INTRODUCTION TO I & C ENGINEERING & DESIGN WORK

(PART 1)GENERAL AND FIELD INSTRUMENT

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B.E 1975,PE0593,ACPE02509/MM

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Engineering Design Work

- I & C- Engineering Design, Construction, Maintenance work.
- Emphasized I & C Engineering Information;(Instrumentation, Control and Telecommunication)
- I & C Engineering General Information is a fundamental aspect of the field Instruments and Control Devices under the guidance of the code and standards. This process involves applying principles of I & C engineering to solve real-world problems, innovate new technologies, and improve existing systems. I & C engineering design has two portions (Field Instrument and , Detail Engineering). It involved some Engineering Software Tools, Microsoft Excel, and Word, Auto CAD,3D Modelling , Smart Plant Instrumentation(INtools),InstruCalc for sizing of control valve, flow meter, safety valve etc,

Instrumentation(Field Instrument)

- **Field Instrument**

1-Measurement= Quantity to be measured-comparison with Reference in numerical values

2-Error=Measured Value-True Value,

3- Accuracy= Degree of Bias,

Precision= Degree of Dispersion,

Uncertainty =Degree of confidence on measurement ,

4-Type of Errors,

4.1-Caused by internal conditions

4.1.1-Zero Error ,

4.1.2-Span Error ,

4.1.3-Non-Linerarity Error,

4.1.4-Hysteresis Error ,

4.2- Caused by external condition ,

4.2.1Power Supply,

4.2.2-Temperature,

4.2.3-Position,

4.2.4-Noise,

4.2.5-Others caused by measuring conditions,

** Signals

1-Pneumatic –0.2 ~1 kg/cm2

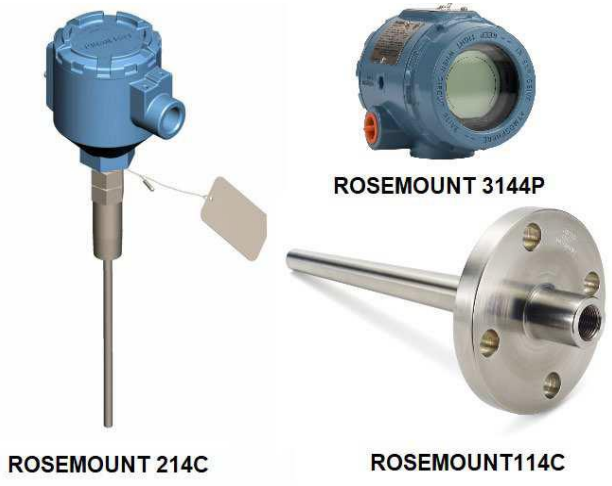
2- Electronic Signals- 0~20 mA dc,

- 4~20 mA dc,

-1~5 v dc,

-0~10V dc,

Protocols,(Modbus RTU ,Modbus TCP/IP,Ethernet , Profinet etc)



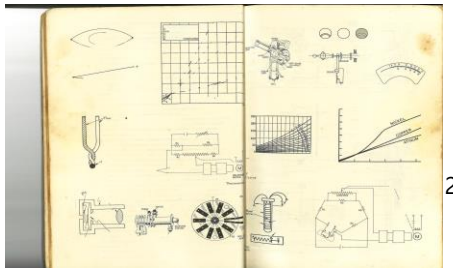
** **Instrument Types** ,

1- Temperature Measurement and Thermometers,

1.1-Thermocouples,

1.2-Pyrometers,

1.3-Resistance Thermometry ,



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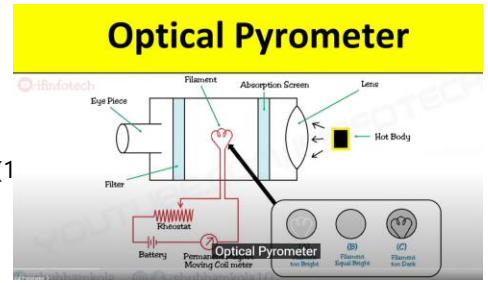
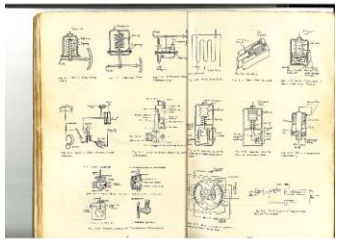


