

INSTRUMENT

I. Instrumentation

II. Instrumentation

1.

2.

3.

4. Level

III. Instrument Requirements

I INSTRUMENTATION

INSTRUMENTATION PROCESS INSTRUMENT

가. PRODUCT QUALITY

. DIRECT MATERIAL SAVING

. COST ACCOUNTING

. PRODUCT TESTING

. MAN & PLANT SAFETY ,

PROCESS ENGINEER INSTRUMENT
PROCESS INSTRUMENT

.

■ Instruments

- Indicating, transmitting, converting, recording, controlling, integrating, calculating
- laws, codes, standards, regulations, or practice conditions
- , Rangeability & accuracy
- leaking
- .
- process installation
- , , slurry , Vibration , Viscosity, explosion proof
- Reliability, Maintenance .

II Instrumentation

1.

1.1

1.1.1

Instantaneous flow rates		Integration rate,	
Refinery Process Flow Measurement		Custody Transfer	
Process Flow Measurement		Orifice	Rotameter 가
Liquid Custody Transfer	PD Meter	Turbine Meter	가

1.1.2

가. (Service Condition)
(,) Service Condition
가 .

- A. Line Size
- B. Range of flow rates : Max, Nor, Min
- C. Fluid Characteristics
 - a) Liquid, Gas, Slurry, etc
 - b) Pressure, Temperature, Viscosity
 - c) Liquid : Sp.Gr at standard and flowing conditions
 - d) Gas : compressibility, Molecular Weight,
 - e) Steam : Steam Quality
- D. Corrosive effects : Material
- E. Fluid : Steady or Pulsating

- : Customer , Control etc
- : (),
- : Rangeability, Accuracy, Scale Range
- : , Maintenance

1.1.3 Flowmeter Selection Table

Flowmeter	Pipe size inch	Gases(vapors)		Liquid					Temp ()	Pres. (kPa)	Accuracy uncalibrated	Reynolds No.	Range- ability	In/Out	
		Clean	Dirty	Clean	Viscous	Dirty	Corrosive	Slurries							
Orifice									Process Temperature to 540 Transmitter limited to -30 ~ 120	To 41,000	±1~2%	RD>2000	1:3~5	10~62D/ 4D	
Square-edged	> 1.5		x		x	O	O	x			±1%	RD>1000			
Honed meter run	0.5-1.5		x		O	x	O	x			±2~5%	RD>100			
Integral	<0.5		x			x	O	x			±2%	RD>200			
Quadrant/conic	>1.5	x	x			O	O	x			2%	RD>10,000			
Eccentric	>2	O		O	x		O	x			±2%	RD>10,000			
Segmental	>4	O		O	x		O	x			±2%	RD>10,000			
Annular	>4	O		O	x		O	x			±1.5 ~ 5%	RD>100			
Target	>0.5-4						O	x			1 ~ 2%	RD>75,000	1:3~5	10D/5D	
Venturi	>2		O		O	O	O	O			±1 ~ ±2%	RD>10,000			
Flow nozzle	>2		O		O	O	O	x			±1.25%	RD>12,500			
Lo-Loss	>3		x		x	x		x			±5%	No limit			
Pitot	>3		x		O	x	O	x			±1.25%	RD>10,000			
Annubar	>1		x		x	x	O	x			±4.25%	RD>10,000			
Elbow	>2		O		x	O	O	O							
Magnetic	0.1-72	x	x						180	10,500	±1%	No limit	1:10~20	Non	Non
Positive-displacement	<12		x		x	x	O	x	Gases:120 Liquid:315	10,000	Gases: ±1% Liquid: ±0.5%	8000cSt	1:10~20	Non	W/Strainer
Turbine	0.25-24		x		x	x	O	x	-450~500	21,000	Gases: ±1% Liquid: ±0.5%	2~15 cSt	1:10~20	20D/4D	W/Strainer
Ultrasonic									-450~500	Pipe rating Pipe rating	±5%	No limit	1:5~20	10D/5D	Non
Time-of-flight	>0.5	x	x		O	x		x	-300~500		±5%	No limit			
Doppler	>0.5	x	x	x	O				-300~250						
Variable-area	3		x			x	O	x	Glass: 200 Metal: 540	Glass: 2400 Metal: 5000	±1 ~ 5% of rate	To highly Viscous fluids	1:10	Non	
Vortex	1.5~16		O		x	O	O	x	200	10,500	±0.75 ~ ±1.5%	>10,000	1:100	20D/4D	

=designed for this application , O=normally applicable , x=not designed for this application

1.1.4 Flowmeter

Type		
1. Differential Pressure	<ul style="list-style-type: none"> Low cost, especially for large lines Accuracy & Reliability 가 Process Shut down Zero check calibration The secondary or differential device 가 . Pipe Size Pipe Size Cost 	<ul style="list-style-type: none"> Rangeability to 1:3 to 1:5 High pressure loss Difficult to use for slurry services Square root rather than Linear Characteristic Meter run length required Connecting Pipe freezing, condensing 가 (Except integral orifice) Accuracy 가 , ,S.G, Compressibility
1-1 Orifice	<ul style="list-style-type: none"> , 가 , 가 Orifice Plate Copy Liquid, Gas, Steam 가 , / 가 application data 	<ul style="list-style-type: none"> Orifice Plate Plate Edge 가
1-2 Flow Nozzle	<ul style="list-style-type: none"> Orifice 가 . Orifice Venturi Tube . 가 . Orifice 가 . 	<ul style="list-style-type: none"> Orifice Rangeability 가 Orifice 가
1-3 Venturi Tube	<ul style="list-style-type: none"> 가 . Orifice Flow Nozzle 가 . 가 . 	<ul style="list-style-type: none"> Orifice Flow Nozzle 가 Rangeability (3:1)가 .
1-4 Pitot Tube Annubar	<ul style="list-style-type: none"> 가 가 가 . 가 . 	<ul style="list-style-type: none"> 가 , . Steam Upstream

