

SPD0019ERN
PROCESS DESIGN MANUAL

DESIGN CONDITIONS

REV. : 2

DATE : 2013.08.28



SAMSUNG
ENGINEERING

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1. SCOPE

This manual covers methods for determining the design pressure and temperature of towers, vessels and piping. [Major equipment design pressures and temperatures are used in the mechanical design of equipment and in the determination of relief requirements.](#)

[For any particular project, client specifications for design pressure and temperature must be reviewed. The more conservative of client specifications and those given below should be applied.](#)

2. DEFINITIONS

2.1. Normal pressure, operating pressure

The pressure at the top of a pressure vessel under normal operating conditions

As a general rule the operating pressure is based on the pressure at the top of a pressure vessel. "Operating Pressure at the Top of a Pressure Vessel" should be clearly stated in the project specification. It equals the set point of a pressure controller if the pressure of the vessel is controlled.

2.2. [Maximum operating pressure](#)

[The highest operating pressure a piece of equipment will see under all applicable hydraulic design cases \(normal, rated and turndown\).](#)

2.3. Design pressure

The pressure which is the basis for calculating the minimum permissible thickness or physical characteristics of the equipment.

[Design pressure of a piece of equipment can be set by adding a margin above the maximum operating pressure.](#)

2.4. Operating temperature, working temperature

The temperature under normal operating conditions.

2.5. Design temperature

The temperature which is the basis for calculating the minimum permissible thickness or physical characteristics of the equipment.

[Design temperature of a piece of equipment can be set by adding a certain margin above the normal operating temperature. Speciation conditions \(regeneration, start-up, etc.\) may require a maximum operating temperature that exceeds that presented in heat and material balance.](#)

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2.6. Normal operating conditions

The operating conditions under which on-spec. products are produced. These conditions correspond to the pressure and temperatures shown in the process flow diagram.

Normal operating conditions, intermediate time conditions and short time conditions are defined by the operating periods tabulated below (Ref. ANSI B 31.3--102.2.4 (a)).

Conditions	Operating Period	
	Continuous Operating Period at Any One Time	Total Operating Period per Year
Normal operating	50 + hr	500 + hr
Intermediate time	10 - 50 hr	100 - 500 hr
Short time	0 - 10 hr	0 - 100 hr

For example, the following conditions are not normal operating conditions generally.

- (1) Operation at start-up, or shut-down when off-spec. products are produced.
- (2) Operation bypassing a heat exchanger or a vessel which is normally operated.
- (3) Regeneration of the catalyst of a reactor, decoking of a fired heater.
- (4) Steam purge, nitrogen purge operation
- (5) Depressuring operation
- (6) Pump discharge block-out operation, when the suction pressure is under design pressure.
- (7) Outbreak of fire and relieving of safety/relief valve
- (8) Mal-operation

2.7. [Maximum Allowable Working Pressure \(MAWP\)](#)

The MAWP is the maximum pressure (at a coincident pressure) permissible at the top of a fabricated vessel. The MAWP is determined by the vessel fabricator based on the vessel design and actual wall thickness (adjusted for corrosion allowance). The MAWP must be equal to or greater than the design pressure.

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3. DETERMINATION OF DESIGN PRESSURE

Please note that the design pressure is always used in design with a coincident design temperature.

3.1. Design Pressure for Towers and Vessels

The design pressure for towers and vessels are determined in the following manner.

3.1.1. Margin above Maximum Operation Pressure to Establish Design Pressure

- (1) Unless otherwise specified, gauge pressures are used.
If the operating pressure is less than atmospheric pressure, absolute pressure should be used instead of gauge pressure.
- (2) Design pressure is determined based on the maximum normal operating pressure and the addition of a design margin (given below).
If pressure fluctuation is expected during normal operation, the maximum value of the fluctuating pressure must be considered.
See Section 2 for a definition of normal operation, and exclusions.

