

WINTERIZATION AND CONDENSATE RECOVERY SYSTEM

JGS 210-120-1-62E

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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 Required Data for Design	3
2.2 Product of Basic Design	4
2.3 Work Steps	4
2.4 Computer Programs	4
3. SELECTION PROCEDURE	4
4. WINTERIZATION	5
4.1 Plant Requiring Winterization	5
4.2 Winterization of Process Piping	5
4.2.1 Basic Principle	5
4.2.2 Liquid Lines	5
4.2.3 Vapor Lines Saturated with Steam	6
4.2.4 Vapor Lines with Higher Dew Point Fluid	7
4.3 Winterization of Utility Piping	7
4.3.1 Water Piping	7
4.3.2 Air and Nitrogen Piping	7
4.3.3 Steam Piping	8
4.3.4 Steam Condensate Piping	8
4.3.5 Fuel System Piping	8
4.4 Winterization of Equipment	8
4.5 Operation Mode Change	9
4.6 Selection of Heat Tracing Method	9
5. DESIGN OF STEAM CONDENSATE RECOVERY SYSTEMS	9
5.1 Steam Condensate Recovery System	9
5.1.1 Condensate Flow Rate	9
5.1.2 Collection Header Sizing	10
5.1.3 Design of Steam Condensate Recovery System	10
5.2 Steam Trap	12
5.2.1 Selection of Steam Trap	12
5.2.2 Steam Consumption	13
6. RELATED DOCUMENTS	14
7. DEFINITIONS	14
8. ABBREVIATIONS	15
APPENDIX-1 TEMPERATURE CHANGE CALCULATION	17
A1.1 Theoretical Relationship	17
A1.1.1 Basic Equations	17
A1.1.2 Overall Heat Transfer Coefficient	18
A1.1.3 Examples	18
A1.2 Maximum Freeze-Free Length of Water Lines	28
A1.3 Temperature Rise with Steam Tracing	29
APPENDIX-2 WATER PIPING ARRANGEMENT	31

1. SCOPE

- (1) This standard practice provides the guidelines and minimum requirements for the basic design of winterization systems, to protect equipment and piping against solidifying or coagulation of contents, and associated steam supply and condensate recovery systems in refineries, petrochemical plants and similar plants.
- (2) Other heating systems using hot oil, hot water, etc. and electrical heating trace system are outside the scope of this standard practice. Winterization for fire fighting systems and systems provided in a building where temperature is maintained at 0°C or above are outside the scope of this standard practice.
- (3) Specific instructions given in the Project Specifications take precedence over the requirements given in this standard practice.

2. WORK PROCEDURE

2.1 Input to the Design

2.1.1 Process Conditions

The data to be used for the design of winterization and condensate recovery system, such as the flow rate, temperature, pressure and so on, should be clarified on the following points:

- (1) Source of the data

The design 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

The diagram illustrates a steam tracing system with the following components and flow paths:

- Steam Headers:**
 - Main steam header:** The primary source of steam, featuring a control valve.
 - Tracing steam header:** Branches off from the main steam header to supply the tracing system.
 - Tracing condensate header:** Collects condensate from the tracing lines and returns it to the main condensate system.
- Tracing Lines:**
 - Steam supply line:** Carries steam from the tracing steam header to the **Distribution Manifold (DM)**.
 - Condensate return line:** Returns condensate from the **Collecting Manifold (CM)** back to the tracing condensate header.
- Manifolds:**
 - Distribution Manifold (DM):** Distributes steam to multiple **Leads** (solid lines) and **Tails** (dashed lines).
 - Collecting Manifold (CM):** Collects condensate from the **Leads** and **Tails** and sends it to the condensate return line.
- Control and Monitoring:**
 - S/T (Sensors/Transmitters):** Multiple units are placed along the steam supply and condensate return lines to monitor temperature and pressure.
 - Valves:** Various control valves are located at manifold connections, header branches, and the final drain point.
- Flow Direction:** Indicated by arrows showing the path of steam from the main header through the tracing system and the return path for condensate.

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- (3) Operating data for process equipment
 - Steam condensate rate from process equipment
- (4) Construction data
 - Line class
 - Line size of fluid lines
 - Line length for winterization
 - Line length for steam recovery system
 - Insulation specification ; table of thickness and materials
- (5) Environmental data
 - Minimum ambient temperature
 - Wind velocity

2.2 Product of Basic Design

- (1) Requirement of winterization
- (2) Heat loss and flow rate of heating fluids
- (3) Line Size
 - Size of supply lines/headers and return lines/headers should be determined.
- (4) Pressure balance of the condensate recovery system
- (5) Equipment data sheet of the condensate recovery system
 - Data sheets of condensate flash drums, condensate recovery pumps, and instruments should be prepared.