Type		
2. Variable Area (Rotameter)	<ul style="list-style-type: none"> ● 가 pressure drop ● Inlet and Outlet Piping ● , Reynolds Number 가 ● Float 가 . ● Liquid, Gas 가 , ● 가 . ● (10:1)가 . ● 가 . 	<ul style="list-style-type: none"> ● Glass tube() , ● Not good in pulsating services ● Small pipe size (< 2') ● Limited to low temperature ● Require in-line mounting ● 100mm 가 ● .
3. Magnetic	<ul style="list-style-type: none"> ● pressure drop large pipe size 가 ● Piping configuration not critical ● Reversing Connection 가 ● (5 μ /cm) , , ● 가 . ● 가 , Rangeability 가 . ● Slurry, , ● 가 . ● , 가 . 	<ul style="list-style-type: none"> ● Minimum Conductivity (0.1 ~20 micromhos) ● 가 Full ● High Cost ● Gas bubble ● In-line Mounting ● Explosion Proof in hazardous electrical area
4. Turbine Meter	<ul style="list-style-type: none"> ● Flow totalizing & Blending System ● 가 , ● 가 가 . ● 가 . ● (± 0.2~ ±0.5%)가 ● . LPG ● 가 Rotor ● 가 ● -250 , 500 가 	<ul style="list-style-type: none"> ● In-line Mounting ● High Cost ● Slurry ● Strainer & straight Run Pipe (about 15D)

Type		
5. Vortex Meter	<ul style="list-style-type: none"> ● Excellent Rangeability ● Blending application and flow totalizing (Digital Reading) ● No moving Part ● , , , ● Very low pressure drop ● , 가 . 	<ul style="list-style-type: none"> ● Limited application data ● In-line mounting ● Up/down Steam Orifice 가 ● high cost ● Slurry 가 가 ● Gas 가
6. Positive Displacement Meter	<ul style="list-style-type: none"> ● Rangeability accuracy 가 ● Easy Calibration ● Linear readout ● Flexibility of readout devices ● Liquid , 가 ● 가 Liquid ● 가 , ● ROOTS METER GAS 가 	<ul style="list-style-type: none"> ● high pressure drop ● Very little overrange protection ● Liquid . ● (Filter Strainer) ● In-line mounting ● 가 가 .
7. Ultrasonic Flowmeter	<ul style="list-style-type: none"> ● . ● , 가 . ● 가 ● Open 가 . 	<ul style="list-style-type: none"> ● .
8. Mass Flowmeter	<ul style="list-style-type: none"> ● . ● , Slurry , Gas 가 . ● Tube Fouling , Range ● ability(100:1)가 . (20:1) ● 가 Maintenance . ● Mass 1 가 . 	<ul style="list-style-type: none"> ●

1.2 Differential Pressure Instruments

Orifice, Flow Nozzle, Venturi Tube, Flow Tube, Pitot Tube etc

가
가
가
가
가

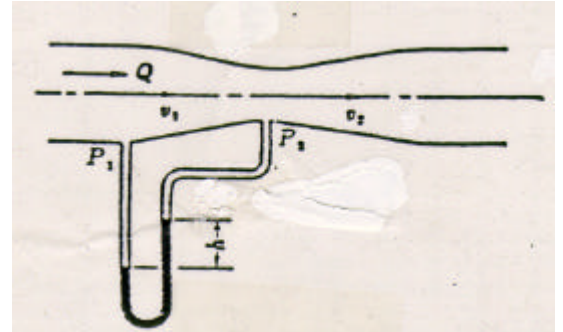


Fig 1.1

1.2.1 Orifice

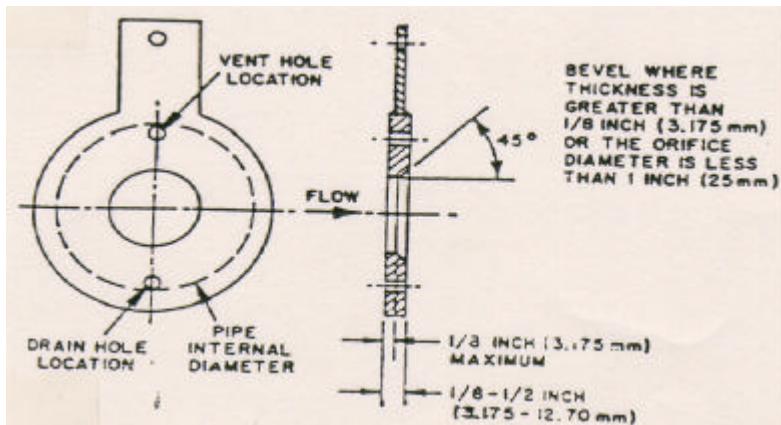


Fig 1.2 Concentric Orifice Plate

Orifice ,
Flowrate 2
Flowrate
Flow (P)

1.2.1.1 Orifice Plates

- 가. Sharp edge, Concentric Orifice Plate 가 Low Cost, Adaptability, Availability of accurate coefficient .
- . Eccentric : Solids-containing materials & Two-phase
- . Segmental : Solids-containing materials
- . Quadrant edged : Viscous Fluid
- . Integral Orifice Flowmeter : Very Small Flow, Pipe Size < 1/2
0.04 SCFM of water equivalent
0.027 SCFM of Air
- . Beta Ratio
Beta Ratio = Orifice Diameter (d) / Internal Pipe Diameter (D)
Flange Tap : 0.15 ~ 0.7
Pipe Tap : 0.2 ~ 0.67

- . Accuracy : around ± 0.6
- . Vent or Drain Hole : Bore Size 1"
(Liquid – Vent , Gas – Drain)

1.2.1.2 Orifice Flange

가. Flange, Pipe, Vena Contracta, Radius, Corner Tap
Tap

Flange

Flange Tap : 12" pipe size and smaller

Vena contracta Tap : 14" pipe size and larger

. Tap Size

1/2" NPT : ~ 600# Flange

3/4" S/W : 900# ~ 2500#

. Rating : Min 300# or Pipe Rating

1.2.1.3

가. Pipe Size 가 Min 1.5" Line 가 가
Line Size-up Rotameter Device .

