Cairo University
Faculty of Engineering
Mech. Power Department

ACC Virtual Labs
Automatic Control Circuits & Virtual Labs for Mechanical Power Systems
معمل التحكم الأوتوماتيكي و المعامل الافتراضية لنظم القوى الميكانيكية

دبلوم تطبيقات التحكم الأوتوماتيكى في نظم القوى الميكانيكية

MEP 599 Diploma Design Project-Term1 2017/2018

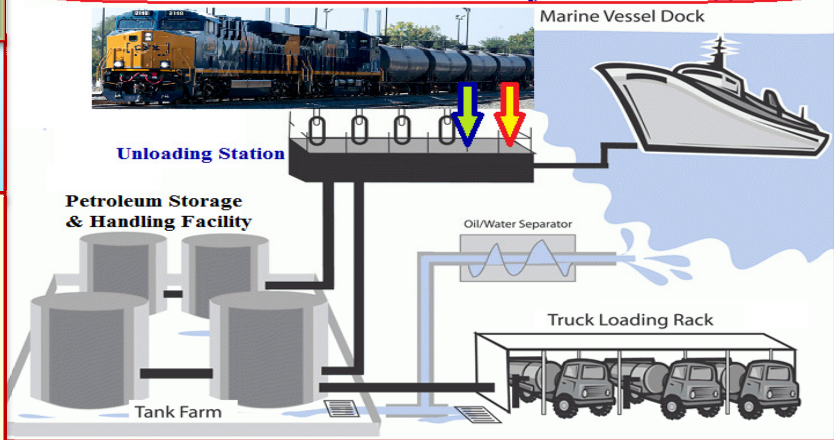
Design of Storage and Handling Facility for Petroleum Products

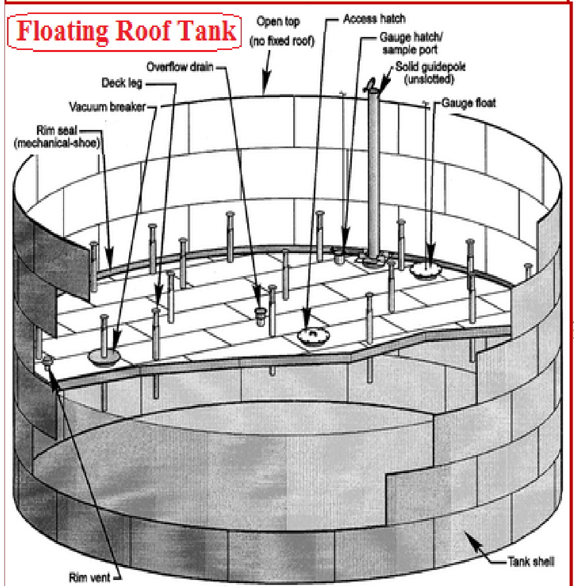
by Eng. Eshak Ibrahim Zaki

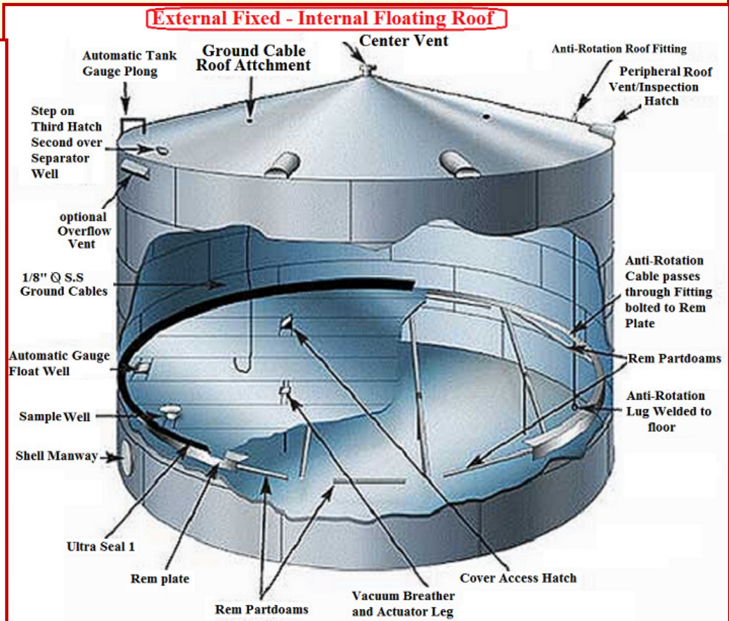
Supervised by Dr. Mohsen S. Soliman, ACC Manager, Mech. Power Eng. Dept.