2.3 Work Steps

The design of winterization and condensate system will be conducted according to the following work steps, as a guideline.

- (1) Prepare input data as listed in section 2.1.
- (2) Decide the holding temperature of process fluids as shown in section 4.1.
- (3) Calculate the heat loss and the flow rate of heating fluid using the computer programs as listed in section 2.4.
- (4) Summarize lines required for heat tracing and indicate these on the P&ID.
- (5) Summarize the flow rate of heating fluids.
- (6) Size lines/headers according to JGS 210-120-1-37E "Hydraulic Design" with the requirements for the condensate headers as described in section 4.3.
- (7) Estimate the flashed steam rates from the steam condensate and calculate pressure drop of the headers, and determine the pressure balance of the condensate recovery system.
- (8) Prepare the data sheet of equipment.

2.4 Computer Programs

Computer programs, details of which are described in relevant manuals, are available to assist the design of winterization and condensate recovery system work as follows :

Table-1 List of computer programs

System	Name	Liquid Vapor Two-Phase			Description
JAPETS	#STMTRACE	yes	yes	-	Calculation of heat tracing
	#PFLOW	yes	yes	yes	Friction loss calculation
	#FLOWMAP	-	-	yes	Flow pattern map drawing
BEST		yes	yes	yes	General purpose pressure balance calculation, working on PC

3. SELECTION PROCEDURE

Blank for future use.

4. WINTERIZATION

4.1 Plant Requiring Winterization

- (1) Winterization for process fluids shall be considered in all circumstances, appropriately for the fluids and local ambient conditions.
- (2) Winterization of water and steam condensate piping

Table-2 Classification of winterization

Lowest ambient temperature	Winterization
$\geq -5^{\circ}\text{C}$	Winterization is not required.
-5 to -10°C	Winterization of pockets or dead-legs in piping is required.
$\leq -10^{\circ}\text{C}$	Winterization is required.

4.2 Winterization of Process Piping

4.2.1 Basic Principle

- (1) Process piping where the pour point or solidifying point of the internal fluid is higher than the lowest ambient temperature shall be winterized. Unless otherwise specified, the fluid temperature shall be maintained above the solidifying point or at least 10°C above the pour point.
- (2) For liquid sulfur lines, steam jacket piping or electric heat tracing shall be applied to maintain the fluid temperature between 118 and 158°C .
For highly viscous fluids such as asphalt and bitumen, the fluid temperature shall be maintained, applying steam tracer piping or steam jacket piping, at the temperatures exceeding the pour point $+10^{\circ}\text{C}$ or temperatures giving a kinetic viscosity of 300 cst⁽¹⁾ or lower, whichever is higher.
- (3) Appropriate measures to prevent fluids from temperature drop are taken for piping in which fluids are always flowing (on-stream) while the plant is being operated. The necessity of winterization, therefore, should be studied for the case where the plant stops operating.
Tank yards have many items of piping, in which fluids are not always flowing (not on-stream). Care should be taken on this point.

4.2.2 Liquid Lines

The following requirements should be applied to the liquid lines containing a fluid which has a higher pour point or solidifying point than the lowest ambient temperature.

- (1) Lines always on-stream
 - (a) Bare pipe lines, in which the liquid is likely to coagulate within about 12 hours after the liquid stops flowing, should be hot insulated (Fig. A1-1 through A1-3).
 - (b) Hot-insulated lines, in which the liquid is likely to coagulate within about 12 hours after the liquid stops flowing, should be steam traced, even though the liquid operating temperature is high (Fig. A1-4).
- (2) Lines not always on-stream (liquid filled lines):
Every size of piping should be steam traced and hot insulated regardless of liquid temperatures.
The same criteria should also be applied to the following lines.
 - Bypass lines for startup and shutdown
 - Liquid blowdown lines
 - Slop oil lines
 - Standby lines in the area around pump
 - Lines to remove small amount of water
 - Instruments (LG, PG, and lead piping of PT, etc.)
 - Liquid relief valves and their inlet/outlet lines
 - Control valve bypass lines
 - Chemical injection lines

¹ : Allowable maximum viscosity during the use of centrifugal pumps

- Makeup water lines
- Sampling lines

Vents and drains provided for the line should, in principle, be hot insulated; the requirement of steam tracing should be according to the line conditions.