. normal flow rate 1.2 ~ 1.5

. Friction Loss 가 Line Restriction Orifice

. Beta Ratio 0.04 . (0.04)

Plate

1.2.2 Flow Nozzle : Better Pressure Recovery

1.2.3 Venturi Tube : Good Pressure Recovery, Solid

Venturi Tube

/

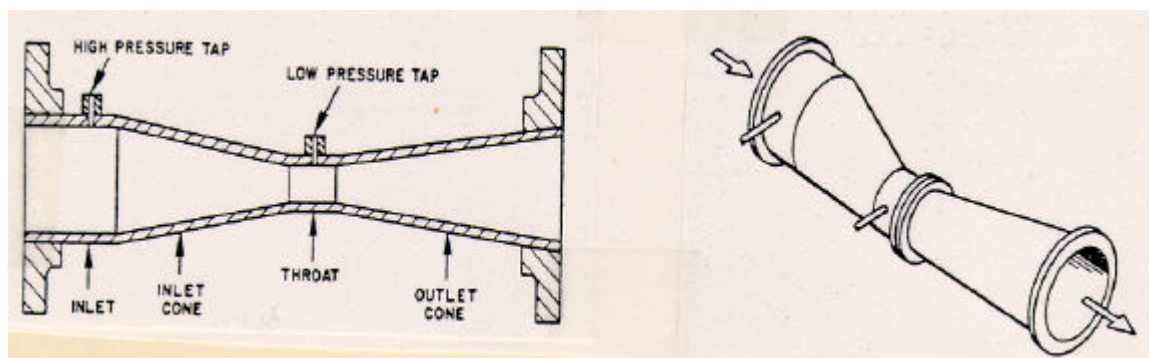
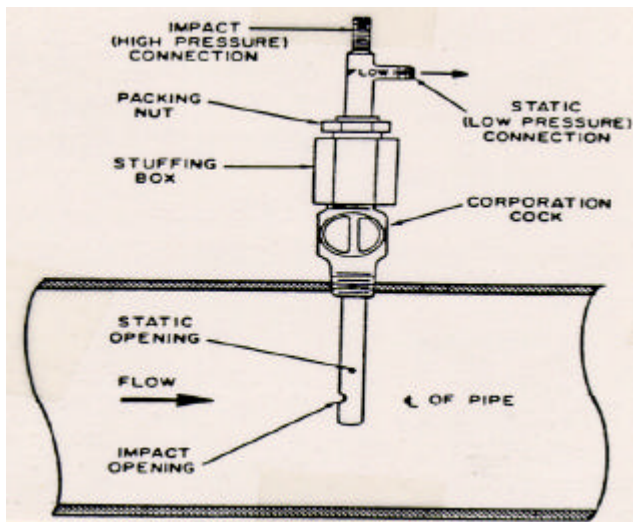


Fig 1.3 Venturi Tube

1.2.4 Pitot Tube :



(Impact Pressure)
(Static Pressure) Sensing Hole

Fig. 1.4 Pitot Tube

1.2.5 Differential Measuring Device

가. Manometer, Bellows, Diaphragm

Manometer

Mercury Cost & Maintenance Cost

Dry meter

(Bellow, Diaphragm)

. Bellows Meter indicating, recording and control mechanism

Diaphragm Meter signal transmission

. Max. differential Pressure for design primary element

Min (625) Nor (2500), Max(10,000) mmH₂O - SK

1.3 Variable Area Flowmeters

1.3.1

Process

Taper

Float

가

Float 가

$$F = C \cdot a \cdot V = C \cdot a \cdot \left(2gH / (1 - (a/A)^2) \right)$$

1.3.2

가. Differential Pressure Type

Small Pipe Size (< 2")

High

Rangeability (> 1:4) 가

. Glass Tube

, Metal

Tube

가

Check Valve

1.4 Turbine Meters

1.4.1

Housing Shaft, Rotor 가 Pick-up coil Pulse Pick-

Housing Rotor 가 Blade up coil Counting

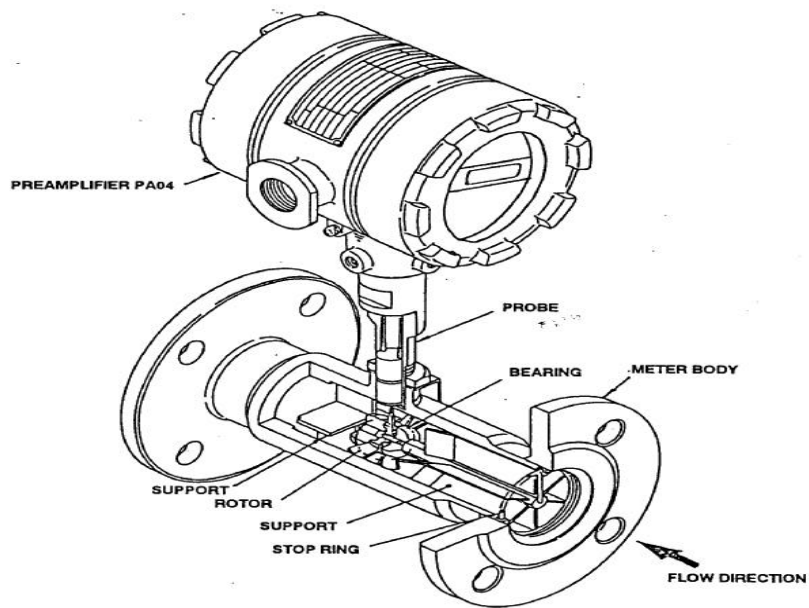


Fig. 1

- Detail View of Bearing Assembly -

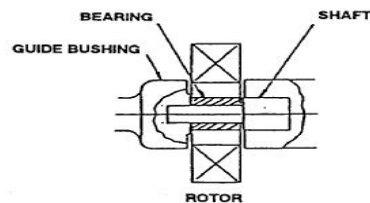
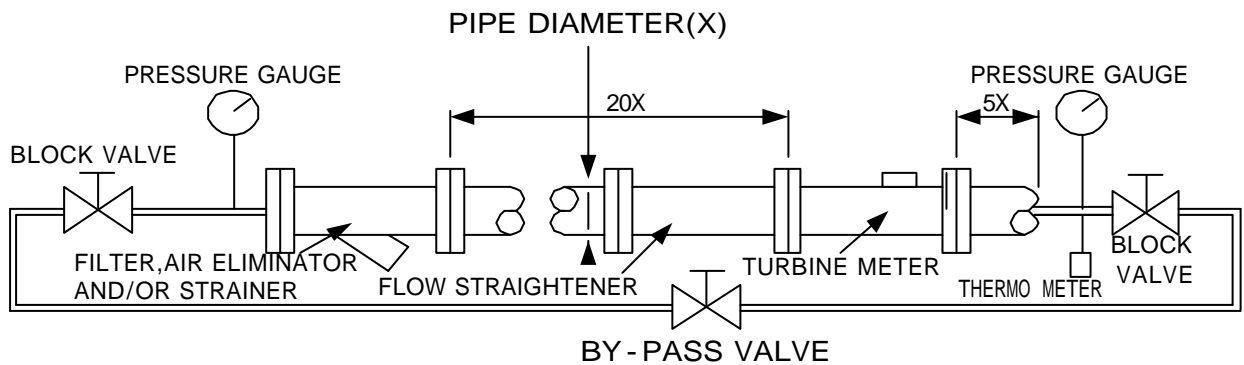