(3) From the maximum operating pressure, apply the following margin:

- | | |
|---------------|---|
| Case A | Normal Pressure: Open Vessel
Design Pressure = Full of Water |
| Case <u>B</u> | Normal Pressure: <u>0</u> Kg/ Cm ² .G - 18 Kg/ Cm ² .G
Design Pressure = Normal Pressure + 1.8Kg/ Cm ² .G
<u>Minimum Design Pressure is 3.5 Kg/ Cm².G</u> |
| Case <u>C</u> | Normal Pressure: 18 Kg/ Cm ² .G - 40 Kg/ Cm ² .G
Design Pressure = Normal Pressure x 1.1 |
| Case <u>D</u> | Normal Pressure: 40 Kg/ Cm ² .G - 80 Kg/ Cm ² .G
Design Pressure = Normal Pressure + 4.0 Kg/ Cm ² .G |
| Case <u>E</u> | Normal Pressure: Larger than 80 Kg/ Cm ² .G
Design Pressure = Normal Pressure x 1.05 |

Margins of less than 10% are likely to pose issues for relief device selection. See Section 3.4.2 on the impact of the pressure relief device design on design pressure settings.

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The design pressure will, in principle, be rounded off as follows:

For numbers smaller than 1 kg/cm² and vacuum condition: Fractions of the second decimal place or smaller will be raised to the first decimal place.
Between 1 kg/Cm².G or higher and less than 20 kg/Cm².G : Fractions of the first decimal place or smaller will be counted as point zero or point five. For numbers 20 kg/Cm².G or higher: Fractions will be raised to the first place of integers.

The design pressure should be indicated in the specification as "Design Pressure at Top."

The maximum pressure at the bottom of the vessel is calculated, by the mechanical design department, to determine the vessel wall thickness. It is thus necessary to indicate the height and specific gravity of the liquid, 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 actual value. As for the internal pressure drop and hold up of a reactor, see the section on reactors.

Example Calculation:

	Example 1		Example 2	
	Op. Press.	Design Press.	Op. Press.	Design Press.
Press. at top (kg/cm ² .G)	2	3.8	50	54
Press. Drop (kg/cm ²)	0.3	0.3	0.3	0.3
BTM Liq. Head (kg/cm ²)	0.2	0.2	0.2	0.2
Press. at BTM (kg/cm ² .G)	2.5	4.3	50.5	54.5

In above Example 1, the design pressure at the top which should be incorporated in the projected specification is 4.0 kg/cm².G (rounded off from 3.8 kg/cm².G). In example 2 it is 54 kg/cm².G at the top.

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- (4) The maximum pressure expected under abnormal operating conditions should be considered. When the maximum pressure under short time or intermediate conditions exceeds the design pressure determined by methods (1) to (3), this maximum pressure should be specified together with the corresponding temperature in the specification. And it should be checked by an engineer of the mechanical design department. In this case, it is necessary to state clearly whether the condition is short time or intermediate.

It is recommended that a check list such as Table 3-1 be filled out with consideration to abnormal conditions. Then the controlling abnormal conditions should be noted in the specifications together with the design conditions.

3.1.2. Vacuum Design Pressure

As a rule, when a vacuum condition is likely to occur due to mal-operation during steam purge or emergency shutdown of reboilers, etc., the vessel should be designed to withstand full vacuum. If a vacuum design is an uneconomical solution, vacuum protection devices such as breather valves can be installed instead of employing a vacuum design. However, these devices should be properly designed and the following matters given full consideration.

Kind, location and response time of devices

Kind, flow rate of inert gas, if used

Confirmation that these devices will function properly even under abnormal conditions.

Some companies allow credit for use of operating procedures in lieu of vacuum design (or operating procedures with a half-vacuum design) for steam-out/ steam purge. If this provision is given in the client standards, it is acceptable (with approval by the Samsung project engineering manager).

