hot Oil Heater

6.2.1 Application

These heaters furnish a heating bath up to 300°C or higher, which is hot enough for process applications such as dry desiccant or hydrocarbon recovery regeneration gas. Another less severe application is heavier hydrocarbon vaporization prior to injection into a gas pipeline to raise the heating value.

Manufactured heat transfer oils are blended for about 90-95°C operating range. For example, Fig. 2, gives typical heat transfer properties for a 150 to 300°C polyphenyl ether.

6.2.2 Advantages of hot oils

The advantages of hot oils are:

- Low vapor pressure at ambient temperature.
- Always liquid and easy to handle.
- Blended for a specific temperature range.
- Higher specific heat than normally occurring hydrocarbons.

6.2.3 Disadvantages of hot oils

The disadvantages of hot oils include:

- Escaping vapors are environmentally undesirable.
- When overheated, the oils will oxidize and coke on the fire tube. Also, they can be ignited.
- Ethers if used, are expensive.
- Ethers are hydroscopic and must be kept dry.

6.3 Design

The following features and criteria shall be considered in process design of each component of the hot oil system.

6.3.1 Heater design

6.3.1.1 Process design of the heater is critical for satisfactory operation. The heat transfer fluid must have sufficient velocity, generally 1.2 to 3 m/s, to avoid excessive film temperatures on the heater tubes.

6.3.1.2 Design and capacity of the heater should be limited so that the maximum film temperature does not exceed the maximum recommended operating temperature of the fluid.

6.3.1.3 Hot spot occurrence should be avoided, since it can lead to tube failure and fluid degradation.

6.3.1.4 The heater shall be rated for the specified output. Multiple identical units may also be employed for the designed total heat load, but care shall be taken in system design to ensure adequate and proportional flow through the heaters.

6.3.1.5 The thermal efficiency of the heater shall be a minimum of 80% based on LHV of fuel. The contractor shall specify the expected and guaranteed values for the thermal efficiency and the basis for their estimation.

6.3.1.6 Based on total outside surface area of the firetube(s) and the return flue(s), the average heat flux shall not exceed 17.35 $kJ/s.m^2$. The flame characteristics and combustion chamber design shall ensure that the maximum heat flux at any point is limited to 23.66 $kJ/s.m^2$.

6.3.1.7 Heating medium (hot oil) shall clearly be specified and it's discharge temperature from the heater shall be limited to a specified value, in data sheet.

6.3.1.8 Under normal operating conditions, the rise in heating medium temperature across the heater shall not exceed the allowable DT specified in the data sheet.

6.3.1.9 The heater shall be designed to give an efficient heater operation over the complete operating load range.

6.3.1.10 Each heater (in case the use of multi-heater units), shall have a self-supporting stack designed to carry the total exhaust under the maximum firing conditions.

6.3.1.11 In general reference should be made to IPS-E-PR-810, "Process Design of Furnaces" for design of heater and auxiliary systems.

6.3.2 Firing system design

6.3.2.1 The hot oil heater shall be designed for a continuous and reliable operation.

6.3.2.2 The burner(s) shall be designed for a minimum of 120 percent of normal full load firing and be suitable for firing the specified fuels (oil, gas or both) without undue maintenance or adjustment.

6.3.2.3 In case of a forced-draft type heater the burner design shall incorporate air/fuel ratio system(s) to ensure complete combustion with minimum amount of excess air. The air/fuel ratio system shall be effective throughout the burner firing range i.e., from low to high fire positions.

6.3.2.4 The burner nozzles and other parts exposed to the radiant heat of the combustion chamber shall be made from heat resisting alloy steel.

6.3.2.5 The burner fuel and air openings shall be arranged to provide suitable velocities for complete mixing resulting in efficient combustion of the fuel.

6.3.2.6 Each burner shall have observation ports to permit sighting and inspection of the flame.

6.3.2.7 Suitable ignitor(s) shall be provided for firing fuel oil or gas and shall be of adequate output to permit safe ignition of the fuel.

6.3.3 Combustion air fan design

In case of forced-draft type heater the following should be considered:

6.3.3.1 The fan shall be designed for maximum ambient temperature.

6.3.3.2 The fan(s), performance shall be stable over the complete firing range i.e., maximum firing down to shut off.

6.3.3.3 Inlet screens shall be provided at fan(s) inlet.

6.3.3.4 Combustion air fan(s) shall be sized to handle a minimum of 120 percent of the normal full quantity of combustion air.