(3) Lines not always on-stream (usually empty)

Such lines should be sloped so as not to form pockets and should also be provided with steam purge connections to completely empty the inside; otherwise they should be only hot insulated.

(4) Other requirements

- (a) Lines, in which highly viscous fluids such as heavy fuel oil flow, should be steam traced.
- (b) Caustic solution and amine solution lines should be steam traced when the freezing point of the solution is higher than the lowest ambient temperature.

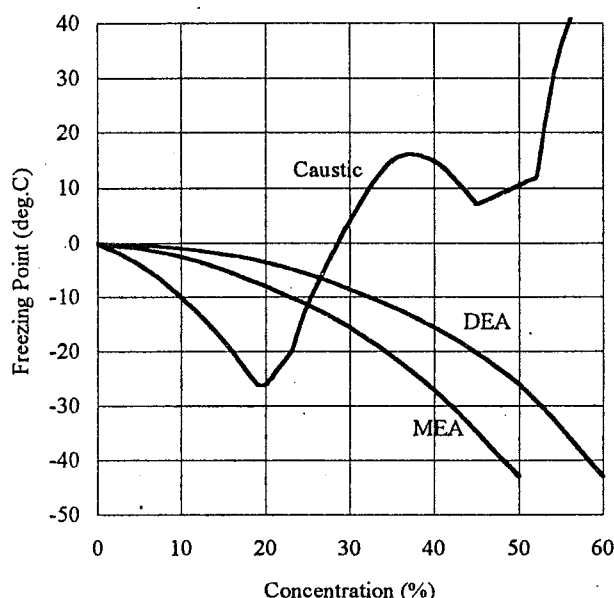


Fig. 4.2.2 Freezing point of caustic and amine solution

- (c) Steam tracing of caustic and amine solution lines should be provided with insulating spacers to prevent alkali embrittlement.

4.2.3 Vapor Lines Saturated with Steam

(1) Lines always on-stream

- (a) The upstream side of the lines of orifice plates or control valves, in which steam could possibly condense, should be hot insulated.

The amount of condensate generated from the gas line has to be calculated by estimating the temperature drop and consequent partial pressure decrease of steam (Fig. A1-5 through A1-8).

- (b) Lines, in which freezing of condensed water is likely to cause trouble with continuous operation, should be steam traced.

- (c) Lines are properly sloped so as not to accumulate condensate.

- (d) Lines in which ice or hydrate can be possibly formed on depressuring should be steam traced.

(2) Lines not always on-stream

Piping should preferably be free draining. The following items should be steam traced.

- Instruments (such as LG, LT, PG, and lead pipes of PT)
- Bypass lines for control valves
- Inlet line of relief valve. In some cases, lines should only be hot insulated depending on pipe size and length, considering heat loss.

4.2.4 Vapor Lines with Higher Dew Point Fluid

The following requirements should be applied to the vapor lines containing fluid which has a dew point higher than the lowest ambient temperature.

(1) Lines always on-stream

- (a) The upstream side of the lines of orifice plates or control valves, in which vapor could possibly condense, should be hot insulated.
- (b) Lines, in which condensate is likely to solidify or is corrosive, should be steam traced.
- (c) Lines, in which condensate is likely to freeze or coagulate due to depressurization during shutdown operation, should be steam traced.
- (d) Piping should preferably be free draining.
- (e) Pockets where condensate accumulates, which may have adverse effects on the indications of instruments (such as PG, and lead pipes of PT), should be steam traced.
- (f) Lines, which are likely to have adverse affects on continuous operation due to the condensing of the fluid, should be hot insulated.

(2) Lines not always on-stream

Requirements of 4.2.3 (2) shall be applied.

4.3 Winterization of Utility Piping

4.3.1 Water Piping

Main pipes should, in principle, be buried below the freezing depth. Aboveground piping or underground piping buried above the freezing depth should comply with the requirements of 4.2 "Winterization of Process Piping". Described below are precautions, in particular, for water piping.

- (1) Piping of 2" or less should be heat traced and hot insulated.
- (2) For piping of 3" or larger, which is always on-stream, measures should be established to ensure that water flow is not interrupted, as far as possible. Along with this, temperature drops in winter have to be calculated, and the piping should be hot insulated for freeze-proofing as necessary. Refer to Appendix-1, A1.1 Equation A1-3 and A1.2 Fig. A1-9.
- (3) Piping, which is not always on-stream, should be heat traced and hot insulated.
- (4) A circulation line should be provided at the terminal of each header so as not to stop flowing. For the details of circulation lines, see Appendix-2.
- (5) For pump coolers, water should also be circulated into spare stand by pumps in order to minimize freeing trouble.