3.1.3. Heat Exchanger Overpressure Protection

Design pressure of heat exchanger is generally selected to provide a margin between design and operating pressure in accordance with SECL design practice. However, the design pressure frequently raised above these margins to provide overpressure protection for equipment failures and/or mal-operation to an exchange. Typical causes of high pressure in an exchanger are :

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- Blocked In : Thermal expansion of cold side fluid
- Blocked In : Vaporization of cold side fluid
- Blocked outlet : Hot side or cold side
- Internal Tube Failure : Low pressure (LP) side

Design options providing overpressure protection for exchanger are :

- Install a Pressure-Safety Valve to limit over-pressure
- Raise the design pressure to eliminate or mitigate one or more over-pressure cases. For example, design the exchanger for pump shut-in pressure to eliminate a blocked outlet case, or design the LP side for ten-thirteenths (10/13) of the design pressure of the HP side to mitigate the tube failure case.

Change the design to eliminate one or more causes of over-pressure.

For Example, lock open or car seal open (CSO) a block valve to eliminate a thermal expansion case. The use of thermal relief valve to atmosphere should be avoided to prevent release of toxic or hydrocarbon material to the atmosphere. The water side of the exchanger should still be designed as per 10/13 rule to contain the effects of tube failure, when appropriate (below). In some cases; e.g., (toxic materials such as HF), the design pressure of low pressure side (water) may set an equal to the design pressure of the high pressure process side.

The choice between raising design pressure vs. installing a pressure safety valve is based on technical and economic conditions.

3.2. Special Cases

3.2.1. Vessels and Other Equipment Located on Pump Discharge Side

When vessels and other equipment located on the discharge side of pumps are not protected by safety /relief valves, the design pressure under normal operation shall be as determined by (1) or (2) below, whichever is greater.

$$(1) \text{ Design pressure} = 1.2(*) \times \Delta P + H_t + P_0 \text{ (kg/cm}^2\text{.G)}$$

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- ΔP Differential head of pump under normal operation (kg/cm²)
- H_t : Head between tangential line of a suction vessel and center of pump (kg/cm²)
- P_0 : Normal operating pressure at tangential line of a suction vessel with the highest liquid level. (kg/cm².G)
This involves the case where the pump is operated for long periods with the valve on the discharge line almost shut and the suction vessel under normal operation.

(2) Design pressure = $\Delta P + H_t + P_d$ (kg/cm².G)

- ΔP : Differential head of pump under normal operation (kg/cm²)
- H_t : Head between tangential line of a suction vessel and center of pump (kg/cm²)
- P_d : Maximum pressure at tangential line of a suction vessel with the highest liquid level. (kg/Cm².G)
This involves the case where the pump is operated for long periods with the pressure of the suction vessel near the design pressure.
If the maximum pressure cannot be determined, the maximum pressure is assumed to equal 1.1. x normal operating pressure when the normal operating pressure of the suction vessel is less than 18 kg/cm².G, or to equal the design pressure when the normal operating pressure of the suction vessel is larger than 18 kg/cm².G

(3) Short time condition $1.2(*) \times \Delta P + H_t + P_d$

- ΔP : Differential head of pump under normal operation (kg/cm²)
- H_t : Head between tangential line of a suction vessel and center of pump (kg/cm²)
- P_d : Design pressure at tangential line of a suction vessel (kg/cm².G)

This involves the case where the pump is operated for a short time with the discharge valve almost shut, and with the pressure of the suction vessel near design pressure.

(*) The 1.2 factor used in (1) and (3) above represents an estimate of the rise to shutoff pressure using Motor. The actual pump shutoff differential pressure should be used in place of the factor "1.2 * ΔP " when the actual pump curve is available.

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To be conservative in equipment design, some engineering companies and clients prefer to specify the design pressure based on (3), the short term condition. Others may use this condition for design based on an engineering judgment of the likelihood that the pump will be operating blocked in simultaneously with the suction vessel operating at its design pressure/relief device set pressure.

