

DETERMINATION OF DESIGN CONDITIONS

JGS 210-120-1-18E

Rev.3 DATE JUL.-31-'96

CONTENTS

	<u>PAGE</u>
1. SCOPE.....	2
2. WORK PROCEDURE.....	2
2.1 Input to the Design.....	2
2.1.1 Process Conditions.....	2
2.1.2 Input Data.....	2
2.2 Output from the Design.....	2
2.3 Work Steps.....	3
2.4 Check List.....	3
2.5 Computer Programs.....	3
3. DESIGN PRESSURE.....	3
3.1 Design Pressure for Pressure Vessels (General).....	3
3.1.1 Indication Rules.....	3
3.1.2 Location Defined.....	3
3.1.3 Estimation Method.....	4
3.1.4 Liquid Head.....	4
3.1.5 Vessels Connected to Flare.....	4
3.1.6 Short Term Condition.....	4
3.1.7 Vacuum Condition.....	4
3.1.8 Short Term Condition.....	5
3.2 Design Pressure for Pump Discharge.....	5
3.3 Design Pressure around Compressor.....	6
3.3.1 Centrifugal Compressor.....	6
3.3.2 Reciprocating Compressor.....	6
3.3.3 Settling-out Pressure.....	6
3.4 Design Pressure of Shell and Tube Exchanger Considering a Tube Failure.....	8
3.5 Design Pressure for Piping.....	9
3.5.1 General.....	9
3.5.2 Surge (Water Hammer) in Liquid Pipeline.....	9
3.6 Safety Device and Tolerance.....	10
3.6.1 A Single Safety / Relief Device for Several Equipment.....	10
3.6.2 Tolerance of Safety/Relief Valve.....	10
3.6.3 Tolerance of Controller.....	10
3.6.4 Rupture Disc.....	10
4. DESIGN TEMPERATURE.....	11
4.1 Design Temperature for Vessels and Piping.....	11
4.2 Special Cases.....	12
4.2.1 Minimum Design Temperature Considering Depressuring Operation.....	12
5. RELATED DOCUMENTS.....	12
6. DEFINITIONS.....	13
7. ABBREVIATIONS.....	13
APPENDIX-1 SAMPLE OF CHECK LIST FOR DESIGN CONDITIONS.....	14
APPENDIX-2 DESIGN CONDITIONS OF OTHER COMPANIES.....	15

1. SCOPE

This standard practice covers the requirements for determination of design pressure and temperature for pressure vessels and piping to be used for petroleum refineries, petrochemical plants and similar plants. It should be noted that specific instructions given in the Project Specifications take precedence over the requirements described in this standard practice.

2. WORK PROCEDURE

2.1 Input to the Design

2.1.1 Process Conditions

The data to be used to determine the design conditions should be clarified on the following:

(1) Source of the data

The data will be obtained from, but not limited to, the following documents;

- Process Flow Diagram (PFD)
- Basic Engineering Design Data (BEDD)
- Piping & Instrument Diagram (P&ID)
- Plot plan
- Equipment data sheet
- Piping material specification

(2) Operation case to be taken as the design base

(3) Related documents to be used as a part of the input data

(4) Related documents to be checked or revised based on the results of the design

2.1.2 Input Data

The following is a summary of input data to be prepared before the determination of design conditions.

(1) Operational data

- Service for identification
- Item number of equipment for identification
- Operating temperature under normal operation
- Operating pressure under normal operation
- Density of the fluid (flowing and standard)
- Pressure drop of internals
- Static heads for the vessel and lines
- Differential pressure of pump at shut-off or design condition
- Operating conditions for other than the normal operation, such as start-up, upsets, shut-down and so on.

(2) Construction data

- Line class or general pressure-temperature rating of flanges
- Elevation at inlet and outlet of piping system
- Location of valves which cause shut-off conditions

2.2 Output from the Design

The following output data should be prepared in the design.

- (1) Design pressure and temperature(s) for the vessels
- (2) Design pressure and temperature for the pump discharge lines
- (3) Design pressure and temperature around compressor.
- (4) Short term design conditions, if required
- (5) Minimum design temperate, if required

2.3 Work Steps

The hydraulic design will be conducted according to the following work steps, as a guideline.

- (1) Prepare input data as listed in section 2.1.
- (2) Evaluate the design conditions as described in sections 3 and 4.
- (3) Evaluate the short-term design conditions.
- (4) Evaluate the minimum design temperature.
- (5) Check the design results.

2.4 Check List

The following should be checked based on the design results.

- (1) Operating/design conditions for adjacent equipment and lines
APPENDIX 1 is useful for this check.
- (2) Line class(es)

2.5 Computer Programs

No computer program is available.

3. DESIGN PRESSURE

The design pressure is the pressure used in mechanical design.

Design pressure refers to at least the most severe condition of coincident pressure and temperature expected in normal operation ¹.

3.1 Design Pressure for Pressure Vessels (General)**3.1.1 Indication Rules**

- (a) Unless otherwise specified, this denotes gage pressure. If the design pressure is less than atmospheric pressure, absolute pressure may be used instead of gage pressure.
- (b) The design pressure should, in principle, be rounded off. The 2nd decimal place of the design pressure lower than 20 kg/cm²G should be raised and rounded up to the first decimal place, and higher than 20 kg/cm²G to be rounded up to a whole number.
For example, 15.43 kg/cm²G becomes 15.5 kg/cm²G and 35.4 kg/cm²G becomes 36 kg/cm²G.