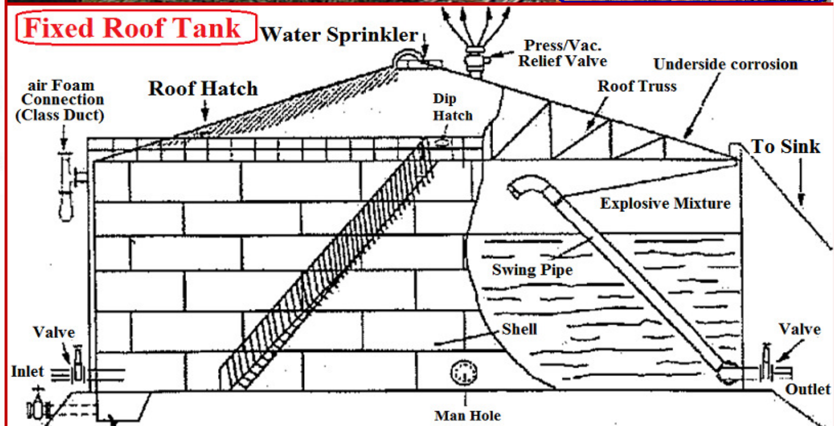
Abstract: This an exercise for design of storage & handling facility for 3 different petroleum products. Tanks are used to store incoming products for later domestic demand such as in small service stations. A total Facility area is assumed about 6000m^2(123x48m). Assumed layout of this facility has inlet unloading station (from railways/ships), 3 vertical tanks, internal pipe-lines, required pumping & truck loading systems. Same capacity 3 tanks (12m D&12mH) are used. Fixed roof tanks are used for Gasoline & Kerosene. Floating roof tank is used for Light Fuel Oil. The design also includes essential flow, level, temperature, pressure measurement, valves, sensors & control equipment. International Standards (e.g., API, ASME, DIN) relevant to the project are given. Design calculations are shown for the shell of tanks and pipe-line head losses. The project doesn't however, include fire protection-fire fighting with tanks cooling systems nor the earthing requirements for tanks nor for the piping system .

Petroleum Terminal/Facility Flow Diagram









<u>Storage Tanks:</u> Selection of # & type of Tanks depends on:

1-Total capacity to be stored, storing rate & storing place.

2-Products type which can affect tank shape and type.

In normal condition, storing rate depend on total production capacity, feature plans &season changes. Transmitting types (by trucks, railway, sail tankers or pipe lines). Pipe lines are consider the beast & cheapest petroleum transport method.

<u>Tank Design:</u> Calculation of optimum dimension -

For given data: D = 12 m H=12m

<u>Calculation the volume of tank</u>

V = H ((Ԉ / 4) D²= (Ԉ /4)* 12²* 12=1357.1 m³

<u>Calculation the area of roof, bottom and land</u>

Area of roof = Area of foundation = area of bottom = area of land = (Ԉ /4)D²= (Ԉ /4) * 12²= 113.09 m²

<u>Calculation the area of shell :</u>

Area of shell = Ԉ D H=Ԉ *12*12=452.38 m²

<u>Calculation the Thickness of Shell Plates:</u> The minimum thicknesses of shell plates shall be computed from the stress on the vertical joints, using the following formula in SI units

$$t = \frac{4.9D(H-0.3)G}{(E)(145)} + CA$$

<u>*Where:-*</u> t: Minimum thickness, in mm.