The estimated pump shut-off pressure obtained using above procedure is a conservative approach. Equipment need not be designed for pump shut-off – the use of a relief valve at a lower pressure or rearrangement of equipment location are other potential design options. The use of a relief valve is frequently not selected as an option when it results in a large liquid relief.

3.2.2. Towers, Vessels and Other Equipment Located around Compressor

- (1) The design pressure of the vessels located on the discharge side of centrifugal compressors is defined as the highest pressure which can exist in the compressor under the most severe operating conditions. It will be the maximum suction pressure to be encountered, plus the maximum differential pressure that the compressor is able to develop in the system when operating under the severest combination of conditions. Consideration should be given to variation in molecular weight, suction pressure and temperature variation to determine the design pressure. In most cases, it is advantageous to limit the design pressure to a lower pressure by a safety/relief valve (Ref. API 617-1.5.1).

The safety/relief valve set pressure should be high enough to avoid discharging during normal operation, but low enough to take advantage of possible material savings in the equipment.

- (2) A safety/relief valve must be used on the discharge of each stage of a reciprocating compressor to avoid possible damage to the machine from excessive pressures and/or to the driver because of overloading.

3.2.3. Reactor Circuit Recycle Compressor Settle-out Pressure

API STD 521, Annex B suggest setting the reactor system design pressure, as a minimum, equal to 105% of the pressure the system equalizes to when the compressor stops (i.e. the “settle-out pressure”).

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Settle-out pressure can be calculated based on the adequate information on the reactor circuit piping and volume.

3.2.4. Refrigerant Compressor Systems

To avoid relieving refrigerant while a refrigerant system is shut down and sitting idle, the minimum design pressure for the refrigeration system equipment should be at least the vapor pressure of the refrigerant at maximum ambient temperature plus 10%.

3.3. Design Pressure for Piping

As a rule, the design conditions for piping shall be determined in the same way as for towers, vessels and other equipment.

The design pressure for piping shall be no less than the pressure existing under the severest condition of coincident internal or external pressure and temperature. Variations in temperature and/or pressure from normal operating conditions, are characteristic of certain services. If the duration of these variations is greater than permitted by (1) and (2) below, as in cyclic operations, the severest combination of pressure and temperature shall be regarded as normal operation. If these variations are infrequent and of short duration, however, the pressure-temperature rating or the allowable stresses of the piping components may be exceeded as indicated in (1) and (2) below.

(Application of pressures exceeding the pressure-temperature rating of valves may under certain conditions cause a loss of seat tightness or difficulty in operation. It is the owner's responsibility to ensure that the operating conditions of a control valve do not exceed its design limits.)

- (1) In the case of a short time condition (as defined in Section 2, above), it is permissible to exceed the pressure rating or the allowable stress at the temperature existing under the increased operating condition by up to 33 percent.
- (2) In the case of an intermediate time condition (as defined in Section 2, above), it is permissible to exceed the pressure rating or the allowable stress at the temperature existing under the increased operating condition by up to 20 percent.

Some materials must not be allowed to exceed the pressure-temperature rating. Refer to ANSI B 31.3 302.2.4.

When the design condition is described on a line index, indication should be given as to whether it is determined by the short time condition, intermediate

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time condition, or long time condition.

For power piping (for power plant and industrial facilities), the design conditions shall be determined in the manner described in ANSI B 31.1.

3.4. Special Considerations

3.4.1. Water Hammering

When a fluid is flowing in a pipe line, rapid opening and shutting of a valve or sudden tripping of a pump causes transient fluctuations of pressure because the fluid velocity changes suddenly. Such variation of pressure resulting from changes in the fluid velocity is called Hammering.

In these cases, surge calculations shall be made, and adequate controls and protective equipment should be provided so that the pressure rise due to hammering does not exceed the design pressure by more than 10% at any point in the piping system and equipment.