Fig. 1.5 Oval Turbine Meter



TURBINE METER SYSTEM SCHEMATIC DIAGRAM

1.4.2

1.1.4 Flowmeter

1.5 Positive Displacement Meters

1.5.1

Case (

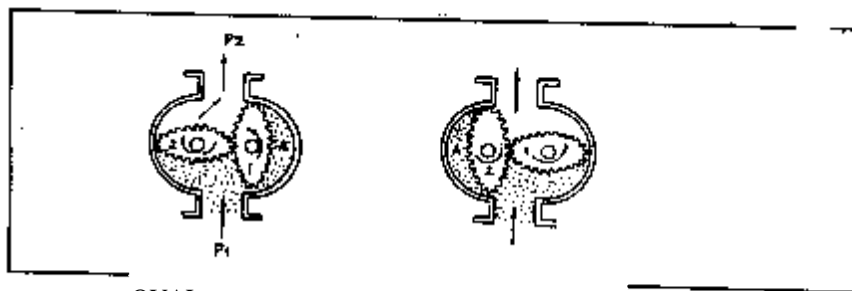
) ,

$$Q = KN$$

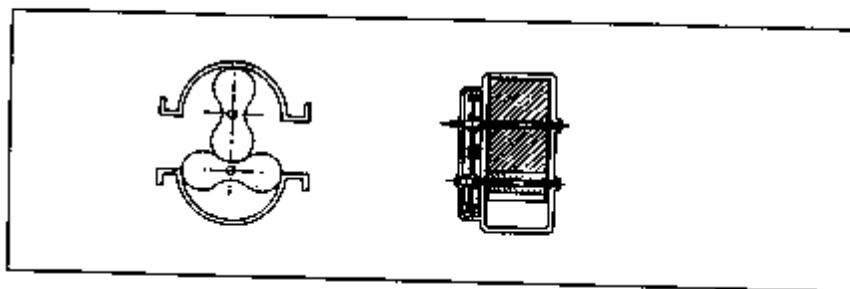
$$K = 1$$

$$N =$$

Oval Meter Root Meter 가



OVAL



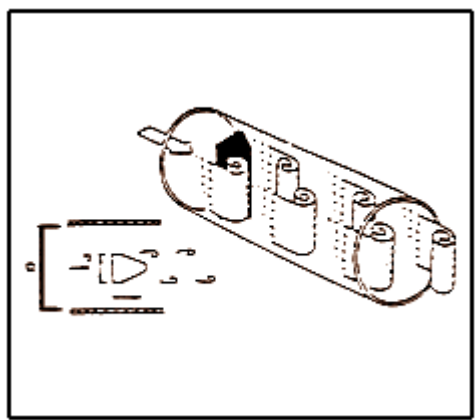
ROOTS

1.5.2

1.1.4 Flowmeter

1.6 Vortex Flowmeters

1.6.1



Body) (Bluff
Bluff Body
가
Karman

$$f = S \times (V / d)$$

f:
V: Bluff Body
S: Strouhal
d: Bluff Body

1.6.2

1.1.4 Flowmeter

1.7 Ultrasonic Flowmeters

1.7.1

) Pulse
(
Doppler Shift
Doppler

1.7.2

1.1.4 Flowmeter

1.8 Mass Flowmeter

1.8.1

Coriolis Pipe
Pipe

1.8.2

1.1.4 Flowmeter

1.9 Magnetic Meters

1.9.1

가

/ Coil

가

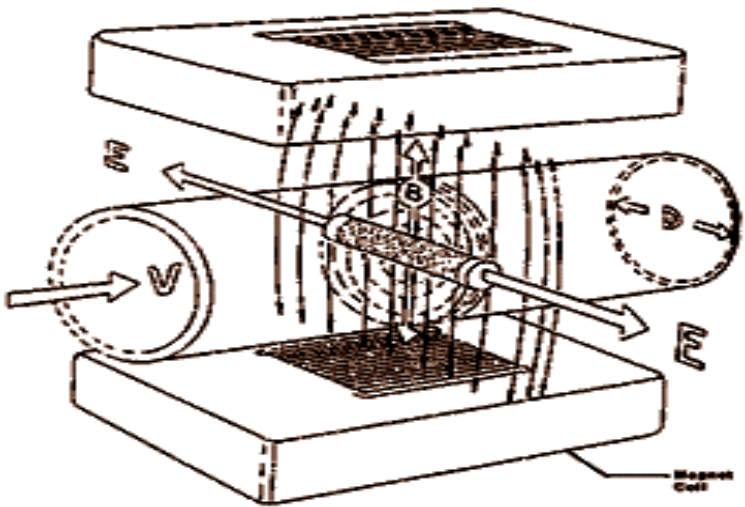


그림 1-1. 전자 유량 측정의 원리

1.9.2

Slurry Service Corrosive Service Meters 가

1.10 Others

Weir , Parshall Flume

2

2.1

2.1.1 Element

가. Element type

Bourdon Tube :