4.3.2 Air and Nitrogen Piping

Requirements of 4.2.3 should, in principle, be applied. Special attention should be paid to the following.

- (1) Instrument air and nitrogen contain little moisture. Instrument air and nitrogen piping, therefore, are not required to be hot insulated; such piping should be constructed of materials for low-temperature services considering the lowest ambient temperature.
- (2) When plant air is dry, plant air piping may be bare. When it is not dry, they should be steam traced and insulated.

4.3.3 Steam Piping

Requirements of 4.2.3 hereof should, in principle, be applied. Attention should be paid, in particular, to the following items.

- (1) Steam traps should be installed in lines where condensate is likely to accumulate such as pockets or control valve bypass lines.
- (2) Even for the lines not frequently used, a steam trap should be installed at the inlet of each block valve to prevent freezing (Fig. 4.2.3).

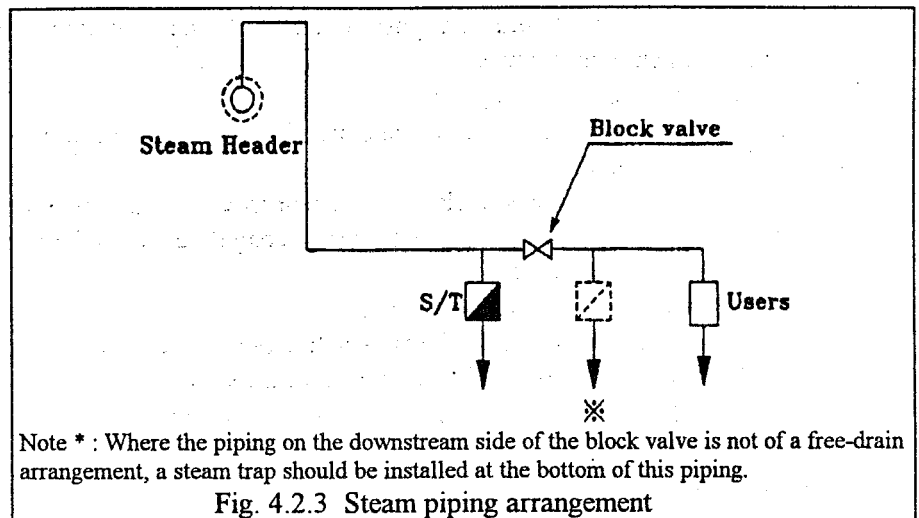


Fig. 4.2.3 Steam piping arrangement

4.3.4 Steam Condensate Piping

- (1) 1½" or smaller steam condensate piping should be heat traced and hot insulated.
- (2) 2" or larger steam condensate piping, which is always on-stream during plant operation, should be hot insulated.
- (3) 2" or larger steam condensate piping, which suffers from intermittent flow or condensate accumulation for long periods of time, should be heat traced and hot insulated.

4.3.5 Fuel System Piping

Fuel-system piping should be in accordance with the requirements of Paragraph 4.2 hereof.

4.4 Winterization of Equipment

- (1) Equipment requiring winterization
 - (a) Equipment containing water and where water accumulates for a long period of time, such as separators, flash drums, and receiver boots, from which water has to be removed.
 - (b) Equipment containing fluids with a high pour point, high solidifying point or high viscosity, which will cause coagulation or hard-to-flow conditions.
 - (c) Equipment that is likely to have adverse effects on the entire unit, due to the partial condensation of hydrocarbons in gas, such as fuel gas drums.
 - (d) Equipment handling chemicals, such as caustic soda solution drums and inhibitor drums.
 - (2) Winterization of equipment
 - (a) Of towers, vessels and heat exchangers, those handling fluids that may freeze should be provided with a drain valve at a position allowing the fluids to be drained completely during the suspension of plant operation.
 - (b) Parts of vessels (boots, etc.) which come into contact with water, nozzles, valves, and piping should be heat traced and hot insulated.
 - (c) No winterization is required for the equipment which can be heated by internal or external heating coils or similar facilities, even if the equipment contains liquid during plant shutdown.
 - (3) Winterization of air-cooled heat exchangers
 - (a) Winterization of air-cooled heat exchangers should be subject to the requirements of API standard 632.
 - (b) Louvers should be installed to prevent excessive cooling when the inside tube skin temperature in winter decreases to lower than the freezing point or pour point of the fluid passing through the tube.
 - (c) For air-cooled heat exchangers handling heavy oils with a high pour point or viscosity, steam coils should be provided to prevent the plugging of tubes due to excessive cooling. The use of a hot-air circulation system may be considered as necessary.
- Data on the consumption of steam by air-cooled heat exchanger steam coils should be obtained from the manufacturer, together with the criteria for use.