There are several methods used to decrease the effect of hammering. These include the connection of a surge relief valve upstream of the block valve, or the installation of a control system which detects the closing of the block valve and stops the pump automatically.

For particulars, refer to the manual which outlines the principle of hammering, estimation of maximum hammering pressure and countermeasures against hammering.

(1) Example

Pipeline from LNG pump discharge to shut-off valve located upstream of receiving tank.

i. Case 1

Shut-off pressure of pump: 9.0 (kg/cm².G)

Maximum pressure due to hammering: 9.5 (kg/cm².G)

$$9.0 \times 1.1 > 9.5$$

Hence, design pressure is 9.0 (kg/cm².G)

ii. Case 2

Shut-off pressure of pump: 9.0 (kg/cm².G)

Maximum pressure due to hammering: 13.0 (kg/cm².G)

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$$9.0 \times 1.1 < 13.0$$

In this case, if no protection is provided to decrease the effect of hammering, the design pressure shall be 12.0 kg/Cm².G [\(13.0/1.1\)](#). Depending upon the results of the cost study, protection is provided or the design pressure is increased.

3.4.2. [Safety/Relief Valve Tolerance and Blowdown](#)

[There are potential issues with relief valve design when specifying the design pressures with a less than ten percent margin from maximum operating pressure.](#)

[First](#), it is necessary to consider the tolerance of a safety/relief valve when deciding the design pressure of a vessel. Safety/relief valves shall have a set-pressure tolerance of plus or minus 2 psi for pressures up to and including 70 psi, and of plus or minus 3 percent for pressure exceeding 70 psi. It should be confirmed whether the vendor can meet the above requirement or not.

[The second issue concerns relief valve blowdown. Blowdown is the difference between the set pressure and the closing pressure of a pressure relief valve \(expressed as a percentage of the set pressure\). Relief valve blowdown is now typically 7% or greater, as compared to a typical 4% years ago.](#)

When the set pressure of a safety/relief valve is considered to be normal pressure x 1.05 (Design Pressure), it is conceivable that the safety/relief valve will operate frequently [and have difficulty reseating](#).

Further, it is difficult to make a safety/relief valve which does not leak under any circumstances below a set pressure. Generally, therefore, the leakage of a safety/relief valve is tested at the set pressure and used at about 90 percent of its set pressure.

[For all these reasons, it is becoming increasingly common to limit maximum operating pressure to 90% of set pressure. Accordingly, the design pressure of a high pressure vessel must be determined with care when using a margin between maximum operating and set pressure below 10%.](#)

3.4.3. Tolerance of Controller

The tolerance of the control system must be taken into consideration when determining the design pressure of a vessel operated at high pressure (normal operating pressure is 80 kg/cm² and over) and protected by a safety/relief valve.

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The tolerance of a pressure control system is generally within 1%. In such a case there is no problem with the safety/relief valve. However, when the tolerance greatly exceeds 1%, it is conceivable that the safety/relief valve will function frequently. In this case, therefore, the design pressure must be made larger or the tolerance of the safety/relief valve decreased.

3.4.4. Tolerance of Pump Performance Curve

As mentioned above, design work is initiated on the basis of an assumed pump shutoff head. When the actual value from the pump curve is known, the assumed pump shutoff head is corrected and the design pressure of the equipment is checked.

However, there is an additional issue in the tolerances of pump performance characteristics. From experience, the tolerances given below are acceptable to the design, and are not taken into consideration for shut-off head of a pump.

Pumps, when operated at rated speed and rated capacity, shall be within the following tolerances of the guaranteed characteristics or the test equivalent (on both regular and suppression tests)

Condition	<u>Rated Point (%)</u>	Shut-off (%)
Rated differential head <u>0 to 75 m(0 to 250 ft)</u>	<u>-3</u> <u>+3</u>	+10 -10*
<u>> 75 to 300m</u> <u>(>250 to 1000 ft)</u>	<u>-3</u> <u>+3</u>	+8 -8
<u>>300m (over 1000ft)</u>	<u>-3</u> <u>+3</u>	+5 -5
NPSH Req.	+0	

*If a rising head flow curve is specified, the negative tolerance specified here shall be allowed only if the test curve still shows a rising characteristics.