6.3.4 Heater control and instrumentation

The heater package shall be provided with the following control and instrumentation as minimum:

a) Fuel gas/oil control system complete with:

- pressure gages in important locations;
- pressure regulators;
- pressure relief valves;
- flow control valves;
- strainers;
- isolating valves.

b) Fuel gas/oil emergency shut-off valve.

c) Heater TIC (modulating type) for hot oil temperature control.

d) Heater manual control for fire regulation.

e) Temperature switches shall be supplied for the following alarm and shutdown functions:

- hot oil high temperature alarm;
- hot oil high high temperature shutdown;
- hot oil low temperature alarm;
- stack high temperature alarm;
- stack high high temperature shutdown;
- fuel oil low temperature alarm.

f) Pressure switches shall be supplied for the following alarm and shutdown functions:

- hot oil high pressure alarm;
- hot oil low pressure alarm;
- *fuel gas/oil high supply pressure alarm;
- *fuel gas/oil high supply pressure shutdown;
- *fuel gas/oil low supply pressure alarm;
- *fuel gas low low supply pressure shutdown.

g) Flow switches installed on the flow transmitter output shall be supplied for the following functions:

- turning Unit down to low flame position on low flow condition;
- shutting Unit down (including circulation pumps) on low low flow condition.

h) Additionally, the following instrumentation shall be provided on the hot oil heater:

- pressure gage complete with isolation and bleed valve;
- temperature indicators complete with thermowells for hot oil inlet and outlet streams;
- stack exhaust temperature indicator complete with thermowell;
- ASME rated relief valve(s), factory set and sealed and located suitably. Relief valves shall have stainless steel trim.

i) Automatic start up/shutdown sequence control is normally not recommended, but if specified by the Company shall consist of:

- pre-ignition purge of the combustion chamber;
- ignition;
- pilot proving;
- firing rate modulation between low flame position and the maximum output;
- post purge after shutdown.

j) The burner management system if specified by the Company shall be housed in a locally mounted panel, suitable for the area classification in which it is installed.

k) The burner management system shall incorporate a remote shutdown facility so that the main burner(s) and pilot(s) can be extinguished by a push-button located in central control room.

l) All other instrument, and controlling systems as per Vendor specification such as flame failure detector, pilot flame monitoring etc., should also be considered.

*** Pressure switches shall be installed on each fuel supply line.**

6.3.5 Hot oil surge tank design

6.3.5.1 A surge tank shall be provided, suitably sized to handle expansion of inventory in whole system, and shall be designed as a pressure vessel in accordance with IPS-E-PR-850.

6.3.5.2 The surge tank shall be arranged on the return side (pump suction side) and shall be blanketed with fuel gas or inert gas.

6.3.5.3 The surge tank shall be located inside the heater building.

6.3.5.4 Two piping arrangements are used for the surge vessel; flow through the vessel or the vessel as a surge riding on the pump suction line.

6.3.5.5 The surge tank shall be provided complete with the following:

a) Level gage(s), spanning the entire operating range.
b) Pressure gage.
c) Pressure relief valve.
d) Blanket gas pressure make-up regulator.
e) Pressure regulator to vent tank over pressure due to expansion or filling.
f) Make-Up connection complete with isolation valve and non-return valve.

6.3.6 Circulating pump design

6.3.6.1 Two centrifugal pumps, each capable of 110% of design circulation rate at the design head shall be provided in accordance with IPS-E-PR-740. However the following requirement shall also be considered in design.

6.3.6.2 Strainer shall be provided at the suction of each pump.

6.3.6.3 Valving around each pump shall include the following:

a) Suction isolation gate valve of the same size as the suction line.
b) Non-Return valve in discharge line.
c) Isolation gate valve in discharge line.
d) Casing vent and drain valves.

6.3.6.4 In design of pump suction and discharge lines, the differential thermal expansion of the lines due to temperature variation shall be taken into account.

6.3.7 Hot oil filter

6.3.7.1 A hot-oil filter shall be provided to handle a slipstream equal to 10% of the design flow rate.

6.3.7.2 The filter shall be of disposable cartridge type, capable of removing all solid particles above 5 micrometers (microns).

6.3.7.3 The hot-oil filter shall be provided complete with the following:

a) DP gage.
b) Isolation valves at inlet and outlet.
c) Restriction orifice, sized for the required flow rate.
d) Vent and drain valves.
e) Relief valve.
f) Filter by-pass line.