D : Nominal diameter of the tank, in m.

H : Design liquid level, in m.

G : Specific gravity of the liquid to be stored, as specified by the Purchaser. The specific gravity shall not be less than 1.0

E : Joint efficiency, which is either 0.85 or 0.70

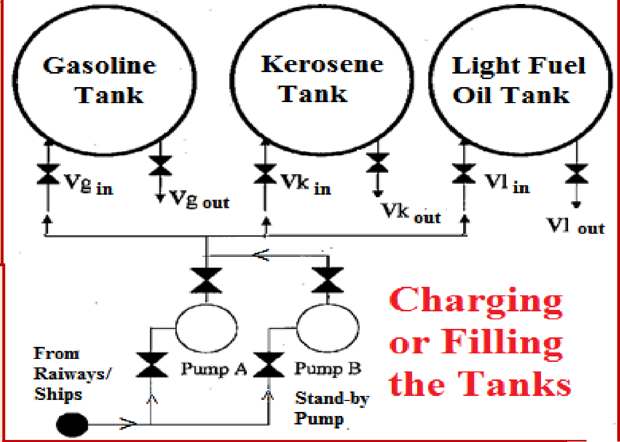
CA : Corrosion allowance, in mm, as specified by the Purchaser.

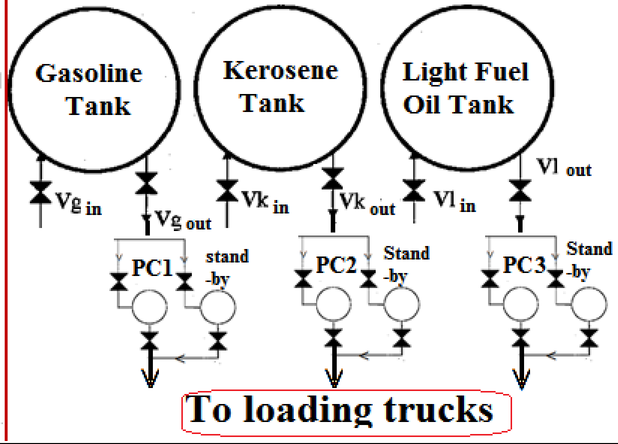
Design liquid level	No. of courses	Thickness	Thickness
12,6	1	0.7156	6
10,8	2	1.2744	6
9	3	2.433	6
7,2	4	3.2921	6
5,4	5	4.1509	6
3,6	6	5.0097	8
1,8	7	6.8685	8

<u>Factors Effecting on Pipe Selection:-</u>

•Max. Pressure by Head of pump, so after selecting pump must be that head in pipe large than head of pump.

•Selection of diameter depend on Flow rate & Recommended velocity. The recommended velocity is from (1 m/s - 3 m/s) from API 610 . - The suction loss which is direct proportional with square velocity and then as diameter decrease the velocity increase and suction loss increase so the ability occurrence of the cavitations increase. The length of the of the pipe line depend on design of network and available area. The final selection of the diameter of pipe line by make comparison between the result that be calculated and pump head and the ability of cavitations.





<u>Pump A or B &Suction Line into 3 Tanks</u>

Length at Suction Side = 52 m

Length at Discharge at Gasoline = 33 m

Length at Discharge at Kerosene = 23 m

Length at Discharge at Fuel Oil = 53 m

Diameter of Suction =10 inch

Diameter of Discharge = 8 inch

Pump A or stand-by Pump B

	elbow	T	Flange	filter	Ball valve	Check valve	Motorized valve
suction	3	2	6	1	1	0	0
discharge (G)	1	3	4	0	2	1	1
discharge (K)	0	4	2	0	2	1	1
discharge (L)	1	4	6	0	1	1	1