Bellows type : low pressure

Diaphragm Sealed type : corrosive, high viscosity, slurry service

. Element Material

Bourdon tube 316 SS 가

Special corrosive services Monel, Titanium, Hastelloy
coated diaphragm

2.1.2 Accuracy

Generally 1.5 %

2.1.3 Selection of Range

Normal Operating Pressure 1.5 ~2.0

2.1.4 Construction

Gauge plastic or light metal Diameter 100 ~150mm

Outdoor Weather proof

Connection : 1/2" pipe thread at the bottom

2.2

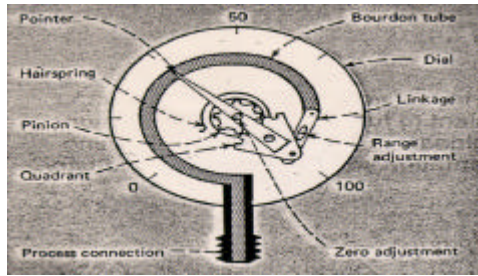
PRESSURE ELEMENT

- BOURDON TUBE
- BELLOWS
- DIAPHRAGM SEAL

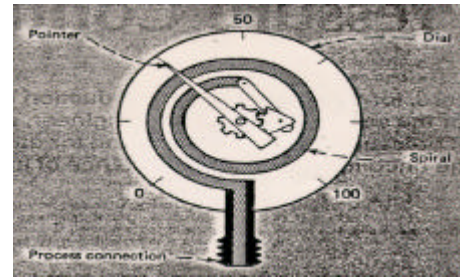
2.2.1 BOURDON TUBE

가

- C BOURDON (FIG 2. 1)
- SPIRAL (FIG 2. 2)
- HELICAL (FIG. 2. 3)



**FIG. 2. 1
BOURDON TUBE TYPE
PRESSURE GAEG**



**FIG. 2. 2.
SPIRAL TUBE
TYPE**

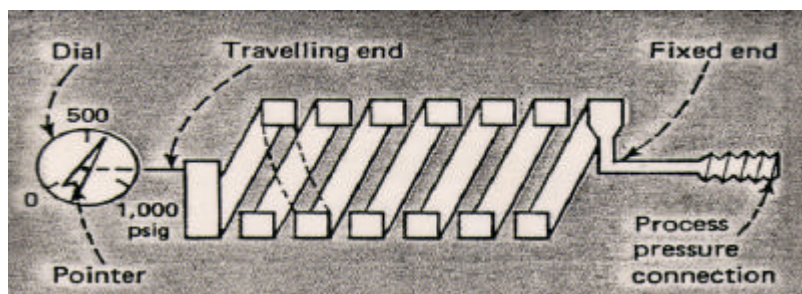


FIG. 2. 3. HELICAL TUBE PRESSURE GAEG

2.2.2 BELLOWS

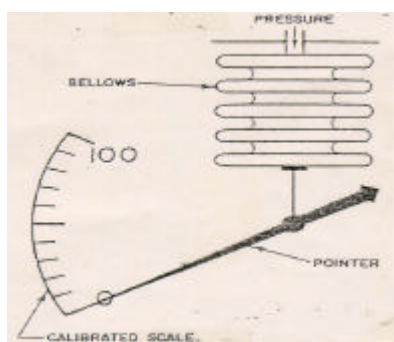
BELLOWS 가

- SPRING LOADED BELLOWS(Fig. 2. 4)

- BELLOWS

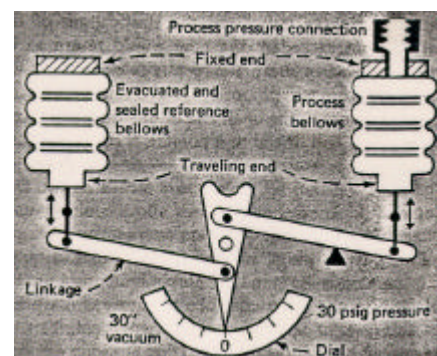
CALIBRATED SPRING

- DOUBLE BELLOWS(Fig. 2. 5)



**FIG. 2. 4. SIMPLE BELLOWS
ELEMENT**

- 1.
- 2.



**FIG. 2. 5.
ABSOLUTE-PRESSURE-BELLOWS
INDICATOR**

2.2.3 DIAPHRAGM (Fig. 2. 6)

Bellows

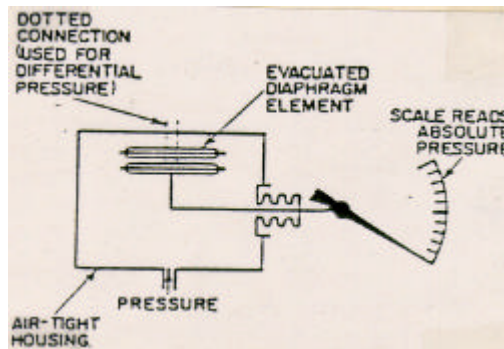


FIG. 2. 6.
EVACUATED DIAPHRAGM ELEMENT

2.2.4

Bourdon Tube	<ul style="list-style-type: none"> 가 가 	<ul style="list-style-type: none"> (Quartz Helix) Hysteresis 가
Bellow	<ul style="list-style-type: none"> Drift, Friction, Elastic Hysteresis 가 가 Local Indicator, Recorder Controller, Switch, Transmitter 가 	<ul style="list-style-type: none"> BELLOW
Diaphragm	<ul style="list-style-type: none"> Elastic Hysteresis, Friction Drift Span $\pm 0.1\%$ 가 가 가 Quartz Diaphragm Min. Hysteresis Drift Button Diaphragm Transmitter 10,000 Psig 가 Slack Diaphragm Type Steam Generator Fired Process Heaters Firebox Breeching 	<ul style="list-style-type: none"> 가

2.3 Accessories

2.3.1 Diaphragm seals

가. corrosive, high viscous & slurry fluid service

inert liquid

. material 304SS

2.3.2 Pulsation Dampeners

가 pump line
material 304SS 1/2"NPT female
connection

2.3.3 Siphons

가. hot service or all steam service bourdon tube service
heating sensing
. 1/2" seamless schedule 80(minimum) steel pipe

3

3.1 Thermowell

3.1.1 Insertion Length : 1/2 ~ 2/3 (normally 1/2)

3.1.2 Materials

Carbon Steel Piping General Service 304SS, 316SS 가

* Corrosive services (such as dilute acids, chlorides, and heavy organic acids)
Material .

3.1.3 Installation

가. Min. Line Size 4" Line Size-up .
. Screw-mounted well Inspection, Special Material,
Temperature Cycling Flange-mounted Well .

3.2 Thermometer

3.2.1 selection of type

Bimetal Primary Element 가 2

. Local Indicating Thermowell .

3.2.2 Selection of Range

Normal Operating Temperature 2

3.2.3 Case of Thermometers

Outdoor Weather Proof 가 , 100mm or 150mm
Diameter 가

3.3 Thermocouple

3.3.1

가 ,
가 .
Zeedback Effect
가 (Thermocouple) .