6.3.8 Carbon filter

6.3.8.1 A bulk-pack type carbon absorber shall be provided downstream of the heating medium filter to remove any products of degradation.

6.3.8.2 The design flow rate of carbon filter shall be the same as the hot-oil filter flow-rate.

6.3.8.3 The carbon filter shall be provided complete with the following:

a) DP gage.
b) Isolation valves at inlet and outlet.
c) Vent and drain valves.
d) Relief valve.
e) Filter by-pass line.

6.4 Performance Guarantees

6.4.1 The Vendor, unless he expressly states any exceptions in his proposal, shall specify the guarantees on which the system furnished by him to meet the requirement with regard to process design, as flow rate, hot-oil delivery pressure and temperature, safety and reliability under all specified operating conditions.

6.5 Specific Project Requirements

6.5.1 The Vendor shall specify the following data and information as the "Specific Project Requirements" in his proposal.

- Project: ....
- Location: ....Elevation .... m
- Environment:......................non-corrosive..................corrosive ....
- Barometric pressure................ kPa (abs)
- Heat transfer medium fluid ....
- Concentration: ....mass% in water
- Circulation rate: ....m^3/h
- Pump differential ....kPa
- Temperature of heat transfer fluid to heater: .... °C
- Temperature of heat transfer fluid from heater: .... °C
- Design circulation rate: ....m^3/h
- Design pump differential: ....kPa
- Design temperature, heater outlet: .... °C
- Design, heater duty: ....MJ/h
- System Design pressure: ....kPa (ga)at .... °C
- Maximum pressure drop accross heater: .... kPa
- Surge tank:..................................... Required..Not required
- Circulation pump: ....Required..Not required
- Hot oil filter: ....Required..Not required
- Carbon adsorber: ....Required..Not required
- Supply header size:... mm
- Return header size:..mm
- System capacity, excluding heater package: .... m^3
- Instrument air: ....Instrument gas

  - Supply pressure..................... kPa (ga) normal
  - Design pressure .... kPa (ga) at .... °C

- Area classification:

- Fuel gas.......................... sweet ....sour

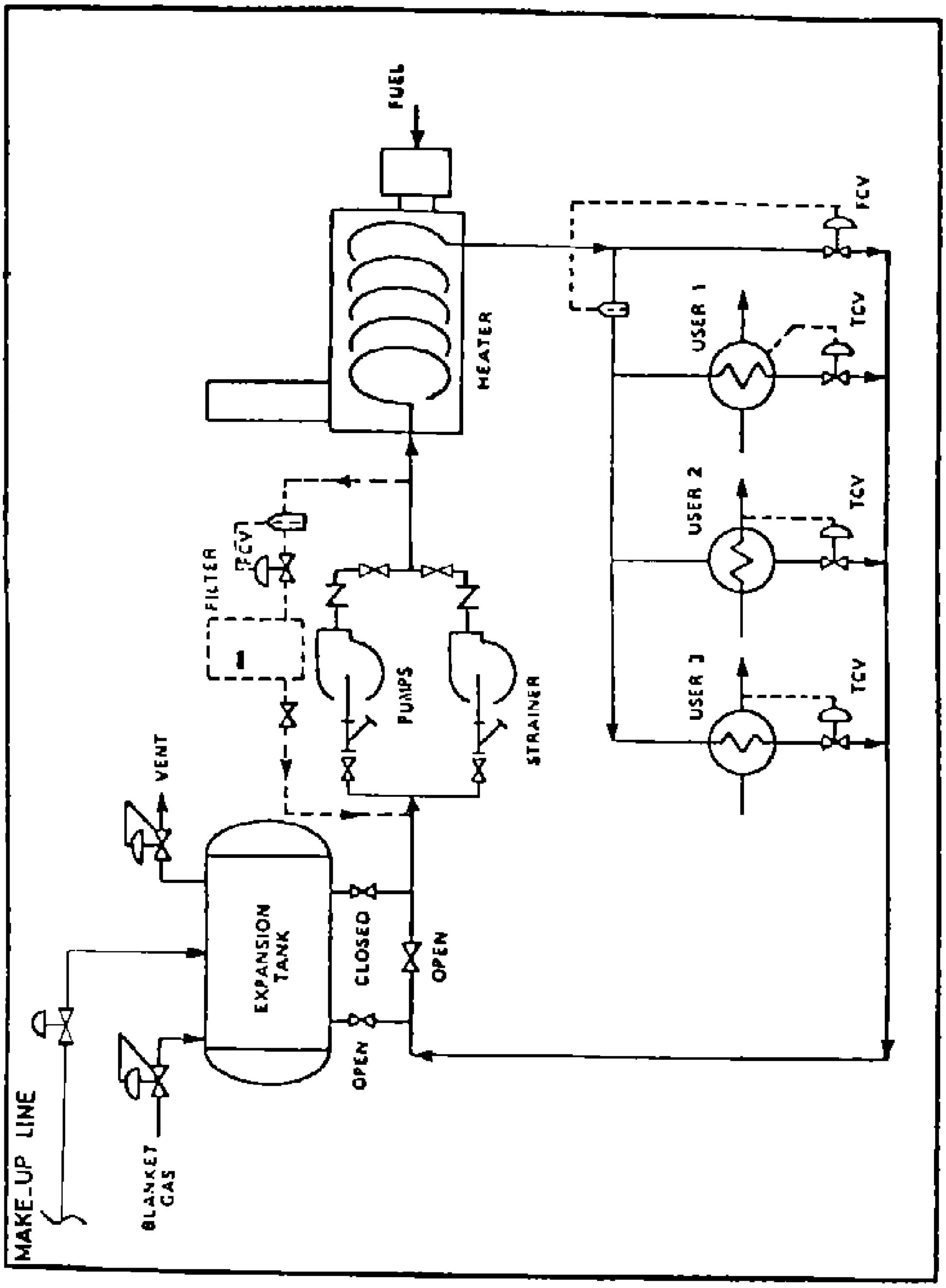
  - Supply pressure ....kPa (ga) normal
  - Design pressure ....kPa (ga) at .... °C
  - Relative density (specific gravity) (Air=1.0).................... Molecular mass (MW)...