PYROMETER.zip

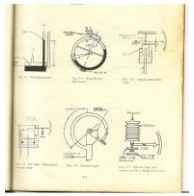
1.4-Liquid Expansion and Bimetal Type ,

2- <u>Pressure Measurements and Pressure Instruments</u> ,



2.1-Mechanical Pressure Transducers ,

PRESSURE-.zip



ROSEMOUNT 3051T +
ROSEMOUNT 306

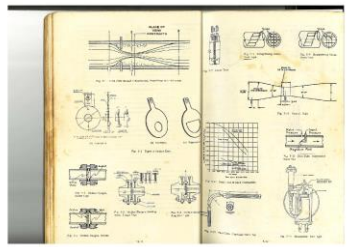
2.1.1- liquid columns,

2.1.2-Elastic Elements,(Bourdon ,Bellows , Diaphragm)

2.1.3-Magnetic/Capacitive Pressure Transducers ,

2.1.4-Strain Gauge/Resistive Pressure Transducers ,

3-<u>Flow Measurement and Flow Meters,</u>



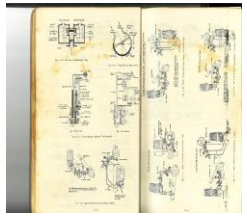
FLOW_.zip

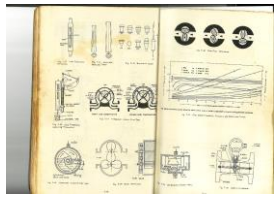
ROSEMOUNT 3051C+
ROSEMOUNT 305

3.1-Head Flow Meters,(Orifice, Venturi, Pitot Tube)

3.2- Area Flow Meters ,(Rotameter, Cylinder & Piston Type,)

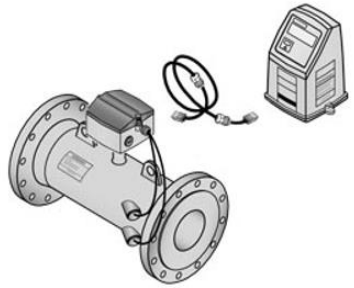
3.3-Positive Displacement Meter-(rotary vane,sealed drum,roots flow,oval gear,bellows meter,reciprocating piston,)



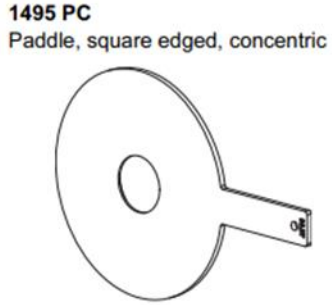


3.4-Turbine Flow Meter,

3.5-Magnetic Flow Meter,



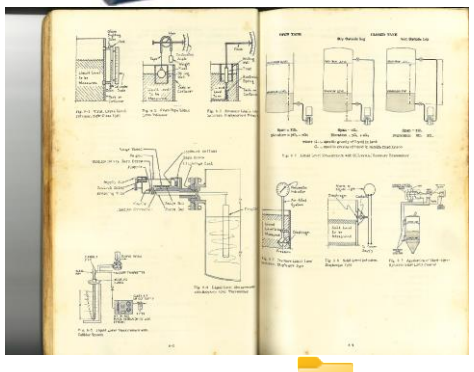
3.6-Acoustic Velocity Flow Meter,



3.7-Weirs and Parshall Flumes,

3.8-Mass Flow Meter ,(Coriolis Mass,)

4-<u>Level Measurements and Level Meters,</u>



LEVEL.zip

4.1-Liquid Level Measurement,

4.1.1-Visual Indicator-(Sight Glass, Gauge Glass)

4.1.2-Ball Float Type-(Float &Tape, Float & Shaft)

