

REFRIGERATED STORAGE TANKS**JGS 210-120-1-63E**

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1. SCOPE

- (1) This standard practice shall be applied to the basic design of a refrigerated storage tank which stores liquefied gas products.
- (2) This practice provides the guidelines for the preparation of the process requirements to tank vendor.
- (3) Codes and Regulations defined in BEDD shall take precedence over any other documents.
Conflicting items, if any, shall be resolved in advance.
- (4) Requirements given in the Project Specifications take precedence over the guidelines given in this standard practice.

2. WORK PROCEDURE

2.1 Input to the Design

2.1.1 Basic Design Conditions

- (1) The following data should be specified in the basic design basis.

- Type of Storage Tank
- Capacity of Storage Tank
- Main Dimensions
- Design and Operating Conditions for Pressure and Temperature
- Boil-off Rate (BOR) due to Natural Heat Leak

If any of the foregoing items are not available, study and clarification activities must be carried out in accordance with APPENDIX-2, 3, 4 and 5 prior to start of the basic design.

- (2) The process conditions should be obtained from the following engineering documents.

- Process Flow Diagram (PFD)
- Basic Engineering Design Data (BEDD)
- Plot Plan
- Preliminary Piping and Instrument Diagram (P&ID)

Maximum rate of barometric and ambient temperature change shall be clarified.

- (3) All operation cases must be identified with needed clarifications and taken into consideration in the basic design.
- (4) The battery limit between tank vendor and JGC, or vendor's scope of supply for piping, instrument and accessories must be clarified in advance.

2.1.2 Input Data

A summary of input data is as follows.

- (1) Design basis as shown in section 2.1.1
- (2) Following service conditions of inlet/outlet product streams
 - Composition Usually 3 cases [standard, rich (in heavier components), and lean (in heavier components) cases]
 - Flow rate
 - Temperature
 - Pressure

2.2 Output Data

The deliverable products of the basic design shall include the following.

- (1) Summary of Design conditions
- (2) Design conditions for tank accessories
- (3) List of nozzles with process conditions
- (4) Developed P&I Diagram around storage tank

This information shall be reported to the relevant discipline for mechanical design and included into the specification for the refrigerated storage tank (Refer to APPENDIX-1).

In addition, review of the vendor's documents shall be included in the basic design activities.

2.3 Work Steps

The basic design of refrigerated storage tank should be carried out in accordance with the following steps.

- (1) Establish the design basis
- (2) Establish the scope of work between vendor and JGC.
- (3) Calculation of BOG rate
- (4) Preparation of basic design information to be included in technical specification
- (5) Preparation of nozzle list
- (6) Planning and/or development of monitoring and safeguarding system
- (7) Development of P&I Diagram around the tank to incorporate the basic design
- (8) Review of vendor's documents and follow-up/incorporate them into the engineering documents

2.4 Computer Programs

The computer program #BOG shall be used.

3. DESIGN

3.1 Calculation of BOG Rate

Since BOR (boil-off rate) in the design basis is only due to natural heat leak into tank, the following operating conditions shall be studied and design flow rate of BOG stream shall be established. The purpose of this calculation is to provide the BOG stream conditions around tank.

All operating modes including upset cases shall be considered in the calculation, and the design of BOG outlet stream shall be based on the severest case.

The following steps are for calculating the BOG rate generated in the tank (Details are shown on Technical Report [1]).

- (1) BOG due to individual cause
 - BOG rate being equivalent to Tank BOR

$$W_1 = \frac{B \cdot V_t \cdot S_\ell}{(100 \cdot 24)}$$

- Feed liquid flashing

$$W_2 = \frac{W_f \frac{dH}{dP} (P_f - P_t) + Q_\ell(f) + Q_p(f) + Q_h(f)}{L_{am}}$$

Flash calculation using process simulator may be used in the following product rundown case.

$$\boxed{\text{upstream temperature in the product stream}} - \boxed{\text{storage temperature}} > \boxed{5^\circ\text{C}}$$

Where dH/dP is the rate of change in saturated liquid enthalpy (kcal/kg) with every increase in saturated liquid pressure (mmH₂O).

$Q_\ell(f)$, $Q_p(f)$, and $Q_h(f)$ should be calculated by the formulas in (2), and "f" means the circulation stream.

- Vapor displacement

$$W_3 = (W_f - W_2 - W_o) \frac{S_v}{S_\ell}$$

- External circulation with pump work

$$W_4 = \frac{Q_p(c) + Q_\ell(c)}{L_{am}}$$

$Q_{\ell}(c)$ and $Q_p(c)$ can be calculated by the formulas in (2), and "c" means the feed stream.

- Barometric change

$$W_5 = C \cdot A \cdot (P_s - P_t - D_{pb})^{4/3} - W_1$$

$$P_s = P_t + \left(\frac{W_1}{C \cdot A} \right)^{0.75}$$

(2) Heat Leak

- Natural Heat Leak through Piping

$$Q_{\ell} = \frac{2\pi k(T_s - T_f)L_p}{\ell_n \left[\frac{D_o + 2 \cdot I_t}{D_o} \right]}$$

- Pump Work

$$Q_p = 860 \cdot P_w$$

- Potential Energy

$$Q_h = \frac{D_H \cdot W}{428}$$

(3) Total BOG rate

$$W_t = W_1 + W_2 + W_3 + W_4 + W_5$$

3.2 Pumping System (Refer to APPENDIX-7)

(1) In the case where the shipping pumps are installed above grade at the outside of storage tank, the pumping system shall be excluded from tank vendor's scope and only information on the suction nozzle shall be provided to tank vendor.