3.3.2 Installation

Thermowell Thermowell .

Table.1 Thermocouple Materials and Temperature Range

ANSI Symbol	Thermocouple Materials	Normal Temperature()
E	Chromel-Constantan	-200 to 900
C	Iron-Constantan	0 to 700
K	Chromel-Alumel	-200 to 1250
R	Platinum, 13 percent Rhodium-platinum	0 to 1250
S	Platinum, 10 percent Rhodium-platinum	0 to 1450
T	Copper-Constantan	20 to 350

3.3.3 Others

- 3.3.3.1 Tube Surface Temperature Measurement
- 3.3.3.2 Averaging Thermocouples
- 3.3.3.3 Temperature Difference

3.4.4 Transmission

가. Thermocouple Transmitter 4~20mA DC
Control Room
Thermocouple Control Room

3.4 RTD (Resistance Temperature Device)

3.4.1

3.4.1.1

Bridge

가

3.4.1.2

- Resistance temperature detectors accuracy narrow temperature span
- Bare element (without well) : very fast(5~6 second) response times
- Temp. Range: -200 ~ 600
- Resistance Thermometer Bulb (, ,), (Constantan), (Thermister, Silicon, Germanium)

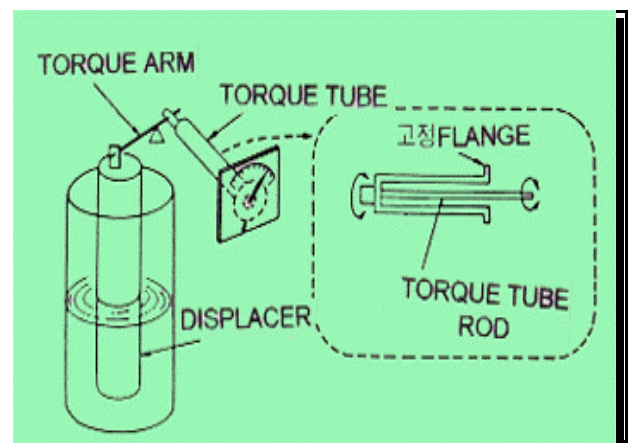
3.5

4 Level

4.1 Level Meter

4.1.1 Displacement Level Meter

Plant Level-Meter Engineering-Spec' [Glass-Gauge Level-Meter Displacement Type Level Meter 가 2m Level-Meter]. Plant Displacement Level Meter 가

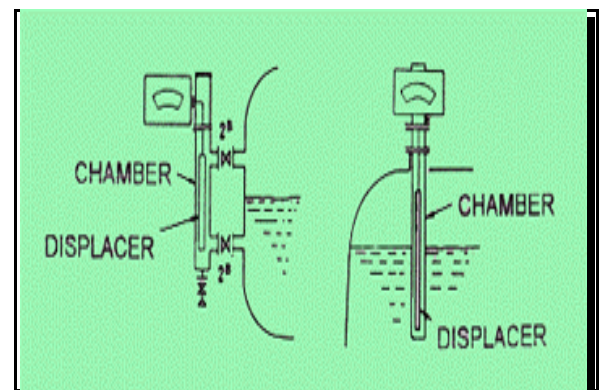


Displace

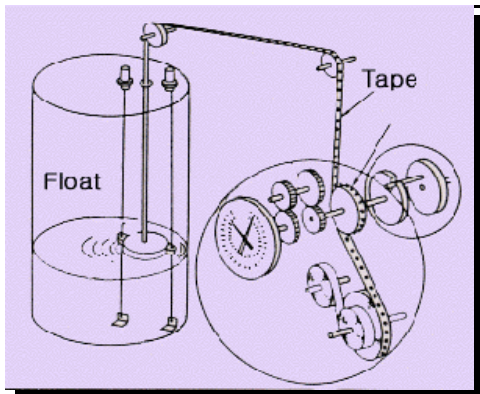
Displace Float
Displace
Displace
Torque-Tube