4.5 Operation Mode Change

Winterization is studied per season, in view of energy saving, and is incorporated in piping design. Such cases are increasingly common.

(1) Winterization for water or moisture freezing prevention

Heat tracing should not be done during seasons in which the lowest temperature is above 0°C.

Experience shows that when the temperature falls to about -5°C, water freezes and bare piping therefore breaks at pockets.

(2) Winterization to maintain process fluid temperature higher than its pour point/solidifying point:

Heat tracing may be suspended per season according to the pour/solidifying points of the process fluid. The heat tracing of the equipment and piping handling process fluids with 10°C or lower pour point may be suspended during seasons in which the lowest temperature exceeds 15°C. Seasons may be divided into two groups, for example, summer season and winter season, in view of the complexity of operation.

4.6 Selection of Heat Tracing Method

Heat tracing for winterization should be steam tracing, as a rule.

Electric tracing may be applied for the winterization of equipment and piping located away from the steam supply source or located in positions to which it is difficult to supply steam.⁽²⁾ Also, where the fluid is required to be maintained at 200°C or higher, electric tracing may be considered.

Where steam cannot be used because of the properties of the internal fluids, hot water tracing may be applied.

5. DESIGN OF STEAM CONDENSATE RECOVERY SYSTEMS

5.1 Steam Condensate Recovery System

Accurately grasping the amount of steam condensate proves to be important in the design of the steam condensate recovery system. In past projects, the amount of steam condensate recovered from the process equipment has been grasped accurately and the data is consistent. It remains difficult, however, to grasp the amount of steam condensate from the steam traps of steam tracing for winterization, due to various reasons. This Specification describes the method of calculating the amount of steam condensate and the method of designing condensate lines.

5.1.1 Condensate Flow Rate

(1) Amount of Steam Condensate from Process Equipment

This amount shall be calculated based on process design data.

(2) Amount of Steam Condensate from Steam-Traced Equipment and Piping

This amount is obtained based on the amount of condensate drained from the steam trap for steam tracing (ST).

$$W_{\text{cond}} = 1.5 \times W_{\text{cal}} \quad (1)$$

$$W_{\text{cal}} = N_{\text{st}} \times W_{\text{st}} \quad (2)$$

The amount of steam condensate per steam trap (W_{st}) is calculated using the steam trace heat release quantity calculation program (JAPETS #STMTRACE).

Calculate N_{st} , using N_1 and N_2 obtained from the plot plan, as follows :

$$N_{\text{st}} = N_1 \times 1.5 + N_2 \times 2 \quad (3)$$

Where :

W_{cond} = amount of steam condensate for design purposes

W_{cal} = amount of steam condensate for calculation purposes

W_{st} = amount of steam condensate per steam trap

N_{st} = number of steam traps

² : It is reported that where the steam condensate recovery system is included, electric tracing is more economical than steam tracing.

N_1 = number of steam traps for winterization to maintain the required temperature, mainly for process fluid lines

N_2 = number of steam traps for winterization for freeze/coagulation-proofing, mainly for instrument lines

5.1.2 Collection Header Sizing

- (1) Pressure balance is obtained at the header piping to recover steam condensate from each item of equipment, and the optimum pipe size should be determined.
- (2) Pressure loss considering the reevaporation of condensed water has to be calculated for the header piping.
- (3) The maximum pressure loss in the steam condensate recovery system should preferably be maintained within 10% of the difference between the maximum allowable outlet pressure of steam trap and the recovery drum pressure in consideration of the allowance of changes in steam flow rate. Pressure loss in piping has to be maintained as follows :

High-pressure system: 0.5 to 0.7 kg/cm²/100 m or less

Low-pressure system: 0.2 kg/cm²/100 m or less

- (4) The total flow rate of condensate from tracing steam traps in a subheader should be 120% (considering the amount of blow-through) of design flow rate of condensate from the steam traps. (This is required to be considered only where thermodynamic steam traps are used.)

5.1.3 Design of Steam Condensate Recovery System

A typical steam condensate recovery system is shown in Fig. 5.1.3.

- (1) Condensate flash drum and pumps should preferably be located within each unit to decrease back pressure of steam traps. Condensate flash drum may be usually installed aboveground and sometimes underground.
- (2) Instead of condensate flash drum and pumps, mechanical pumping trap(s) may be used.