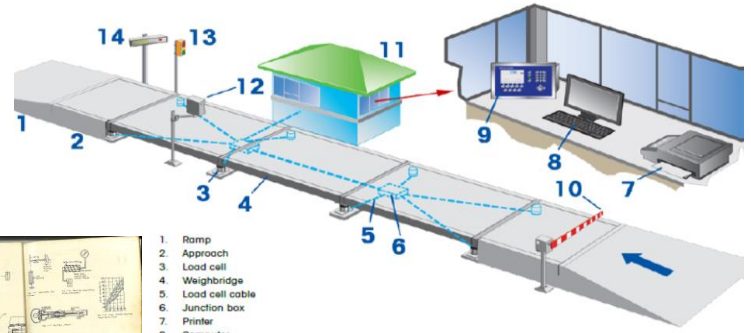
4.1.3-Displacement Type-(Torque Tube-Force Balance)

4.1.4- Pressure Measurement-(Closed vessel , open vessel)(manometer Type , Bubble type)

- Solid Level Measurement,(Guide Wave Radar, Float Type , Tuning Fork)

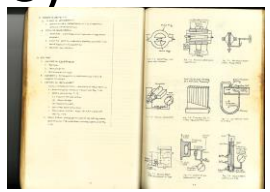
5-Special Measurement,

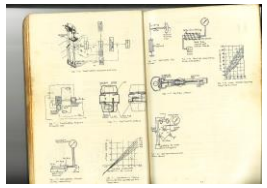
5.1-Weigh Scale,(Strain Gauge , Inductance Bridge , Balance Beam , variable differential transformer)



5.2-Techometer,(Mechanical , Stroboscope,)

5.3-Air Velocity Measurement(Pitot Tube)

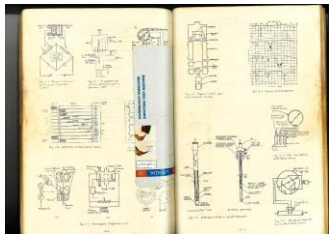




5.4-Density,

5.5-Hygrometer,(Relative Humidity)

5.6-Dew Point ,(The temperature at which water vapour In gas will condense into a liquid,)



6- Analysis Instrumentation,

GAS DETECTOR - BAY

6.1-Thermal Conductivity ,

6.2-Combustible Gas Detector,(Catalytic , IR Point Type , IR Open path Type)

6.3-Paramagnetic Oxygen Analyzer,

- Make: Rosemount 400
- Measure Range: 0-0.5µS/cm
- Electrode Material: Titanium
- Insulator: Glass Filled PEEK
- Body :316 Stainless Steel
- O-ring: EPDM
- Process Connection: ¾in. MNPT

- Make: Rosemount 3900
- Measure Range: 0-14
- Sensor body: Ryton - Polyphenylene Sulfide (PPS)
- EPDM
- PH electrode Material: Glass
- Solution Ground: Stainless steel
- Reference Junction: PTFE (Teflon)
- Process Connection: ¾in. and 1 in. MNPT

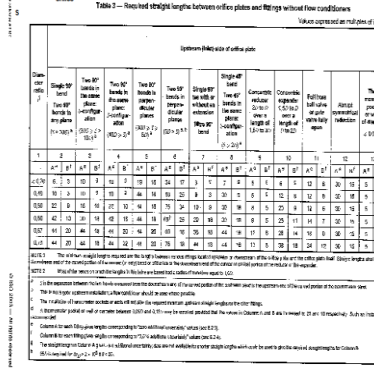
6.4-Ph(Hydrogen Ion Concentration)

6.5- Electrical Conductivity-

- **GENERAL INFORMATION FOR FIELD INSTRUMENTS**

1- Flow Measurement and Transmitters,

ISO 5167-.zip



1.1-DP type Orifice flow meters—

Beta Ratio-D/d-----0.2~0.7 , prefer one is 0.45 effect with straight run,

Reynold Number < 20,0000 which is effect with fluid properties,

Orifice Plate- Eccentric , square edge –for slurry liquid/Concentric , tapered-normal steam , water

- If the Minimum flow required to measure is lower than 33% of the meter maximum then a additional transmitter shall be provided to achieve the required turn down for DP type flow meters,
- Straight run requirement – Beta ratio/upstream 90”elbow distance , 90’ two plane position,(10D/5D~44D/5D),S is distance between downstream elbow and upstream elbow before flow meter .