Level

가



4.1.2 Float type level meter

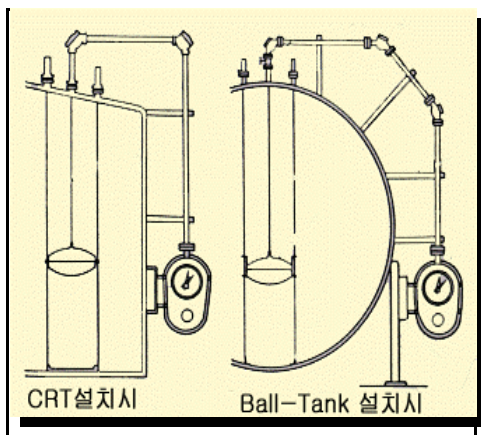


Tank. Product Storage-Tank
Float Type Level Meter 가

Level mm

$\pm 1.5 \text{ mm}$

Level 가 Tank,
Tank. LNG-TANK



Float

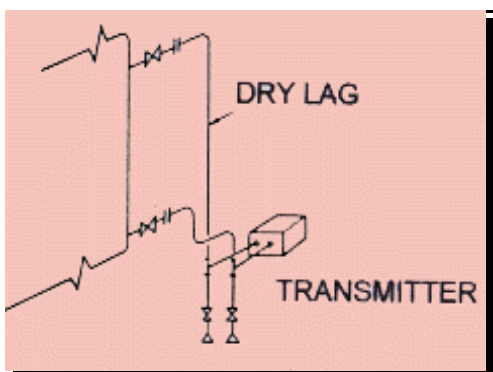
Float

Float

. Float

Float

4.1.3 Level-Meter



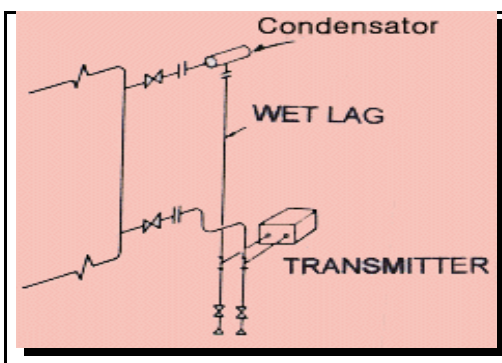
Level-Meter

가

2000mm

Displace Type

가



가

.Tank

Tank

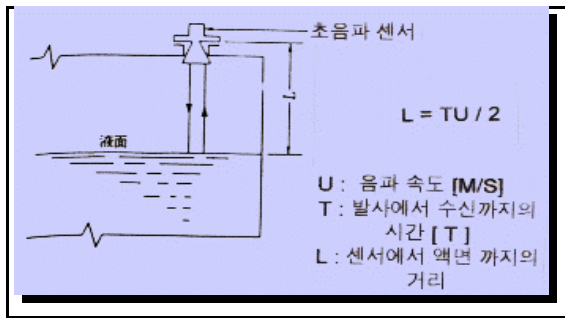
Gas
Head

.Tank

Head

가

4.1.4 Level Meter

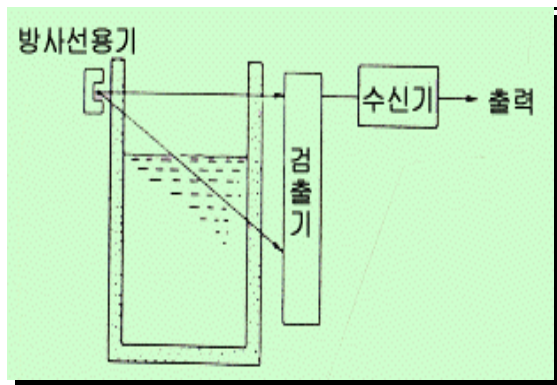


Level-Meter

Tank

Tank
가

4.1.5 Level Meter

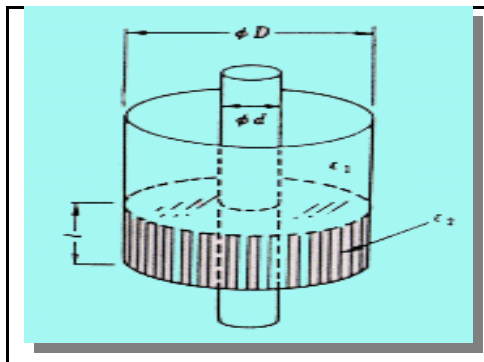


Tank

Tank
Level

가

4.1.6 Level Meter

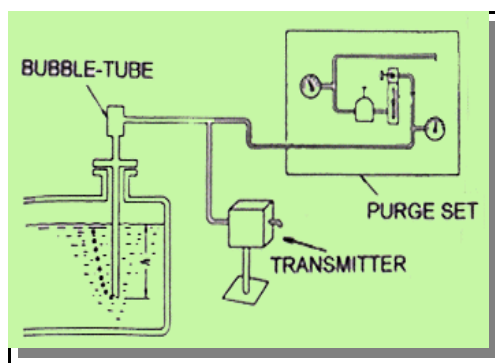


Tank

Tank

가
Level

4.1.7 Purge Type Level Meter



Tank

Bubble-Tube

Bubble-Tube

Purge

Bubble-Tube

Head * Density가

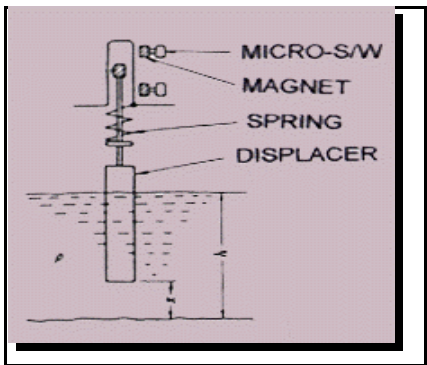
Level

가

Tank

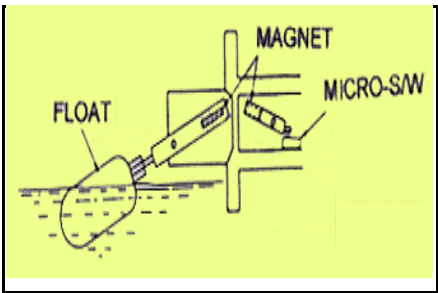
4.2 Level Switch

4.2.1 Displacement Level Switch



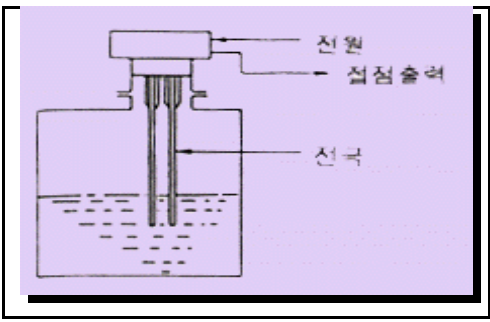
Plant 가
Level-Switch . Displace
Displace
Micro-s/w . Micro-s/w
가 Set Point

4.2.2 Ball Float Level Switch



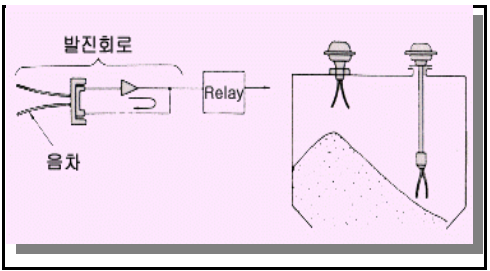
Rod Float
Magnet
가
Float Micro-s/w
Point Switch .