- Composition: ....

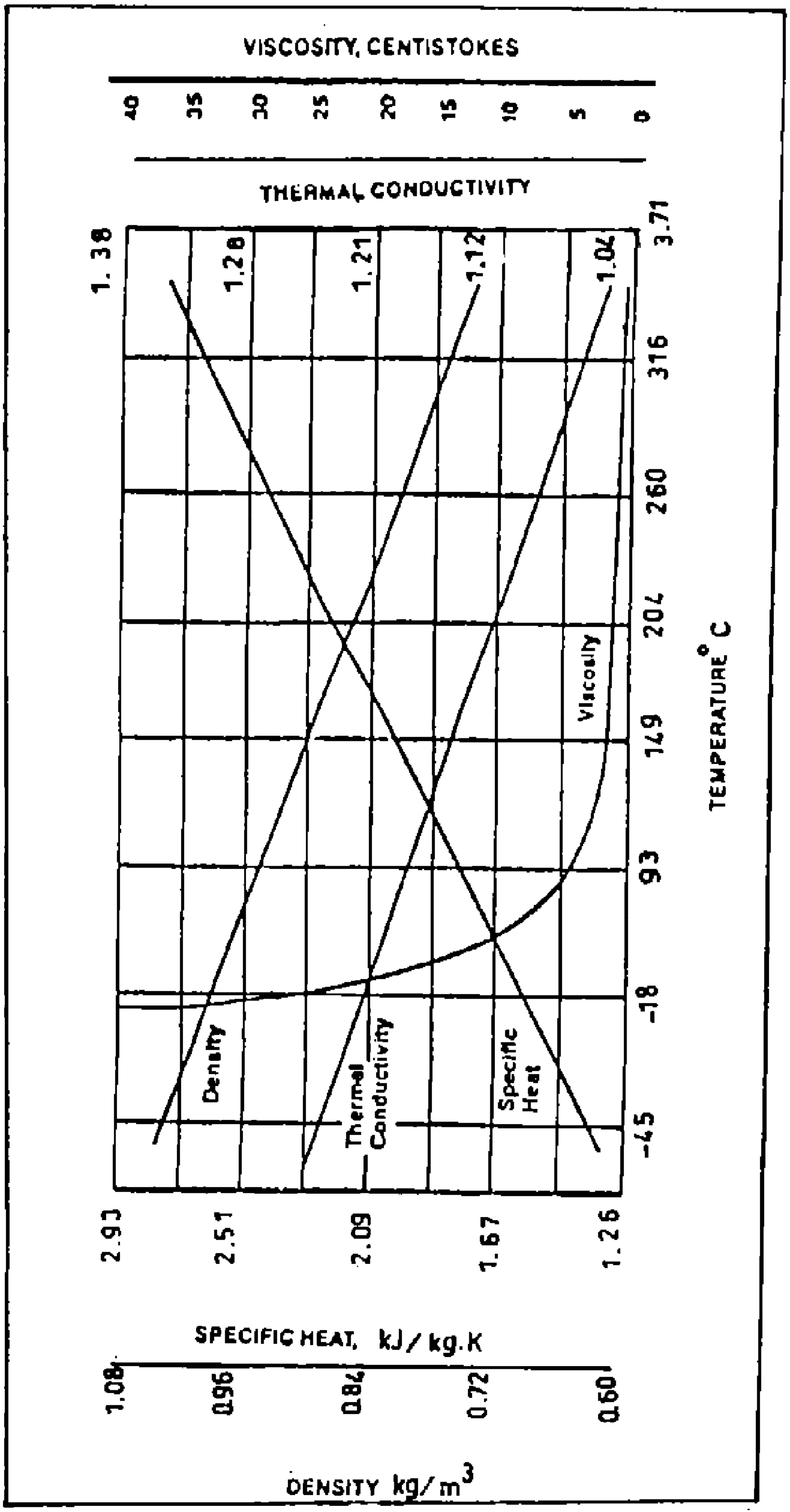
....