<u>Pump Cl System with Stand by Pump</u>

Length at suction side = 52 m

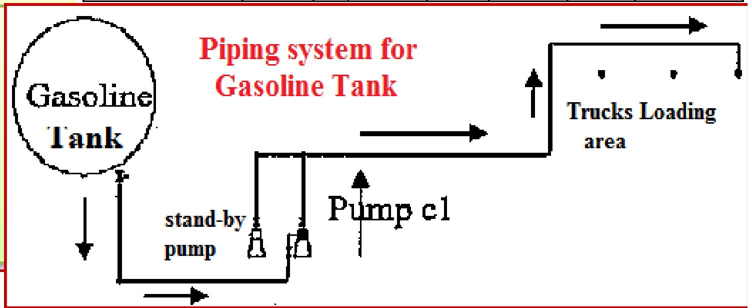
Length at discharge = 90 m

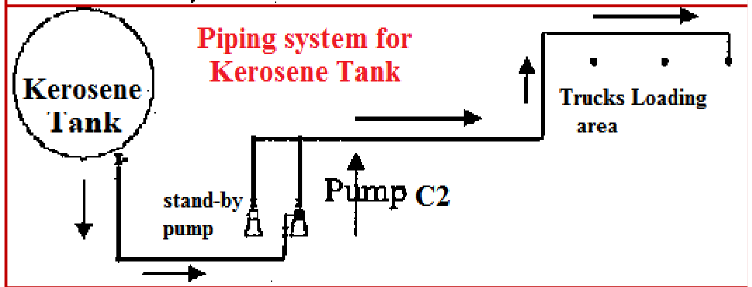
Diameter of suction =10 inch

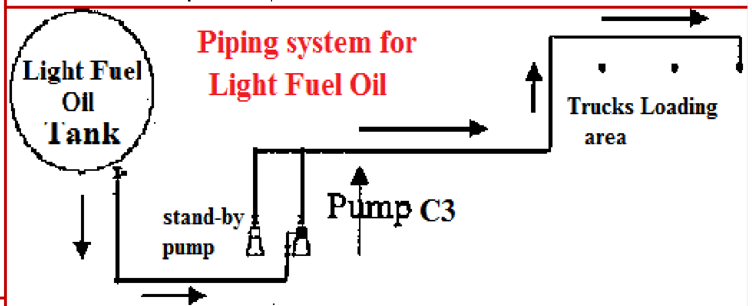
Diameter of discharge = 8 inch

<u>Pump Station Design:-</u>

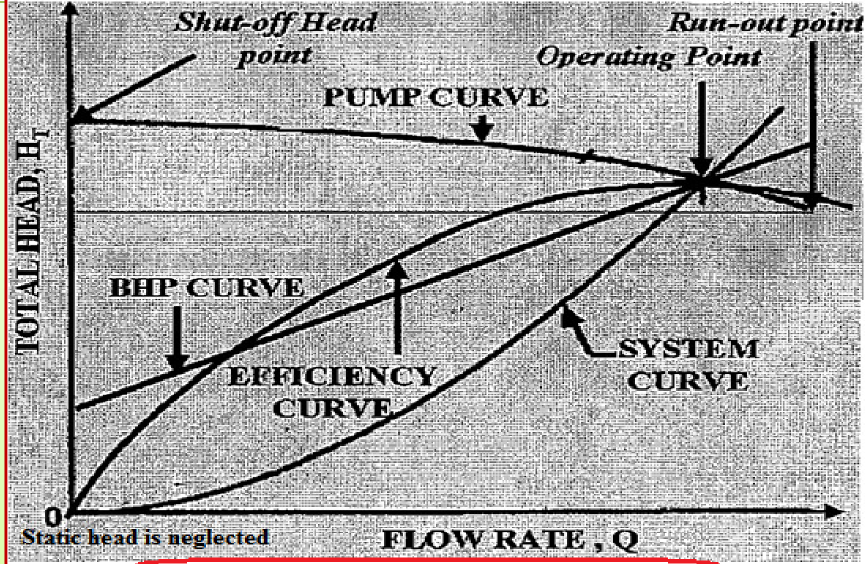
The design needs only one pump A (with stand-by one B) for suction where the plant doesn't received more than one product at the same time so, the design need only one pump for receive the products. The plant contains three products and the de-livery of products can be done at the same time then the plant needed three delivery pumps C1, C2, C3 (3 stand-by ones).