1.2-PD ,Coriolis Mass flow meter – not much effect the required straight run requirement ,

- Custody measurement- Max. Permissible Error(MPE) class0.3, Accuracy is the principle & MPE is the measurable, regulated expression of it,
- Min-30% FSD @turndown ratio 10:1,NOR-70%FSD,Max-90%FSD,(MPMS)
- Accuracy- +/- % value of reading at measurement time , Uncertainty-+/-0.27%

Calibration- Check orifice dimension, calibrate DP transmitter with Manometer, transmitter output signal shall be square root scale ,

- -Turbine Meter – send it to international lab for calibration,
- -Compare standard calibrated meter (prover) in series with main meter,
- -Check 5 point calibration (0%,20%,50%,75%,100%)
- -Check hysteresis error ,zero/span error,
- -Mass flow meter – check zero calibration, Volume flow cutoff adjustment,

2-<u>Temperature Measurement and Transmitters,</u>

2.1-Scaling – Normal operating temperature indication shall be at approximately mid scale.

2.2-Accuracy- Liquid filled thermometer- 1% of measuring range

- Transmitter- 0.1% of Span,

2.3 General--- temperature for remote transmission shall be measured by resistance thermometers or by thermocouple as follows :

-(-200 to 500°C)Resistance thermometer Pt 100, 100 Ohm at 0°C

- 500 to 1100°C Thermocouple (type K)

- over 1100°C Thermocouple (PtRh – Pt)

- For all temperature measurement dual temperature element shall be used. Smart temperature transmitters shall be used to convert the RTD or Thermocouple signal into 4 to 20 ma in the field for all temperature measurements.

- Resistance thermometers shall be connected using a three-wire loop

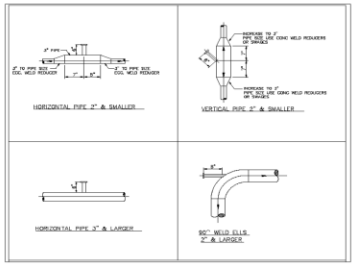
or four-wire loop. RTD in general applications shall be encased in ceramic insulating material which is firmly compacted within a metallic sheath.

- BI-METALLIC THERMOMETERS-shall generally be used as local indicators with "yoke free angle" type, 100 mm dials and shall be furnished with separate sockets.
- LIQUID FILL THERMOMETERS-shall be used for locally mounted when bimetal type thermometers cannot be applied. Bulbs shall be stainless steel 1/2 inch maximum and 150 mm maximum length. Capillary tube shall be stainless steel with stainless steel armour cover.
- THERMOWELLS-The minimum Insertion length of thermo wells shall be 50mm inside the Pipe line. Natural frequency and stress calculation shall be done for all thermowells as per ASME PTC 19.3 and the thermo wells shall be designed to prevent mechanical, failure due to vibration. In case of gas/steam service the ration of wake frequency to natural frequency shall be less than 0.4 and for liquid service it shall be less than 0.8.
- TEMPERATURE TRANSMITTER--The Transmitter input shall be field configurable. It shall accept all types of thermocouple , all types of RTD. The transmitter shall have the facility to select any mv/temp or ohms/temp conversion tables per JIS, ASME or IEC.
- Range - Gauge: Select ranges where normal operation is at 50% scale.

  - Transmitter: Ensure operating points within 10–90% of URL (LRL-0,URL-100

  - Gauge and transmitter range shall be same .

THERMOWELL ..



TW.zi

- Calibration- Calibration Baths: Temperature-controlled liquid baths provide stable, uniform temperatu calibrating multiple instruments simultaneously.

  - Fixed Points: Some calibrations use physical reference points like the melting point of ice (0°C) or boiling point of water (100°C at standard pressure), though these are less precise than modern methods.

3-Pressure Measurement and Transmitter,

- 3.1-Scaling – All pressure instruments shall be specified with a range of approximately twice the operating pressure, except where process conditions dictate otherwise . Gauges shall be provided with bleed and block valve for isolation and venting. The bleed and block valve shall be of SS316. The block and bleed valve (Instrument Manifold) shall be in addition to isolation valve provided

by piping Double root isolation valves shall be ensured for guage installation for all application of the pressure range 39 BarG and above.

