

PREPARATION OF INSTRUMENT DATA

JGS 210-120-1-36E

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1. SCOPE

This standard practice covers primary instructions for planning and selection of Instruments and Instrumentation System in the preparation of instrument data sheets and P&I diagrams.

Sections cover the Instrument design note for Flow rate, Liquid level, Pressure, Temperature measurements along with requirements for Analyzer.

Following JGS regarding Control Valve and Safety Valve shall also be referred. "Control Valve" (JGS 210-120-60E), and "Pressure Relief Device" (JGS 210-120-61E).

2. WORK PROCEDURE

Process engineer shall fill all the process data columns of Instrument data sheets and shall prepare P&ID drawing.

It must be recognized that if the basic engineering practices for the design of Instrument and Instrumentation systems are defined in following (or other applicable) documents, data sheet and P&IDs shall be prepared to reflect the requirements.

- (a) Owner's or Licensor's Project Specification for Instrumentation.
- (b) Basic Engineering Design Data (BEDD) for Instrumentation
- (c) General Specification for Instruments.

If any case, the Instrument Application Engineer shall consult the detail of planning and selection of Instruments and Instrumentation System.

2.1 Input to Data Sheet

Design condition on Instrument data sheet shall be based on PFD, Material Balance and Heat Balance.

Blank forms of Instrument data sheet are shown in Attachment 1 ~ 5.

Special care shall be taken when filling data into following Instrument data sheet.

2.1.1 Differential Pressure Type Flow Instrument (Attachment-1, Form-843-3)

- (1) All the applicable range of process data such as max, nor, min flow rate expected, specific gravity change, pressure or temperature variation for each operation case should be prepared.
- (2) Specific heat ratio (C_p/C_v) and Compressibility factor shall always be specified for Gas and Vapor services.
- (3) Viscosity must be specified for all the services.
- (4) "Diff. Press" means Pressure difference across the orifice plate.
Permanent pressure loss used in hydraulic calculation may be estimated from the following relation.
Permanent pressure loss = "Diff. Press" * 0.3 ~ 0.8

2.1.2 Displacement Type Level Instrument (Attachment-2 Form-844-4)

- (1) If operating pressure is above 50kg/cm²G, density of vapor phase shall also be specified in data sheet.

2.1.3 Temperature Instrument (Attachment-3 Form-846-3)

- (1) Flowrate, specific gravity, viscosity and velocity shall be specified for well-resonance calculation.

2.2 Preparation of P&ID

Followings shall also be applied for the preparation of P&ID.

- (a) Design criteria for P&ID preparation (JGS 210-120-1-71E)
- (b) Process Control Scheme (JGS 210-120-1-13E)
- (c) Control Valves (JGS 210-120-1-60E)
- (d) Preparation of LC and LG Arrangement (JGS 210-120-1-56E)

Following ISA standard may be referred for the preparation of P&ID.

- (a) ANSI/ISA-S5.1-1984
Instrumentation Symbols and Identification
- (b) ISA-S5.3-1983

Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.

3. DESIGN

3.1 Flow Instrument

To obtain necessary and correct information for the process operation and evaluation, flow instruments shall be installed on several important and fundamental streams.

Feed, products, reflux, and utilities are examples of these to be monitored for the process material balance calculation.

Requirements of indication, recording, control, alarming, etc. shall be identified in P&ID.

In any case, duplicated installation of flow instruments on the same stream shall be avoided.

For services only used for very limited operation, such as steam/air flow meter for furnace decoking as an example, local Flow Element (FE : Orifice Plate and Impulse line only) may be applied.

Necessary temperature and pressure measurement of the stream shall be provided, if compensating calculation is required for flow measurement.

The type of flow instruments shall be selected examining conditions such as :

- Required range for measurement

- Process and fluid properties of the stream

- Purpose of measurement and required accuracy

Basic and primary design criteria for each type of flow instrument is discussed hereunder.

3.1.1 Differential Pressure Flow Instruments

(1) Orifice plates :

Orifice plate is one of the “Differential pressure type flowmeter-elements”, and is most widely applied in process industries. Reasons of its wide applications are :

- Simple construction without moving parts,

- Reliable standards and data for flow calculation,

- Good reproducibility and high accuracy,

- Lower cost,

- Easy maintenance, and flexibility of changing flowmeter range.

Design considerations are as follows.

- (a) Concentric orifice plates are mostly applied for differential pressure flow instruments.
- (b) Quadrant edge orifices are used for viscous flow whose Reynolds number is between 3,000 and 10,000.
- (c) Segmental or eccentric orifices are applicable for services where slurry or foreign material are contained in the fluid.
- (d) Integral orifices are applicable for small-size flow services.
- (e) As per the International Orifice Standards (ISO/JIS), the orifice plate can not be applied for use for tube/pipe whose inner diameter is below 50 mm or exceeding 1,200 mm
- (f) Since orifice flow meter always causes permanent pressure loss across the element, they can not be applied to the services where higher pressure loss is not allowed.
- (g) Orifice plates are not applicable to measure the gas-liquid mixed flow rate. Location or elevation of orifice plate shall be examined to ensure sufficient pressure is available at the orifice plate to prevent the liquid from flashing.
- (h) Flow calculation by orifice or other differential pressure type meter is affected by the deviation of actual pressure or temperature data from the design data. The location of flow elements shall be selected so that such deviation will be minimized.
- (i) Flow elements always require straight meter runs before and after the elements. Locating elements at downstream of tee, elbow, valves, wells, or others which disturbs the straightened flow, therefore, shall be avoided.
- (j) The pipe diameter will be enlarged (or reduced) to satisfy the flow meter design condition. The instrument design engineer shall consult to review the requirement.