....

....



TYPICAL HOT OIL SYSTEM
Fig. 1



TYPICAL HEAT TRANSFER PROPERTIES OF HOT OIL (POLYPHENYL ETHER)

Fig. 2

PART II
PROCESS DESIGN OF TEMPERED WATER SYSTEM

7. PROCESS DESIGN OF TEMPERED WATER SYSTEM

7.1 General

7.1.1 Using tempered water as a cooling medium for solutions that would freeze or cristallize at usual cooling water temperatures is a common practice.

7.1.2 A special tempered water circulating system shall be designed to minimize the chance of fouling by deposition of these type materials on heat exchanger surfaces.

7.1.3 Condensate or treated process water shall be used as circulating tempered water, the water should efficiently be treated for corrosion inhibition according to material specification and design procedures. Provisions for corrosion inhibitor facilities shall be made. Fig. 3 represents typically installation of such system consisting of a surge drum with cooling and controlling facilities, circulating pumps, air cooler and/or shell-tube heat exchanger and associated piping and measuring devices.

7.1.4 Single or multiple user(s) may be incorporated in a single tempered water system. All components of the system should accordingly be designed to maintain required cooling load capacity when all or part of the user(s) are in operation.

7.1.5 The water return from the various users shall be cooled to specified temperature depending on the local climatic conditions.

7.1.6 All applicable parts of general requirements set forth in Clause 6, "Part I" of this Standard shall be considered for this part unless is in contrary with Vendor specification.

7.2 General Layout and Operational Facilities

7.2.1 For layout and operation of the system, Vendor should take into account an adequate space being allowed for operational access, cleaning and maintenance.

7.2.2 The arrangement of installations should be such that, instruments and indicators can readily be seen from the appropriate working position. Valves and controls should be nearly arranged and accessible.

7.2.3 In case the system admitted for indoor installation, access facilities should be so arranged that major items of the system can be brought in and taken out or removed as necessary.

7.2.4 Applicable provisions of IPS-E-PR-190, should also be considered in system layout design by the Vendor.

7.3 Process Design Requirements

7.3.1 General

7.3.1.1 Design of the system and it's associated controls should take into account the following:

- **a)** The nature of the application.
- **b)** The type of installation i.e., indoor or outdoor installation.
- **c)** Cooling load patterns.
- **d)** Tempered water supply requirements.
- **e)** Economic factor and minimizing the use of primary eneregy.

7.3.2 Surge drum

7.3.2.1 Surge drum (Fig. 3) for required capacity shall be designed in accordance with IPS-E-PR-850.

7.3.2.2 Make up water to surge drum will be taken from condensate system, moderately heated to required temperature by hot condensate circulation and chemical treatment should be practiced to minimize corrosion.

7.3.2.3 The drum should be blanketed with steam. Provisions shall be considered for automatic controlling of water level and adding make-up water as required.