Wika pressure gauge 232.30 and 233.30.zip

Snubber (Dampener) and chemical seal to pressure gauges shall be provided based on application (Pump/compressor discharge,corrosive/slurry service)

- Transmitters shall be supplied with integral LCD displays that shall be configured to read out the process parameters locally, in engineering units, in order to assist operation crews. The LCD displays shall not be separate but shall be a part of the manufacturer's unit and equally certified for IP and hazardous area ratings.

PRESSURE SWITCH (2).zip

*Pressure Switch-Set value of the switches shall be between 20% to 80%.

4-Level Measurement and Transmitters,

- When displacer transmitters are required, they shall be limited to a length of 60” When used in boiling liquids; displacer shall be purged to prevent bumping.
- Float-and-tape-type gauging shall be employed on tanks with contents at or near atmospheric pressure.
- Reflex-type gauge glasses may be used for local level indications with the following exceptions: interface; very high viscosity fluids; acid or caustic service; steam and condensate above 20 BarG. These exceptions require through-vision or transparent gauge glass and consideration of illuminators.
- Minimum 1” overlap is required between gauge glasses when two or more are used.

- Local level indication for large tanks or spheres shall be float and graduated tape. The level shall be read directly in meters (or feet) from the tape at a convenient elevation. This type shall be used with a transmitter for remote indication or recording.

Float and board le

- Differential pressure type level instruments shall be furnished for any level range in cryogenic service or in non-cryogenic services. Remote seal differential pressure transmitter will be used .
- Range – 0~100 % or mm,m scale ,

5- <u>SIL Classification</u>,(Safety Integral Level)
SIL1, SIL2,SIL3,SIL4—SIL study and SIL Classification,

6- <u>Voting Logic-</u> 2out of 3(2oo3), 1 out of 2 (1OO2)-for SIL 2 loop,

7- <u>Electrical, I&C</u> <u>required</u> suitable zone classified ATEX certified Equipment, (EEx d,EEx e,EEx p, EEx ia , EEx ib,etc)

8-INSTRUMENT ACCURACY,

The various types of instruments shall have accuracy which are equivalent to or better than the values specified below.

Instrument Type	Required Accuracy
Liquid-filled thermometer	1 % of measuring range
Temperature transmitter	0.1% of span
Pneumatic receiver gauge	1 % of span
Pressure gauge	1.0 % of span
Electronic pressure and differential transmitter	0.1 % of calibrated span drift 0.25 % max span in 6 months
Displacement type level meter	0.3 % of measuring range
Positive-displacement type flow	0.5 % wt. Flow meter
Orifice flow	1 %
Custody measurement for Flow	+/- 0.25% actual reading flow (uncertainty)

Rotameter (for process use)	2 % of full scale
Magnetic flow meter	1 % of actual flow rate
Turbine flow meter	0.5 %
- For custody transfer	0.15% of reading
repeata bility	0.02% at any point
Vortex flow meter	1 % of reading
Mass flow meter	0.5 % of reading
Combustible gas detector	zero drift 5 % in 12 months
Tank gauging	+ 1 mm.

9- Measuring Units

The following units shall be utilized for the measurement system.

• A) Flow (Liquid / steam)	kg/h
H2,N2 and other gas	Nm3/h
• B) Level (Standard)	0-100 %
(Tank Gauge)	Meters

C) Pressure (Standard)	Kg/cm2G
(Vacuum)	mm Hg
(Low pressure of Draft)	mm H2O
(Absolute)	mm Hg A
D) Temperature	oC
E) Weight	kg
F) Composition of vapor sample	Mol %
G) Composition of liquid sample	Wt %

10-INSTRUMENT CONNECTION

Instrument measurement connections shall be as follows except other particularly specified.

• **Flow :**	**Inst.Connection**	**Process Connection**
Differential pressure (D/P) type In-line flow meters	1/2 “NPT female screwed	1/2” flanged ASME Flanged(Min 300#RF) (according to size)