Pump Selection:- 1st determine flow rate of pump for filling tanks and filling trucks and determine it where the volume of tank is 1356.48 m^3 then if required time is estimated as about 4.5 hours then the flow rate is 300 m^3 /hr and at that flow rate the truck will fill at about 14.28 min where the truck volume is about 71.4 m^3 (50 ton) and its suitable time then the working pump flow rate is 300 m^3/hr. After determination of the flow rate of the pumps then head is required. Determi-nation of pump head takes by calculation the loss in fuel oil line where it is the highest loss because of the greater length and higher viscosity and that in case of suction pump but in case of stand by pump calculate head in all type of product lines in delivery process where it is the longer line so, max. Losses so, the greater pump head. From the previous the calculation is done on the max. Losses where all pumps in the system will be selected similar. In delivery pumps calculate the head in each pump line. After determine the head of all pumps select the greatest head which is 25.2m then select the head of all pumps 52m. Then from H-Q curve determine the efficiency which is 79%. Then pumps that will be selected with discharge 300 m /hr, head 52 m and efficiency of 79%.



Centrifugal Pump Performance Curve.

Calculation of head of pump:-

-Determine the system curve equation $R = H_{ST} + K_R Q^2$

- The unknown in this equation is K in which:-

$$K_R = \frac{8 \Sigma k_S}{\pi^2 D_S^4 g} + \frac{8 f L_S}{\pi^2 D_S^5 g} + \frac{8 \Sigma k_D}{\pi^2 D_D^4 g} + \frac{8 f L_D}{\pi^2 D_D^5 g}$$

Where:- **R** : Resistance in line. H_{ST} : Static head .

K_R : Summation of losses in suction and delivery line

f : Friction factor. **Ls:** Length of pipe in suction side.

L_D: Length of pipe in delivery side.

V : Velocity.

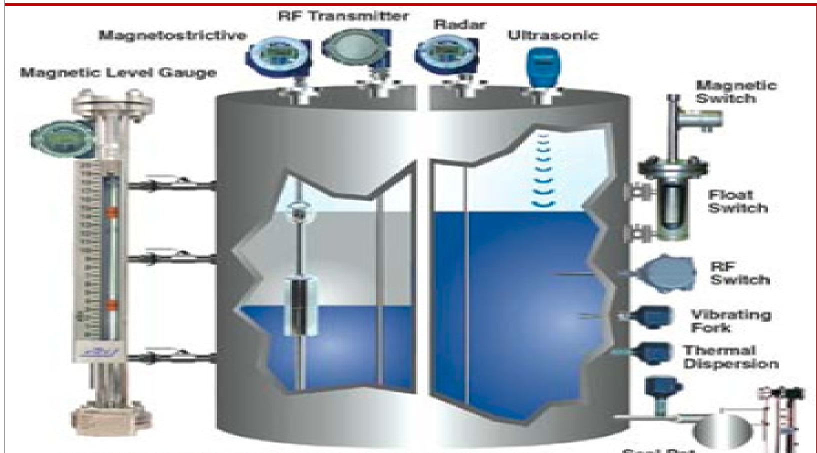
Σk_D : Summation of minor loss coefficient in delivery side

Σks : Summation of minor loss coefficient in suction side.