4.2.3 Level Switch



가 2
가 가
가 Relay 가

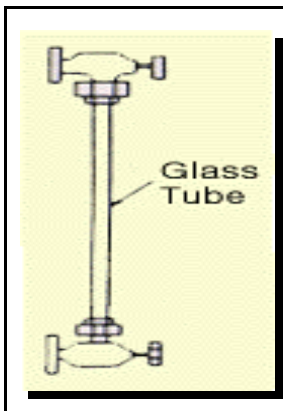
4.2.4 Level Switch



Level Switch
가
OpenLoop 가
Relay

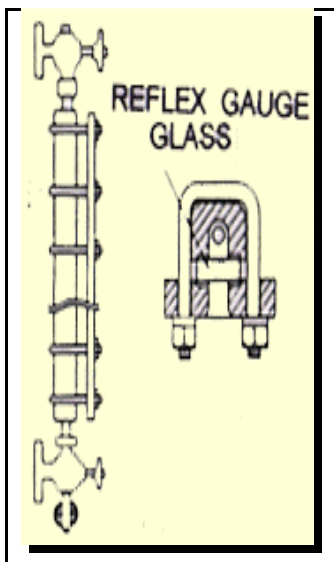
4.3 Gauge Glass

4.3.1 Glass Tube Type



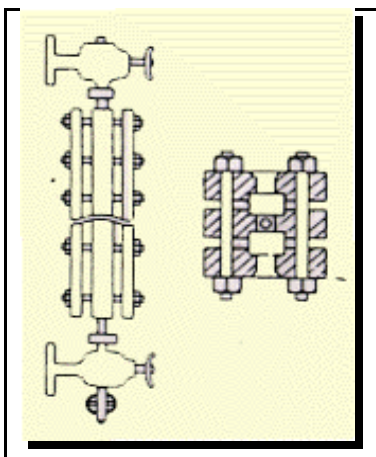
- : Glass () Gland Packing Gauge Valve
- : - 가 , , 가 .
- Gland
- : Sheet Metal, Plastic, Safety Glass Protectors
- : 30in. 가 가
30in. Gauge Glasses Overlapping
- :

4.3.2 Reflux Type



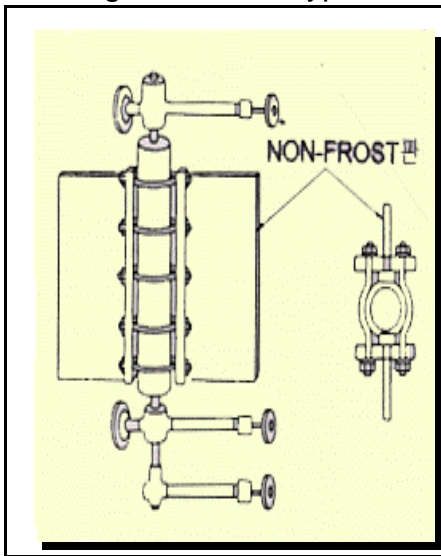
- : Gauge Body Cover Glass
. Glass
- :
: Glass 가
200 (),
Glass
: Water, , LPG, LNG

4.3.3 Transparent Type



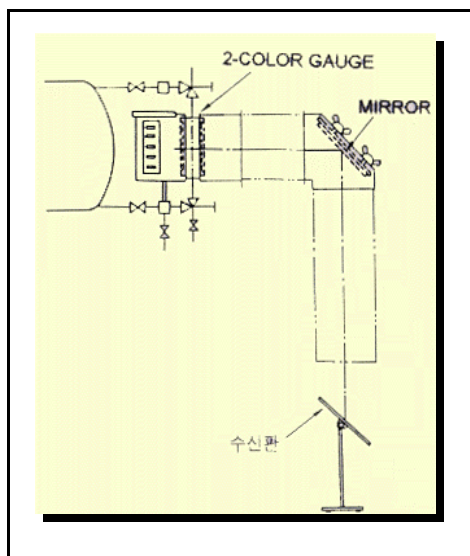
- : Gauge Body Glass
- : 가
- : Steam, Caustic, Acid, Glass
(,), Liquid-
Liquid Interface Service
- : Boiler - Gauge Body Gauge
Valve Bending Tube
- 300 kg f/cm² 가

4.3.4 Large Chamber Type



- : Gauge Body Pipe ,
- Glass 가 가
- Gauge Cover Pipe (=Gauge Body)
- Glass Bolt, Nut .
- : Gauge Body
- : Ethylene, LNG ,

4.3.5 Two-Color Type



- : Multi-pot Glass
- Two-Color Filter .
- :
- Gauge Glass . Boiler
- 가
- : (Hot Water)
- : 가 .

4.4 Level Meter

형 식	원 리	측정범위	정 도	온도한계	압력한계	특 징
GAUGE GLASS	GLASS TUBE	—	+ . - 1 mm	5 0 0°C	350 Kg/Cm	간편.정도가 높다.가격이 저렴.원격전송불가.파손위험
FLOAT TYPE	부력이용	0. 5 ~ 3 0 M	1. 5 ~ 3 mm			정도가 높다.취급간단.원격 전송가능.수리시 탱크개방
DISP' TYPE	부력이용	0. 2 ~ 3 M	0. 5 ~ 1. 5 %	4 5 0°C	30 Kg/Cm	고내압.내고온.원격전송가능 내식성.비중변화 따른 오차
차 압 식	액주압 차압이용	0. 5 ~ 2 0 M	0. 5 ~ 1. 5 %		400 Kg/Cm	고내압.내고온.원격전송가능 내식성.비중변화 따른 오차
PURGE TYPE	BACK PRESS	0. 3 ~ 1 0 M	+ . - 2 %		대기압	내식성.고점도액체.부유물 포함액체.개방탱크
초음파식	초음파 반사시간	0. 3 ~ 1 4 M	1 ~ 2 %	1 2 0°C	10 Kg/Cm	물성에 무관.비접촉.바람과 NOISE영향을 받는다.
정전용량식	전기용량 변 화	0. 5 ~ 2 0 M	1 ~ 2 %	1 7 0°C	70 Kg/Cm	분말.SLURRY.고점도 부식성 액체.유전율변화 따른 오차
방사선식	방사선 투 과	—	—		—	내고온고압.물성영향적음 방사선 자격 필요

III. Instrument Requirements

1. Temperature Instruments

- at top and bottom of all fractionation columns
- at the inlet and outlet of all fired heaters
- on the suction of all pumps, unless suction vessel temperature is measured
- on all product streams which are metered
- on the outlets of coolers, unless a receiver temperature is known into which the outlet flows. Also provide on the cooling water outlet
- a temperature indicator for checking all temperature controllers, using a separate thermowell.
- a temperature indication on the suction and discharge of all compressors.

2. Pressure Instruments

- pressure measurement at the top and bottom of each fractionation column.
- on the discharge of all pumps and compressors : also on suctions of compressor
- on the inlet and outlet of each reactor.
- a check instrument on all pressure controllers. On pneumatic transmitters this is a standard item, but on electronic instruments it must be called for.

3. Flow Meter Instruments

- at least a recording flow meter on all feed and product streams.
Some customers require integrating meters on all product streams
- a flow recorder on the reflux to each fractionation column
- on all recycle gas streams as well as a low flow alarm
- on the feed to all heater

4. Level Instruments