• **Level :**		
-Magnetostrictive external chamber	2” flanged	2” flanged
-Magnetostrictive gauge with guided wave radar external chamber,	4” flanged	4” flanged
-D/P type (Remote seal)	1/2” flange	1/2” flanged
-Gauge glass(standard)	3/4” flanged	3/4” flanged
-Gauge glass (slurry)	1-1/2” flanged	1-1/2” flanged
• **Pressure :**		
-Transmitter (standard)	1/2”NPT(female)	1/2” flanged (line)
-Transmitter (Diaphragm seal)	2”flanged	2” flanged
- Pressure gauge (standard)	1/2”NPT male-	1/2” or 3/4”flange
- Pressure gauge (diaphragm)	2” flanged	2” Flanged
***Temperature:**		
- Welded thermowell	1” Socket weld	1” coupling line
- Flanged thermowell (vessel)	1-1/2” flanged	1-1/2” flanged

11-FLOW INSTRUMENT (seminar)

11-1– Mass Flow measurement

- Coriolis Mass Meter, Thermal Meter ,

11-2-Volumetric Measurement,

-Positive Displacement Meter---(oval gear , Bi-roter)

-Velocity Meter---(Magnetic,Vortex,Ultrasonic,Turbine)

11-3-Head Flow Meter-DP Flow meter(Annubar,Orifice,Venturi,Nozzle,Pitots)

-Target Meter(Disc,Spherical,Flat Plate)

Flow Seminar.zip

12- FINAL CONTROL ELEVENM ENT

- The final control element must be fabricated in compliance with the data for the design and operation specified in the engineering data sheets.
- ESD valves located in potential fire hazardous areas shall be fire safe design to API 607 or BS 5146.
- Control valves with globe - body shall be specified for all applications except *where low* pressure drops, high capacities or other adverse operating conditions make other types more suitable.
- **Control Valve Types –**Globe Valves-Single seated ,double seated , Cage style

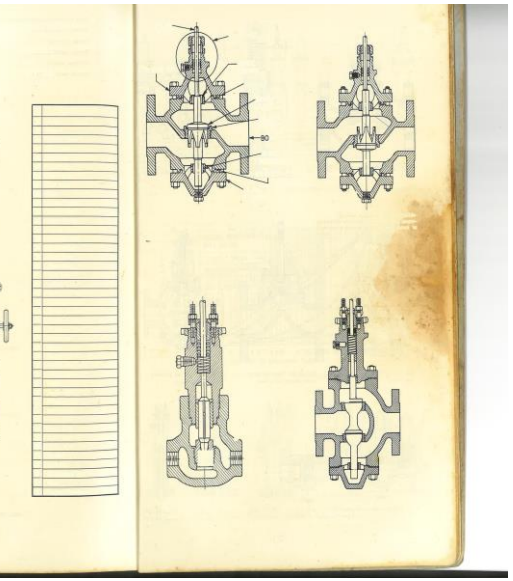
  -Rotary Valves-Ball Valve, Butterfly Valve , Plug Valve,

*__Flow Characteristic-__ Linear Flow Characteristic-

(Equal increments of valve travel produce equal increments of flow, Good for liquid level control, Pressure drop remains relatively constant)

[Re

-Equal Percentage Flow Characteristic



(Equal increments of valve travel produce equal percentage changes in flow, Good for flow and pressure control, Most common characteristic for process control)

-Quick Opening

(Large flow change with small valve movement, Primarily for on/off service, Used in safety shutdown applications)

- **Actuator Integration-** Pneumatic Actuators (Spring-and-diaphragm or piston types)

Valve & Curve.zip

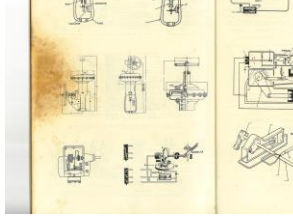
- Electric Actuators(No air supply required)

- Hydraulic Actuators(Fast response times)

***Material Considerations-**

Body Materials-Carbon steel, stainless steel, cast iron-following pipe material

- **Trim Materials-**(Stainless steel standard, Hardened materials for erosive service, Special alloys for high-temperature applications)



*** ACTUATORS, POSITIONERS AND ACCESSORIES**

- Control valve actuation shall be pneumatic; the actuator shall operate between 0.2 - 1 kg/cm2 for full stroke as a standard. Where pneumatic actuation of control valves is applied in electronic control systems, an Electro/pneumatic smart positioner shall be installed.

EP POSITIONER.zip

- **POSITIONER**

All throttling control valve actuators shall be provided with smart positioners . When a solenoid valve is installed on a control valve with a positioner, the solenoid valve shall be mounted between positioner and actuator.