(2) For column mounted submerged pumps installed in the tank, the following work steps are required through the basic design activities.

- Submit pump data sheet in accordance with hydraulic calculation.
- Transfer the information provided by pump vendor to tank vendor. This information includes the details of pump itself, foot valve and discharged column size and minimum flow requirement.
- Finalization of the tank specification incorporating all above information.

Pumping system should preferably be included in the tank vendor's scope to minimize JGC's coordination work.

3.3 Tank Accessories

The refrigerated tank should be equipped with the following accessories, and the breakdown on the scope of design engineering is summarized as follows.

Table-1 Breakdown on design engineering for tank accessories

Item	Process Operating Conditions		Design	
	JGC	Vendor	JGC	Vendor
Feed spray ring	O		O*2	O
Spray ring for cool-down		O		O
Jet mixing nozzle	O	O *1		O
Pressure relief valve		O		O
Vacuum relief valve		O		O
Internal shut-off valve	O			O
Local instrument				
Liquid level	O			O
Pressure	O			O
Temperature	O			O

Remarks :

- (1) *1 Vendor to verify mixing time.
- (2) *2 JGC to prepare the skeleton of spray ring and its arrangement of holes or nozzles. Vendor to finalize. (Estimation method is shown on Technical Report [2])
- (3) All design documents shall be reviewed by JGC.

Special accessories to mix the liquid space in the tank should be provided for LNG/LPG. The purpose of this provision is to prevent rollover. In principle, LNG storage tank shall be equipped with these mixing devices as a standardized system (Refer to APPENDIX-6). According to past experiences of LPG storage, these devices have not been provided, unless such requirements is stated in tender specification.

3.4 Nozzle List

The nozzle list, which indicates the size, piping class and location, should be shown in the specification. The nozzle size shall be corresponded with relevant piping size based on the hydraulic calculation results. Usually the scope of supply on piping is at tank nozzle. However, if some piping portion is included in tank vendor's scope, all related information on piping specification shall also be prepared to vendor.

In principle, service conditions and size should be specified by JGC. However the following nozzles shall be verified and finalized by Tank Vendor.

- Cool-down nozzle
- Vent and drain
- Nozzles for pressure and vacuum relief
- Nozzles for Instrument service
- Nozzles for Nitrogen service

3.5 Requirement for Monitoring system

Planning and development on tank monitoring system shall be carried out based on the following requirements. Although the design of control system is out of tank vendor's scope, all local instruments supplied by the vendor shall meet these requirements.

3.5.1 Liquid Level

- (1) The refrigerated tank shall be equipped with two independent liquid level gauging devices.
- (2) The refrigerated tank shall be provided with high and low alarms.

3.5.2 Pressure

- (1) The refrigerated tank shall be provided with a pressure gauging device at a point above maximum liquid level.
- (2) High and low alarms shall be provided, where the normal operating range should be defined as a range between high and low alarm points.

3.5.3 Temperature

- (1) Temperature indicators shall be provided to monitor the temperatures in both vapor and liquid phase.
- (2) Skin temperature indicators shall be separately provided at the points on bottom plate and side wall for controlling cooling down operation. Number of indicators and locations should be determined by vendor.
- (3) Special monitoring device to indicate the distribution of the temperature in liquid phase should be provided for LNG/LPG. The purpose of this provision is to detect the stratification of liquid phase for rollover prevention.

In principle, LNG storage tank shall be equipped with this monitoring device as a standardized system.

According to past experiences of LPG storage, this monitoring need not be provided unless a requirement is stated in tender specification.

3.6 Requirement for Safeguarding System

Planning and development on tank safeguarding system shall be carried out based on the following requirements in the same manner as described in 3.6.

3.6.1 Liquid Overfilling and Pump Protection

- (1) The storage tank should be equipped with a high liquid level flow cut-off device.
- (2) The storage tank should be equipped a low liquid level pump trip system.
- (3) These devices should be independent from the level monitoring system.
- (4) The guideline for the alarm/trip set points on liquid level is shown in Appendix- 8.

3.6.2 Over-pressure and Vacuum Protection

- (1) During normal operation, pressure in the tank shall be controlled at a certain set point or within the operating range by means of BOG treatment unit.
- (2) Primary pressure relief system
Relief system to flare using pressure control valve should be provided to release BOG against operational disturbances such as a trip of BOG handling facilities. This relief system is out of tank vendor's scope, however, BOG outlet nozzle size shall meet the maximum relief capacity requirement.
- (3) Pressure relief valves
Pressure relief valves shall be provided based on the maximum relief load.
Vapor released may safely be disposed to atmosphere on condition that primary relief to flare is provided. Relief to atmosphere shall be considered as a final protection device. In addition, associated problems such as vapor dispersion, ignition source and so on should be evaluated.
Since the load calculation sheet and data sheet for safety relief valves shall be prepared and issued by vendor, all design basis and stream conditions shall be informed to vendor in the specification.
- (4) Primary vacuum protection
Since activating vacuum relief valve which results in introducing air into the tank shall be avoided as much as possible, either device (a) or (b) must at least be provided against operational disturbance due to pressure decreasing.
 - (a) Gas injection system from outside
Fuel gas or nitrogen should be injected into the tank at a certain set point through the pressure control valve.
 - (b) Low pressure trip system on BOG treatment unit and ship loading pump.
- (5) Vacuum relief valve
Vacuum relief valves which should allow air into the vapor space shall be equipped as a final protection device.
In the case of suspended deck type, air should be injected into the space between outer tank roof and suspended roof.