Get value of R & selecte head of pump greater than R to overcome resistance in system& from H-Q curve determine value of pump head at Q= 300 m /hr which work near max. efficiency. After determining pump head, check that cavitations not to occur. This done by calculating $NPSH_a$ & from (H-Q curve) get $NPSH_R$ if $NPSH_A$ > NPSHr then there is no cavitations', otherwise the pump is cavitated. $NPSH_a$= «P_{atm}- P_v)/ɣ) - (Z+h_{LS}) Where:- h_{Ls} : Losses, in Suction Side. Z: Suction Head. P_v: Vapour Pressure of The Liquid used in the Pipe. P_{atm}• Atmospheric Pressure, y: Specific Gravity.

Note:- $NPSH_a$ will increase by making level of plant under land surface about 2m. So the pumping process will be safe.

Factor affect on Pump Selection:-Head required. Flow rate. $NPSH_A$. Efficiency. Selecte from(ALLWEILER-FARID)Pumps Characteristic curve at n-1450 rpm and N_s=l 7.740 so type of pump used in the system is Volute Casing Centrifugal Pumps with Hydraulic Capacity according to DIN 224255.



Liquid Level measurement

Control System:

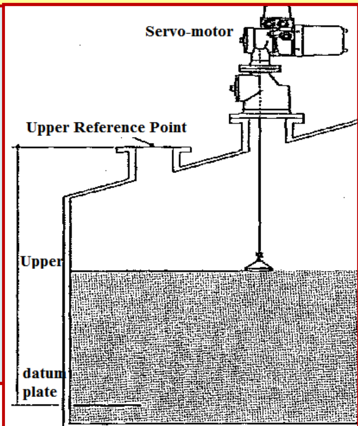
Types of measurement in the storage Facility:

-Liquid level /height measurement.

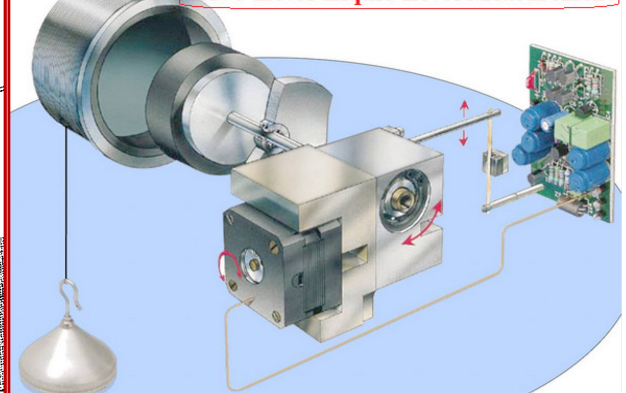
-Volumetric Flow rate Measurement.

-Temper.measurement

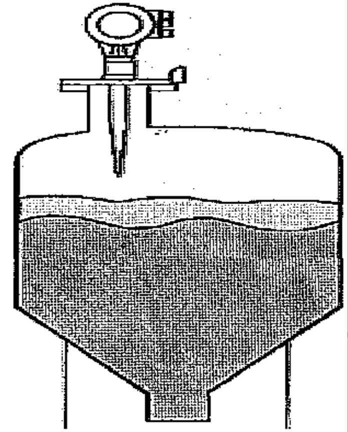
-Pressure Measurement.