3.4.5. Rupture Disks

Rupture disks have a manufacturing range, or tolerance. A typical

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value is +5%/-5%, though it varies depending upon the type of disk. As ASME code does not allow the stamped burst pressure to exceed the protected vessel's MAWP, the entire range must be below the vessel MAWP/design pressure.

For instance, for a vessel with a 10 kg/cm²G design pressure, where the manufacturing range or tolerance is 5%, the specified burst pressure should be 9.52 kg/cm²G. The range for the burst pressure is then 9 to 10 kg/cm²G (which is 9.52 kg/cm²G +/-5%)

It is suggested that a rupture disk vendor should be contacted for appropriate information prior to preparing the process specifications for a rupture disk.

This burst pressure tolerance must be taken into account when setting design pressure of equipment protected by a rupture disk.

4. DESIGN TEMPERATURE

Please note that the design temperature is always used in design with a coincident design pressure.

4.1. General

The design temperature for towers, vessels and other equipment shall be determined in the following manner.

- (1) Design temperature is determined based on the maximum normal operating temperature and the addition of a design margin (given below). If temperature fluctuation is expected during normal operation, the maximum value of the fluctuating temperature must be considered. If the design temperatures at the bottom of a pressure vessel is significantly different from that at the top, both temperatures should be specified.
- (2) The design temperature shall be calculated as follows:
Design temperature: Maximum Normal operating temperature + 28°C
(In this case, the calculated temperature shall be rounded to the nearest 5°C in general).

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- (3) The 120 °C (250°F) minimum design temperature was selected because it would not be exceed during a steam out operation. If the 120 °C minimum results in a flange rating increase, then a lower design temperature may be considered if the other design guidelines will be met.
- (4) When caustic is present, limit design temperature to 65 °C to avoid caustic embrittlement of carbon steel vessels.
- (5) A minimum design metal temperature is also specified. This is the lower of the minimum operating temperature less 5°C, the minimum ambient temperature, or the lowest temperature caused by depressuring. Though the design temperature is to be determined based on the actual steel temperature, for convenience, the temperature of the fluid contained within the vessel is considered as a design basis. In special situations, such as depressuring, calculations can be made to determine actual metal temperatures, instead of fluid temperature, to reduce costs.
- (6) For a single component such as propane, saturated steam, dowtherm, certain kinds of cooling medium, etc., of which pressure and temperature relationships are known, the design temperature shall be determined by the design pressure.
- (7) With the exception of fire, temperatures under abnormal/upset conditions need to be considered. Where the cost is minimal, the design temperature should be raised to include the upset scenarios. Where the expected maximum temperature under the upset conditions considerably exceeds the design temperature determined according to (1) and (2) above, causing significant cost increases, these temperatures should be indicated on the Specification and shall be checked by the Mechanical Department. In this case, classification under short time or intermediate condition shall be definitely indicated.

4.2. Steam Out Design Temperature

It's recommend that a minimum design temperature of 120 °C to accommodate the steam out temperature. If caustic is present in the vessel, limit design temperature to the use of nickel alloy metallurgy. Stress relieving may also be required. Use the following guidelines for vessels containing caustic:

- Do not steam out the equipment, but use a water wash and/or nitrogen to hydrocarbon free equipment.
- For Caustic strengths of 15wt% or less, specify carbon steel metallurgy, set the design pressure as 65 °C and do not specify PWHT.

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- For Caustic strengths of 15-30wt% , specify carbon steel metallurgy. A design temperature of 95 °C requires PWHT.
- For Caustic strengths of 30-50wt% , specify carbon steel. A design temperature of 65 °C requires PWHT.