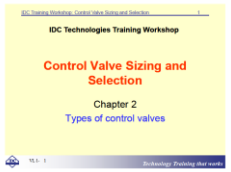
***DEFINITION OF THE CV -VALUE**

- The Cv-factor of a control valve is defined as the quantity of water inU.S.gallons per minute that will flow through the valve in the fully open position with a pressure drop of 1 pound per square inch (psi). The Cv-Factor is usually determined from capacity tests with water under moderate pressure drop. The valve size shall be selected in accordance with the calculated Cv values for the normal, maximum and minimum flow. A valve trim shall be selected so that the normal operating Cv of the

valve is achieved at 60 % of the valve opening. The Cv for maximum 85 % of the Cv. the valve is less than 0.3 mach for continue operation , and less than 0.5 mach for Intermittent operation.

- **ENERGENCY SHUT OFF VALVES** (ESD valve)
- Shut - off valves are supplied for automatically interrupting the process fluid or utility supply in emergency conditions. Also in the view of mechanical strength, shut - off valves shall usually be the same size as of line size.
- Stroke Test is recommended for ESD valves for safety.

02-VL-slides 02-R2 (Presentation).zip




Split Body

- No leakage is allow, TSO-tight shutoff valve ,
- **RELIEVING DEVICES**
- Flanged relief valves shall be with enclosed spring (except for air and steam) with bolted bonnet, screwed cap, full nozzle type with stainless steel nozzle, disc, guide and spindle, and cast carbon steel bodies.)
- To select the set point of the safety valves in such a way that the maximum operating pressure is always below 86 percent of the set point. The Design pressure of the equipment or the line shall be selected accordingly.

PRV-slides 1.zip

- Motor Operated Valve-(MOV)

Valves which require high torque, where slow action can be tolerated

and where cylinder operated valve become large and uneconomical

MOV shall be used. Rotork or Auma , Limitorque ,Bettis (Emerson)Actuators shall be used for MOV's.

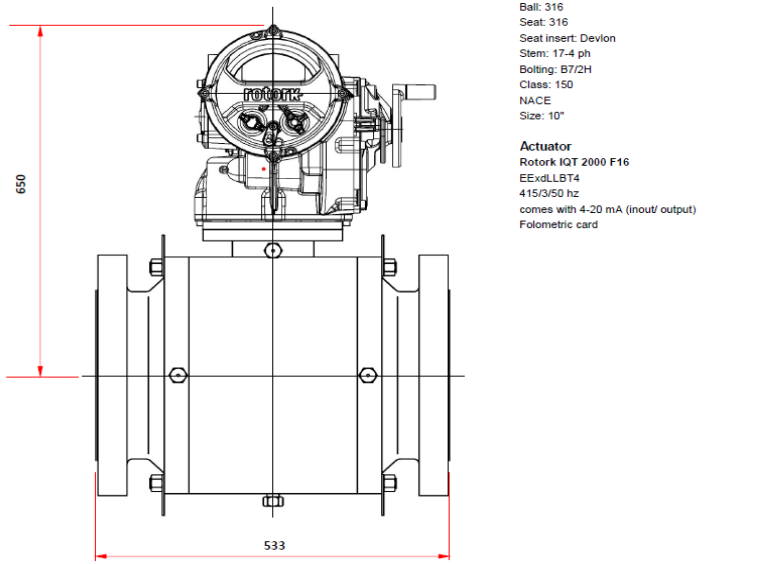
-Operation---Local open/close

---Remote open/stop/close

---Remote modulating(4~20mA)

---Remote Profibus DP , Foundation Fieldbus,

Rotork IQ & IQT catalogue (2022).zip



Valve
Heaton API 6D Trunnion Mounted Ball Valv
3 pc side entry, anti-static, fire safe
Body: A105N
Ball: 316
Seat: 316
Seat insert: Devlon
Stem: 17-4 ph
Bolting: B7/2H
Class: 150
NACE
Size: 10"

Actuator
Rotork IQT 2000 F16
EExdLLBT4
415/3/50 hz
comes with 4-20 mA (inout/ output)
Folometric card

GA drawing

- THANK YOU