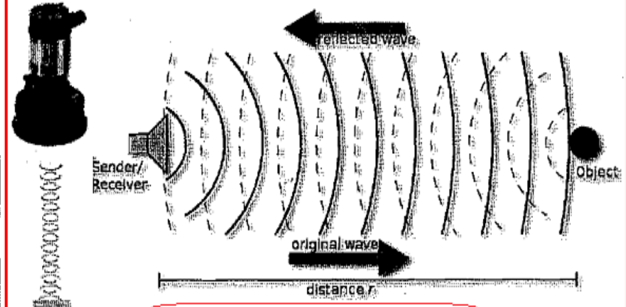
Servo-motor Liquid Level Measurement



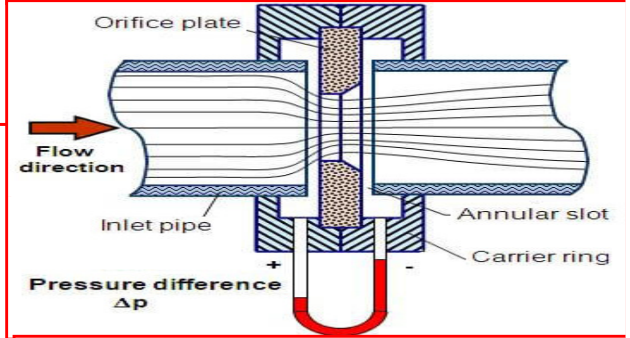
Liquid Level Measurement:- Automatic Tank Gauging (ATG) is a scalable solution for liquid inventory, custody transfer, tank farm, and reconciliation applications. A unique hydrostatic measurement technique provides continuous monitoring of volume, level, density, mass, temperature& water bottoms at levels of reliability,accuracy& safety not possible using conventional hydrostatic measurement methods or other ATG system measurement technologies also provides leak, overfill, & theft monitoring. ATG System consists of accurate measurement recording instrumentation, flexible intrinsically-safe communications network& user friendly Windows based tank management software. The available type of (ATG): Pressure Sensor (GAUGE). Servo gauge. Level Gauging Radar Transmitter. Ultrasonic level detector.