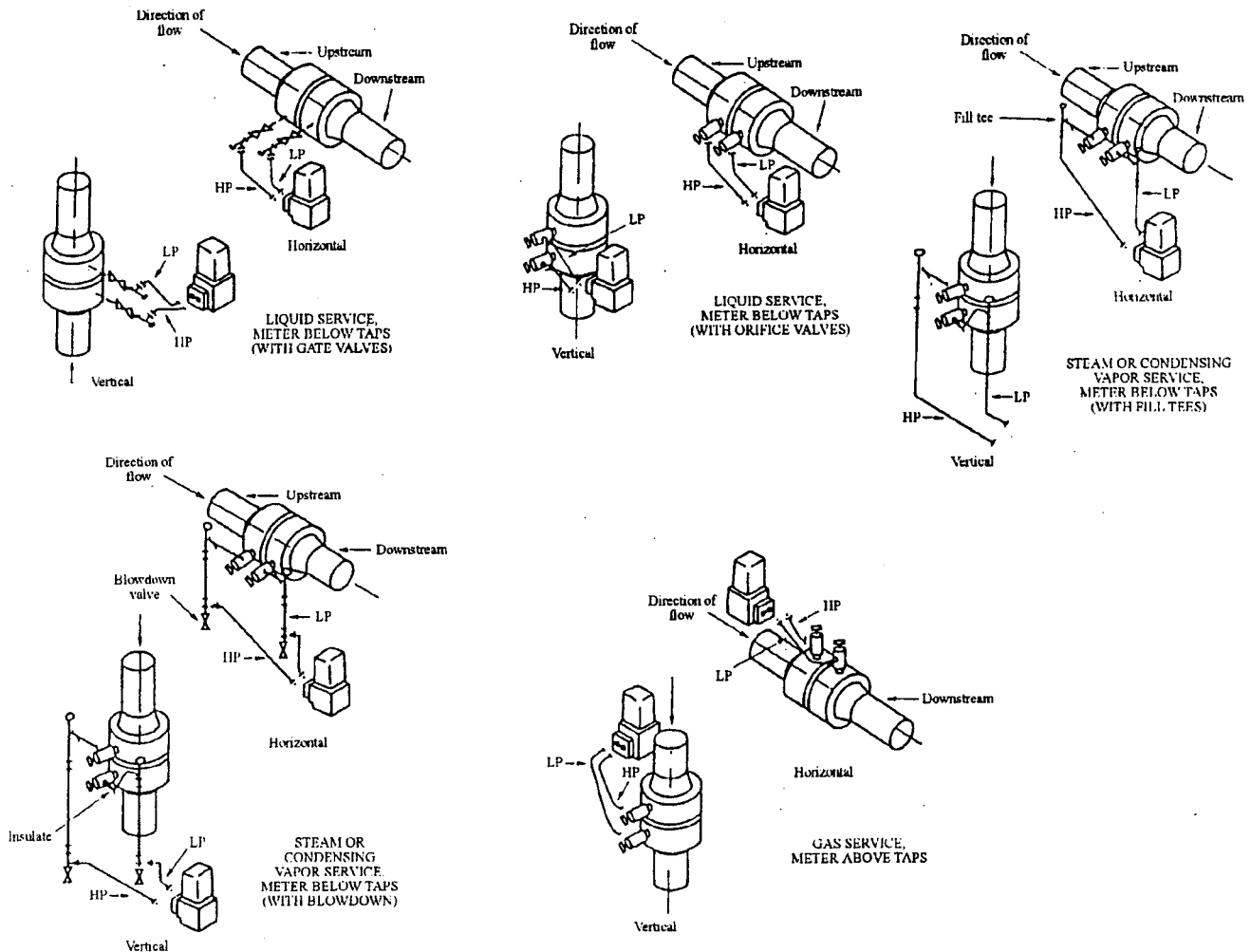


Fig. 3.1.1 Differential-Pressure Flowmeters (API 551)

(2) Flow nozzles:

Flow nozzles are used in cases where a small quantity of slurry is contained in the fluid or where the flow velocity is high such as in the case of High-pressure steam.

(3) Venturi tubes:

Venturi tubes are used in cases where the pressure drop shall be low (such as, compressor suction lines), or where foreign materials such as slurries, powders or catalysts are suspended in the fluid.

(4) Pitot tubes:

Pitot tubes are used in cases where very small pressure loss is allowed, and where high measurement accuracy is not requested (as in the case of cooling water lines, flare gas or plant air lines).