7.3.2.4 Drum operating above 7.0 kPa shall have a minimum design pressure of 110 kPa (abs). The drum shall be designed for full vacuum.

7.3.2.5 All applicable loads, including wind load, earthquake and hydrostatic testing load shall be considered in design as acting simultaneously.

7.3.2.6 All outline drawing shall be furnished and shall contain the data indicated in Table 1 below. Location of the drum marking or nameplate shall be indicated on this drawing.

TABLE 1 - DATA IN DRAWING

DESCRIPTION	UNIT	DATA
•Design pressure	kPa	——
•Design temperature	°C	——
•Operating pressure	kPa	——
•Operating temperature	°C	——
•Maximum allowable stress at design temperature	kPa	——
•Hydrostatic test pressure at uppermost part of drum	kPa (ga)	——
•Hydrostatic test temperature	°C	——

7.3.2.7 A manufacturer's data report shall be furnished and shall contain the same information as required by form U-1 of ASME Code, Section VIII, Division 1.

7.3.2.8 Provisions for entering, cleaning, venting and draining of vessel shall be considered on the bases of basic practice as specified by the Vendor/manufacturer.

7.3.2.9 Surge drum shall be furnished with following auxiliaries:

a) Pressure gage.
b) Temperature gage.
c) Level gage.
d) Steam blanketing regulator.
e) All inlet, outlet piping nozzles.

7.3.3 Circulating/recirculating centrifugal pumps

7.3.3.1 The circulating and recirculating pumps as shown in Fig. 3 shall be centrifugal with 100% spare and shall be designed in accordance with specification and criteria setforth in IPS-E-PR-740 and following requirements:

a) Unless otherwise specified, the pumps and auxiliaries shall be suitable for unsheltered outdoor installation in the climatic zone specified.

b) Flanged suction and discharge nozzles shall be integral with the casing.

c) Gate valves shall be used for vents and drains.

d) All required vents shall be valved.

e) Nameplate data shall be in SI units.

f) Vendor's piping shall terminate with a flanged or threaded connection, of a line rating at least equal to the design pressure and design temperature rating of the equipment.

g) Vendor shall specify the spare parts and shall include his proposed method of protection from corrosion during shipment and subsequent storage.

h) Vendor's proposal shall state the minimum flow rate recommended for sustained operation on the specified tempered water.

i) Isolation gate valves shall be used at suction and discharge line with the same respective line size.

j) Non-return valves shall be installed in discharge lines.

k) Globe valve shall be sized for blanketing line.

7.3.3.2 The pumps shall be of proven modern design and shall have operating characteristics as specified in pump data sheet.

7.3.3.3 The arrangement of equipment, including piping and auxiliaries shall provide adequate clearance area and safe access for operation and maintenance.

7.3.3.4 The equipment and component parts shall be warranted against defective materials, design and workmanship for specified guaranteed period.

7.3.4 Cooler

7.3.4.1 Unless otherwise required, air cooler shall be used in tempered water system, in accordance with IPS-E-PR-785.

7.3.4.2 In case shell-tube heat exchanger is required, its design shall be in accordance with IPS-E-PR-771.

7.3.5 Piping design

7.3.5.1 All applicable portions of IPS-E-PR-440 shall be considered in pipe sizing and design of the tempered water system. It shall apply to auxiliary piping connecting the equipment of the system and the piping between the system and the consuming Units. However, the following considerations shall be admitted to accomplish the whole requirements of piping process design.

1) In piping layout, the location of operating and control points such as valves, flanges, instruments, vents and drains shall enable operation of the system with minimum difficulties.

2) The piping system shall be laid out to allow easy repair or replacement of any portion of the system.

3) Basic design data for each line shall be given in the line designation table as per Company's project specification.

4) The actual minimum corrosion allowance shall be listed for each line in the line designation table. In general, a nominal corrosion allowance at 1.25 mm for carbon steel piping is recommended.

5) Flanges or other removable connections shall be provided throughout the piping system to permit complete removal of the piping.

6) A gate valve shall be installed in each instrument take-off connection except thermowells and shall be located close to the pipe.

7) All piping connections to equipment shall be suitable for the equipment design and the hydraulic test pressure.