4.3. Failure or By-passing of Upstream Heat Exchangers

Consider the failure of upstream heat exchangers and coolers or open exchanger by-passes when determining the design temperature of equipment.

The following are examples of how this should be applied:

- On loss of feed to feed-bottoms exchanger the bottoms flow will continue until the bottoms level goes low. Downstream equipment should be designed for the normal bottoms temperature to account for the loss of heat exchange.
- When there are several heat exchangers in an exchange train (such as in a reactor effluent circuit) it is necessary to consider the effect of full bypass of each exchanger individually on all of the downstream equipment, not just the immediate downstream equipment. Unless there is a specific operational requirement, assume only one exchanger is by-passed at a time.
- For a typical air-cooled exchanger the power failure duty is assumed to be 20% of the normal duty. If an air-cooled exchanger is provided with a chimney up to 50% of the normal duty can be assumed. However, if louvers are specified for the air-cooled exchanger, then no credit can be taken.
- Assume zero cooling duty for the loss of cooling water (or process cooling media) to a cooler (or process exchanger) upstream of other process equipment. Review the impact on piping.

The following are examples of how this should be applied:

The design temperature based upon failure or bypassing of upstream heat exchangers, should, in general, be set equal to the temperature resulting from a failure or exchanger bypass. Some engineering judgment should be applied; however, in general design temperature for these situations is not based upon SECL normal practice of maximum operating plus 28°C.

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4.4. Special Consideration

- (1) Some vessels and exchangers which have alternate operations such as regeneration may see significantly different operating conditions such that it is not apparent which set of operating conditions should be used to determine design conditions. In this situation determine both sets of design conditions and list multiple design conditions under "Notes" for example
 - Normal Design Conditions : 45 barg @ 205 °C
 - Regeneration Design Conditions : 10 barg @ 350 °C
- (2) The relieving temperature shown may sometimes be higher than the vessel design temperature. Short-term temperature excursion occurring under relieving cases can be tolerated and need not, in general, impact the design temperature of the Pressure Safety Valve, or of process equipment downstream of the Pressure Safety Valve location. If the relieving temperature is above 343 °C, consult with a vessel Mechanical Design Specialist for specific guidance.

5. DESIGN CONDITIONS OF OTHER COMPANIES

Each major client and contractor has his own philosophy for determination of design conditions. Table 5-1 shows such information for reference. For any particular project, client specifications for design pressure and temperature must be reviewed. The more conservative of client specifications and those given in this Basic Design Manual should be applied.

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6. TABLES AND FIGURES

Table 3-1 Check List for Design Condition

Operation Time	Long Time Conditions								Short (S) or Intermediate (I) Time Conditions							
Operation Mode	Normal Operation		Design		Pump S/O		Steam Purge		Regeneration		Pump S/O		Decoking(I)		Depressuring(S)	
Conditions	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Item Name	kg/cm ² G	°C	kg/cm ² G	°C	kg/cm ² G	°C	kg/cm ² G	°C	kg/cm ² G	°C	kg/cm ² G	°C	kg/cm ² G	°C	kg/cm ² G	°C