3.1.2 Variable Area Meters (Rotameters)

Rotameter with glass-made tapered tube is primary applied for local flow measurement of utilities, such as water, air, nitrogen, or other non-hazardous small size liquid or gas flow.

Metallic tube rotameters will be applicable for the measurement of high viscous, high temperature flow such as very heavy oil, molten sulphur, or etc.

Rotameters with proper internal finish with lining or coating are applicable for very corrosive services such as acids or alkaline.

3.1.3 Positive Displacement Type Flowmeters (PD meters)

PD meters are applied for high accuracy flow measurement such as the custody transfer service.

It is recommended to apply them for flow measurement of viscous fluid (gasoline and heavier fluid) and not recommended for LPG or less-viscous liquid flow measurement.

It is not recommended to apply PD meters to the large size piping because of manufacturing and installation difficulties, to high pressure-temperature rating service, or to the service where high pressure loss across the meter is not acceptable. Positive Displacement Meter is often applied for local flow totalizer of heavier fluid such as Fuel Oil.

3.1.4 Turbine Meters

Turbine meters are used for high accuracy flow measurement such as the custody transfer service. It is recommended to apply them for flow measurement of low viscous fluids (kerosene and lighter).

Turbine meters are not used for gas flow measurement, except for special type.

Turbine Meters can be applied on high pressure-temperature rating services.

Flow measurement using Turbine Meters require straight runs before and after the meter. Locating elements at downstream of tee, elbow, valves, wells, or others which disturbs the laminated flow, therefore, shall be avoided. Flow conditioning device called straightener may be used to shorten the required straight run.

In most applications, strainer is required to prevent instrument from damage.

3.1.5 Vortex Flowmeters

Vortex flowmeters can be applied for wide application of liquid, gas/vapor and steam flow measurement.

They may be less expensive than orifice flowmeter (including piping works), when installing on small size line.

3.1.6 Coriolis Flowmeters

Coriolis flowmeters are used for high viscous fluid such as hot asphalt and tar.

They are also well applied to LPG metering system since they directly measure mass flow rate.

3.1.7 Electro-magnetic Flowmeters

(1) Electro-magnetic flowmeters are applied for the measurement of fluid suspending slurries since it has no restricting or obstructing the flow.

(2) Since meters require the fluid to have electric conductivity of $2 \mu\Omega\text{cm}$ or higher, they cannot be applied for hydrocarbon liquid or for other non-electro-conductivity fluid.

3.1.9 Ultrasonic Flowmeter

Ultrasonic flowmeters are applied for the measurement of large size gas pipeline, water pipeline, etc..

Table 3.1.a Rangeability

Rangeabilities of flow meters are generally as shown below.

Items	Rangeability
Differential pressure flow instruments	3:1
Variable area flowmeters	10:1
Positive displacement type flowmeters	10:1
Turbine meters	10:1
Vortex flowmeters	10:1
Coriolis flowmeters	10:1
Electromagnetic flowmeters	10:1

Table 3.1.b Accuracy

Measurement accuracies of flowmeters in combination with their primary sensing devices and transmitters are generally as shown below.

Items	Accuracy (% of full scale)
Differential pressure flow instruments	±1 to 2%
Variable area flowmeters	±2%
Positive displacement type flowmeters	
For general purposes	±0.5%*
For custody transfer	±0.2%*
Turbine meters	
For general purposes	±0.5%*
For custody transfer	±0.2%*
Vortex flowmeters	±1%
Coriolis flowmeter	±0.2%
Electromagnetic flowmeters	±1%

Note : * Mark as % of actual value.

Table 3.1.c Permanent Pressure Loss

Permanent pressure losses used in hydraulic calculations may be estimated as shown below.

Items	Permanent pressure loss (kg/cm ²)
Orifice plates	0.02 - 0.5
Flow nozzles	0.15 - 0.20
Ventury tubes	0.005 - 0.05
Variable area flowmeters	0.05 - 0.15
Pitot tubes	Negligible
Positive displacement type flowmeters	0.2 - 1.4
Turbine meters	0.2 - 0.5
Vortex flowmeters	Negligible
Coriolis flowmeters	Negligible
Electromagnetic flowmeters	Negligible

3.2 Level Instruments

For all equipment holding liquid inside such as Vessels, Towers, Drums, Reactors, Tanks, etc. shall be equipped with level Instruments for monitor and control.

Requirements of indication, control, alarming, shall be identified in P&I diagram.

The measuring range of level instrument shall be decided to cover the required range for the process operation, and the instrument shall be backed-up by local reading level instrument.

The local instrument shall cover the whole measuring range of the level instrument.

3.2.1 Displacement Type

Displacement type level instrument provides durable and reliable level measurement for very wide application. It suits for level transmitter and/or field level controller application.

- (1) The displacement level instrument, however, is not recommended for very viscous fluid level measurement, or where bubbling or boiling may cause violent agitation of the liquid surface, or where hydraulic resonance may occur.
- (2) For the service where steam stripping is provided, it is indispensable to furnish gas purging into the top of the instrument to prevent steam condensate from entering into the instrument. In many cases, differential pressure type level instrument is recommended for such application.