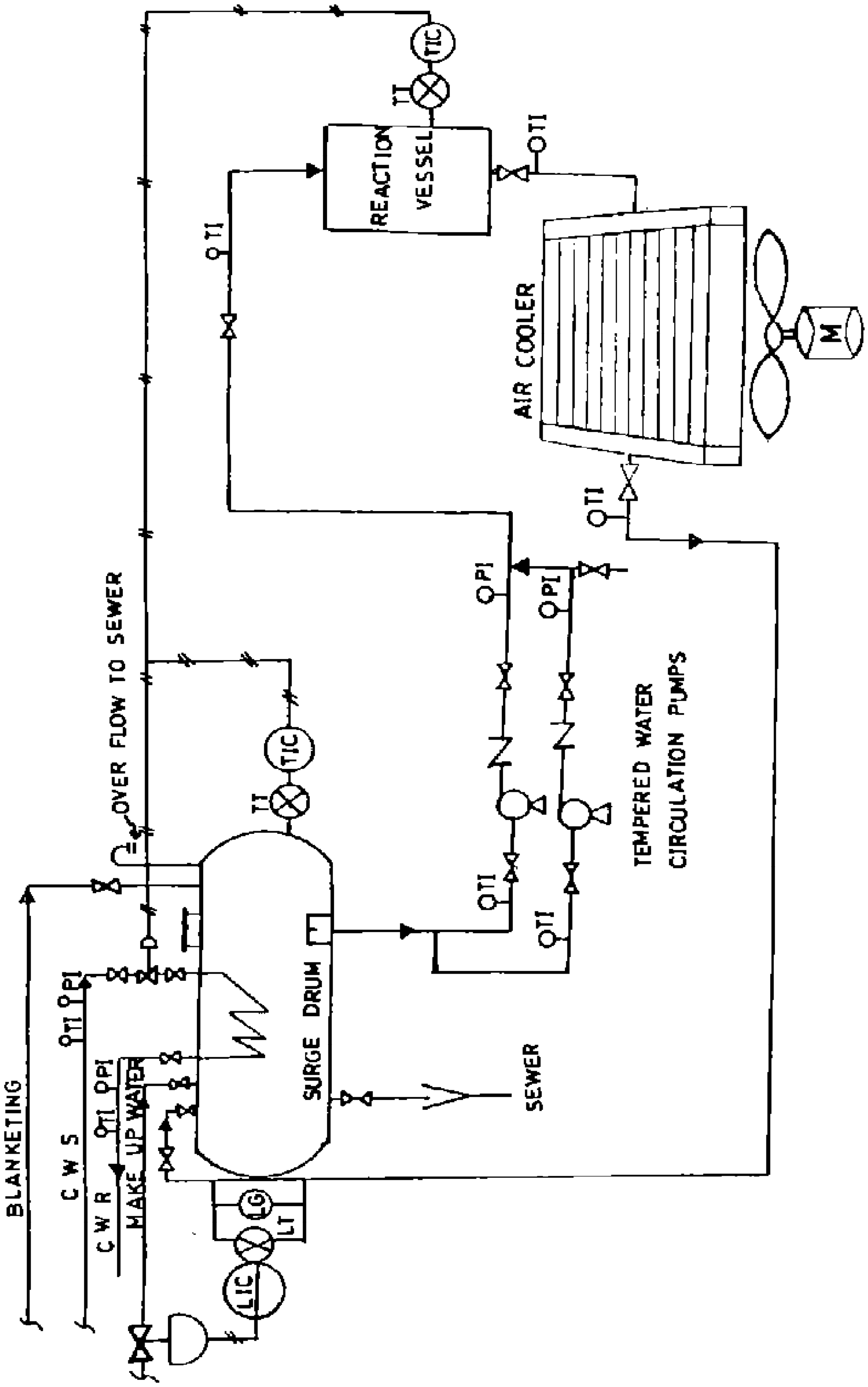
7.3.6 Other requirements

7.3.6.1 The whole system should be arranged and sized so that the design cooling load can be met by an appropriate flow of tempered water within the applicable system temperature limits.

7.3.6.2 Circulating piping should be thermally insulated and traced where local climatic condition implies.

7.3.6.3 Isolating valves are normally fully open or fully shut and should be provided to facilitate isolation of individual items of equipment.

7.3.6.4 An appropriate and compatible automatic controls should be arranged for the system elements.



TYPICAL TEMPERED WATER CIRCULATING SYSTEM (USING CONDENSATE/PROCESS WATER)
Fig. 3