3.1.2 Location Defined

- (a) Design pressure shall be based on the expected maximum pressure at the top of vessel under normal operation.
The design pressure should be indicated in the vessel specification as "Design Pressure at Top".
Operating pressure under normal operation should be indicated in the vessel specifications as "Operating Pressure at Top".
- (b) The maximum pressure at the bottom of the vessel is calculated, by the mechanical design engineer, to determine the thickness of the vessel. It is thus necessary to indicate the high liquid level and specific gravity of the liquid at the bottom of vessel, and also the pressure drop through the internals.
A pressure drop of 0.3 kg/cm² through trays may be assumed, unless this is largely different from the calculated value. As for the internal pressure drop and hold up of a reactor, see the section on reactors.

¹ ASME Section VIII, Div. 1, UG-21 and APPENDIX 3-2

3.1.3 Estimation Method

- (a) When the maximum pressure during normal operation can not be estimated, the design pressure should be determined as follows :

Table 3-1 Design pressure estimation

Operating Pressure P_n	Design Pressure, P_d
Less than 18 kg/cm ² G	$P_d = P_n + 1.8 \text{ kg/cm}^2$
18 - 40 kg/cm ² G	$P_d = P_n \times 1.1$
40 - 80 kg/cm ² G	$P_d = P_n + 4.0 \text{ kg/cm}^2\text{G}$
Larger than 80 kg/cm ² G	$P_d = P_n \times 1.05$

P_n = operating pressure under normal operation (kg/cm²G)
 P_d = design pressure (kg/cm²G)

(Example)

$P_n = 2.0 \text{ kg/cm}^2\text{G}$ (TOWER) in example 1 and $P_n = 50 \text{ kg/cm}^2\text{G}$ (TOWER) in example 2.

Table 3.1.3 Example results

Pressure in Vessel	Example 1		Example 2	
	P_n	P_d	P_n	P_d
Pressure at to (kg/cm ² G)	2.0	3.8	50.0	54.0
Pressure drop of internals (kg/cm ²)	0.3	0.3	0.3	0.3
Bottom high liquid head (kg/cm ²)	0.2	0.2	0.2	0.2
Pressure at bottom (kg/cm ² G)	2.5	4.3	50.5	54.5

3.1.4 Liquid Head

- (a) When the vessel is venting to atmosphere, the minimum design pressure shall be full of water or full of liquid, whichever is bigger.
- (b) When piping connecting equipment, is full of liquid, design pressure of the piping should be equipment design pressure plus liquid head.

3.1.5 Vessels Connected to Flare

- (a) When the vessel is connected to the flare system, the minimum design pressure is often specified to be 3.5 kg/cm²G.

3.1.6 Heat Leak from Outside

- (a) When overpressure is occurred due to heat leak from outside in shut down operation, design pressure should be determined considering outside temperature especially for refrigeration system.

3.1.7 Vacuum Condition

- (a) When a vacuum condition is normal or likely to occur due to maloperation during steam purge, if required or emergency shutdown of reboilers (all condensable vapor services), etc., the vessel with small volume such as stabilizer, splitter will be designed to withstand full vacuum or the vessel with large volume such as crude column or FCC main column should be designed to withstand half vacuum (-0.5 kg/cm²G) or 1/4 vacuum (-0.25 kg/cm²G).
- (b) Should vacuum protection devices such as vacuum breaker be provided, external design pressure (vacuum side) may be reduced to the set pressure of vacuum protection device.

3.1.8 Short Term Condition

The normal operation, intermediate and short term conditions are defined by the operating periods tabulated as below ².

Table 3.1.8 Class-of operating conditions

Operating conditions	Continuous operating period at any one time	Total operating period per year
Normal operation	Longer than 50 hours	Longer than 500 hours
Intermediate term	10 - 50 hours	100 - 500 hours
Short term	0 - 10 hours	0 - 100 hours

- (a) When the maximum pressure under short term or intermediate term conditions exceeds the design pressure determined by above mentioned methods, this maximum pressure should be specified together with the corresponding temperature in the specification. And it should be checked by the mechanical and piping engineer. In this case, it is necessary to state clearly whether the condition is short term or intermediate term conditions.
- (b) It is recommended that a check list, such as APPENDIX-1 be filled out with consideration to short term or intermediate term conditions (Refer to Para. 6. DEFINITIONS)

3.2 Design Pressure for Pump Discharge

When vessels located on the discharge side of pumps are not protected by pressure relief devices, the design pressure shall be determined as the bigger of the followings two criterias :

$$(1) P_d = \Delta P_s + H_t + P_n \quad (1)$$

Where :

P_d = design pressure (kg/cm²G)

ΔP_s = differential head of pump at shut-off condition (kg/cm²)

If not available, $\Delta P_s = 1.25 \times \Delta P$ (for moter drive) or $\Delta P_s = 1.38 \times \Delta P$ (for turbin drive)

Refer to JGS 210-120-1-27E "PUMPS"

H_t = head between tangential line of a suction vessel and center of pump (kg/cm²)

P_n = normal pressure at tangential line of a suction vessel with the highest liquid level (kg/cm²G)

$$(2) P_d = \Delta P + H_t + P_m \quad (2)$$

Where :

ΔP = differential head of pump under normal flow rate. (kg/cm²)

P_m = maximum pressure at tangential line of a suction vessel with the highest liquid level (kg/cm²G)

= design pressure of a suction vessel + pressure drop across internal, such as tray.

NOTE : The value 0.3 kg/cm² may be taken as the pressure drop across internal if data not available.

² ANSI B31.3 302.2.4