Table 5-1. Design Conditions of other Companies

	E	C	M	S
DESIGN TEMPERATURE	Op. temp. < 60 °F : Min. temp. including Abnormal Condition Op. temp. 60 to 650 °F : Op. temp. + 50 °F Op. temp. >650 °F - : Only the case of temp. fluctuation, for flexibility of operation op.	Apply ASME Section VIII. Div. 1 UG 20, 21 The min. temp. shall be the min. temp. of the contents either during nor. operation, shut-down, start-up or unit up set or, for uninsulated equipment, the minimum ambient temperature plus 18 °F, whichever is the greater.	The design metal temp. of vessels shall not be less than the max. operating temp. of the fluid in the vessel, with the following exceptions : for internal insulated vessels, calculated value using ambient temp. The shell shall also be designed so that the operating stress doesn't exceed the stress-to rupture in 100 hrs at the fluid temp. vessels in service below 70 °F shall be designed for a temp. equal to the min. operating temp.	Upper Des. temp.: Max. work temp. +10°C For, crude atm. column or vacuum distillation equipment, 343°C or above mentioned whichever greater. Lower Des. temp.: Min. work temp.
DESIGN PRESSURE	Which ever is greater Op. press. x 1.1 or Op. press. + 25 psi As for pump discharge vessel whichever is greater, : Nor. Suct. press. + 1.2 x pump head or max. suct. press. + pump head	o Vessel 1) Op. press. Nor* ____ °F ____psig *top of vessel Max. ____ °F ____psig 2) Regene. press. ____ °F ____psig 3) Margin press 10% or 25 psi ____psi 4) Op. hydrostatic head ____+t x 0.433 x ____ S.G. ____psi 5) Press. drop Through vessel ____psi 6) Design press.=K 50 psig = 1) + 3) + 4) + 5) 7) Safety valve set press. = 1) + 3) or = 50 psig - 4) - 5)v	Max. work press. - 500 psig : 1.1 x Max. work press. or max. work press. +5 psi whichever greater max work press 500 psig : shall be specified or approved by vessels operating under vacuum shall be designed for 15 psi external pressure	Max. op. press. < 17 barg : max. op. press. +1.7 Max. op. press. 17-40 barg : 1.1 x max. op. press. Max. op. press. 40-80 barg max. op. press. +4.0 : max. op. press. > 80 barg : 1.05 x max. op. press. for sub-atm. press. vessel, Des. press. = 0 bar A. If sub-atm. press. is determined by the vapor pressure of the vessel content, 1.1 x (1.0 bar-abs. vap. press)

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Table 5-1. Design Condition by Other Companies (concluded)

	E	C	M	S
NOTE	- o Crude atm. & vacuum tower Des. temp. = Op. flash zone temp. +50°F - o Des. temp. of vessel injected superheated vapor is determined from temp. of liq. In vessel - o Short time or Intermediate time condition should be considered. - o Consider internal insulation leakage	- o Vessel located at pump discharge line Des, press = $P + F1 + F2 + pH + Ps$ P: Design head of pump pH: Max. normal liquid level at pump suction Ps: Suction vessel op. press. F1: 1.2 for single-stage-pump 1.3 for multi-stage-pump F2: Factor for turbine governor variation - o Max. oper. press. The highest press. encountered during nor. op., start up or shut down op. - o Consideration shall also be given to the max. external press. which may be imposed under start-up, shutdown or maintenance conditions and vessel shall be designed accordingly.	o Short time condition Metal thickness shall be designed for short time upset conditions, start up and shut-down. only one upset condition shall be considered at a time, and wind or earthquake loading shall not be included. The required metal thickness shall be determined by using an allowable stress of 1.3 times the code stress.	Design conditions shall be related to properly conducted start-up operation, including where appropriate, catalyst regeneration cycles, etc. and shutdown operation. Where the occurrence of severer conditions is predicted under the effect of abnormal circumstances, their effects shall be evaluated. For the purpose of such evaluation the nominal design stress may be increased by 20% and rupture and creep properties may be related to a life of 1,000 hrs.

7. REVISION HISTORY

REV NO.	DATE	SCOPE	DESCRIPTION
0	1998.4.17	All Pages	-Team: Process Engineering -Prepared by: H.N.Oh, Y.S.Kim -Checked by: B.I.Lee, S.B.Cho, J.C.Noh -Approved by: S.K.Oh
1	2010.11.25		Document number change due to new numbering system -Team: Process Engineering -Prepared by: C.H.Yun -Checked by: J.H.Park -Approved by: Y.Y.Koo
2	2013.08.28		Design Criteria is changed as per latest practice -Team: Process Engineering -Prepared by: I.Hwang -Checked by: P.M.Hur, M.H. Oh -Approved by: S.B.Lee