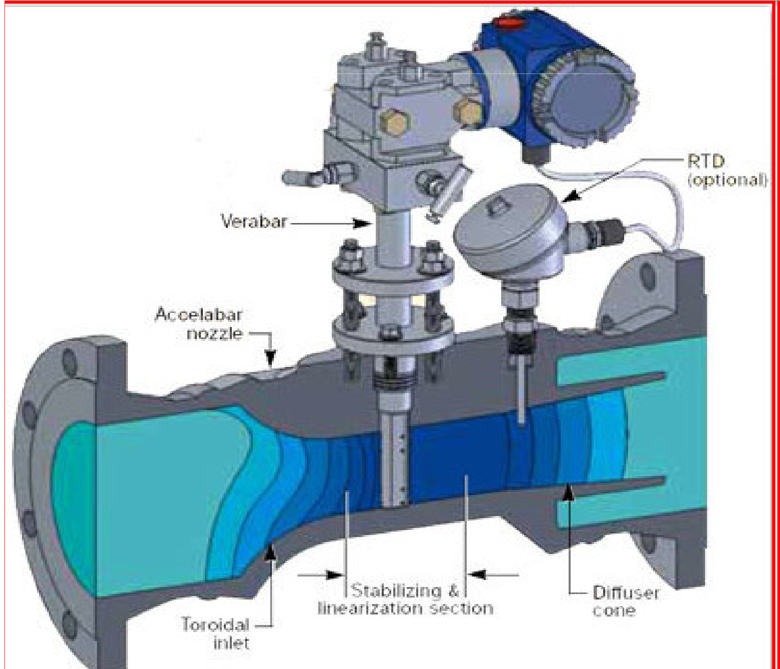


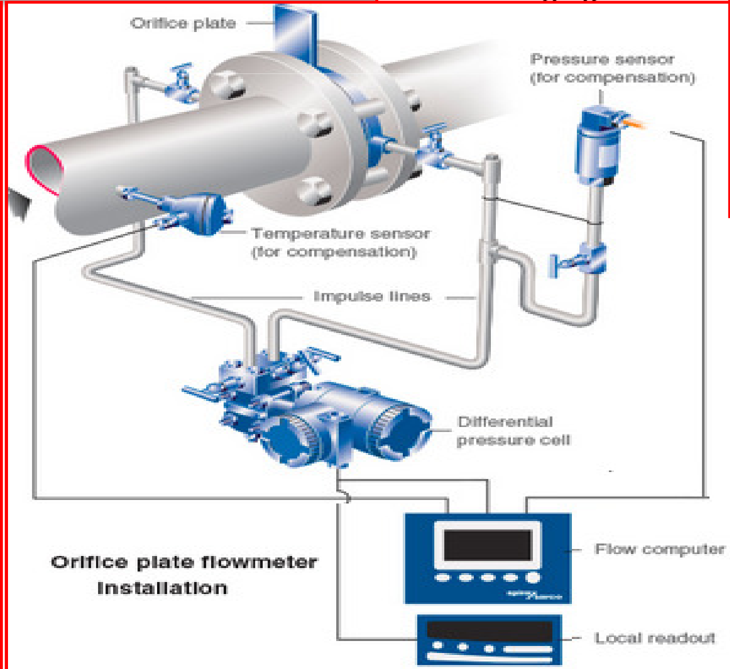
Level Gauging Radar

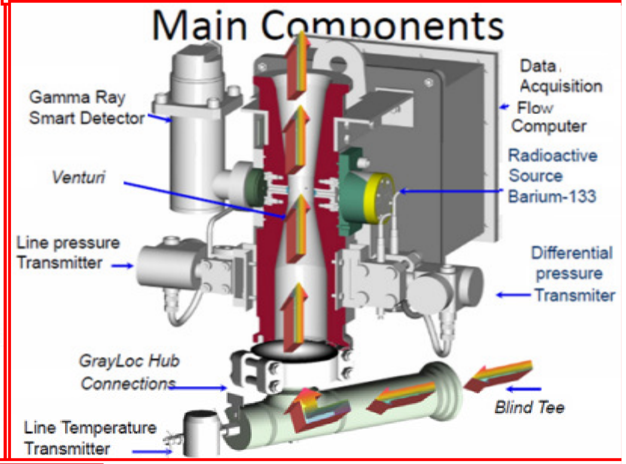


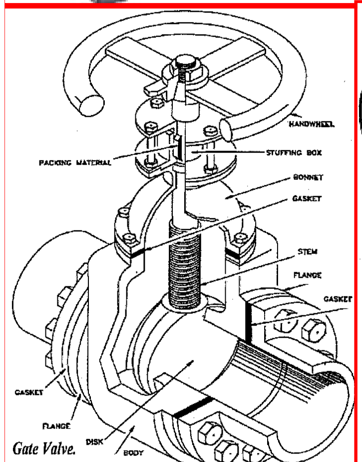
Ultrasonic level measurement

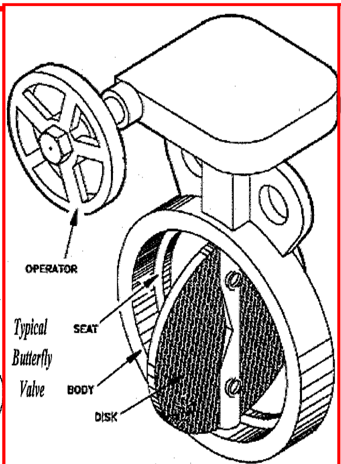


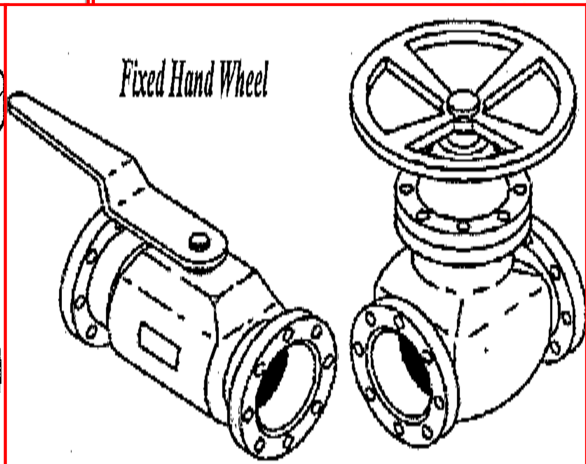












Electric Motor Actuator