ME444 ENGINEERING PIPING SYSTEM DESIGN

# CHAPTER 2 : PIPING MATERIALS

# LAST SESSION

1. INTRODUCTION
2. STANDARDS
3. BASIC UNITS
4. BASIC FLOW IN PIPE
5. QUICK LOOK AT PIPE DRAWINGS

# CONTENTS

# 1. PIPES

## CONSIDERATION

***Properties of the fluid***

° Corrosive or scale-forming properties

° Unusual characteristics, for example, viscosity or sludges

***Service conditions***

° Pressure (including surges and transients)

° Corrosive environment for exposed piping or buried piping

° Soil loads, bearing capacity and settlement, external load

## PIPE SELECTION:

- MATERIAL
- SIZE
- THICKNESS

# PIPE SIZES

NPS = NOMINAL PIPE SIZE (INCHES)
DN = DIAMETER NOMINAL (mm.)

| NPS | DN | NPS | DN | NPS | DN | NPS | DN |
|---|---|---|---|---|---|---|---|
| ⅛ | 6 | 3½ | 90 | 22 | 550 | 44 | 1100 |
| ¼ | 8 | 4 | 100 | 24 | 600 | 48 | 1200 |
| ¾ | 10 | 5 | 125 | 26 | 650 | 52 | 1300 |
| ½ | 15 | 6 | 150 | 28 | 700 | 56 | 1400 |
| ¾ | 20 | 8 | 200 | 30 | 750 | 60 | 1500 |
| 1 | 25 | 10 | 250 | 32 | 800 | 64 | 1600 |
| 1¼ | 32 | 12 | 300 | 34 | 850 | 68 | 1700 |
| 1½ | 40 | 14 | 350 | 36 | 900 | 72 | 1800 |
| 2 | 50 | 16 | 400 | 38 | 950 | 76 | 1900 |
| 2½ | 65 | 18 | 450 | 40 | 1000 | 80 | 2000 |
| 3 | 80 | 20 | 500 | 42 | 1050 | — | — |

# STANDARD SIZES

| Nominal pipe size (NPS), in IP | ASHRAE std. wt. size, mm | AWWA pipe size, mm | NFPA pipe size, mm | ASTM copper tube size, mm | Nominal pipe size DN |
|---|---|---|---|---|---|
| 1/8 | — | — | — | 6 | 6 |
| 3/16 | — | — | — | 8 | 8 |
| 1/4 | 8 | — | — | 10 | 10 |
| 3/8 | 10 | — | — | 12 | 12 |
| 1/2 | 15 | 12.7 & 13 | 12 | 15 | 15 |
| 5/8 | — | — | — | 18 | 18 |
| 3/4 | 20 | — | — | 22 | 20 |
| 1 | 25 | 25 | 25 & 25.4 | 28 | 25 |
| 1 1/4 | 32 | — | 33 | 35 | 32 |
| 1 1/2 | 40 | 45 | 38 & 38.1 | 42 | 40 |
| 2 | 50 | 50 & 50.8 | 51 | 54 | 50 |
| 2 1/2 | 65 | 63 & 63.5 | 63.5 & 64 | 67 | 65 |
| 3 | 80 | 75 | 76 & 80 | 79 | 80 |
| 3 1/2 | — | — | 89 | — | 90 |
| 4 | 100 | 100 | 102 | 105 | 100 |
| 4 1/2 | — | 114.3 | | | 115 |
| 5 | — | — | 127 | 130 | 125 |
| 6 | 150 | 150 | 152 | 156 | 150 |
| 8 | 200 | 200 | 203 | 206 | 200 |
| 10 | 250 | 250 | — | 257 | 250 |
| 12 | 300 | 300 | 305 | 308 | 300 |
| 14 | — | 350 | — | | 350 |

# STANDARD SIZES (CONT'D)

| Nominal pipe size (NPS), in IP | ASHRAE std. wt. size, mm | AWWA pipe size, mm | NFPA pipe size, mm | ASTM copper tube size, mm | Nominal pipe size DN |
|---|---|---|---|---|---|
| 1/8 | — | — | — | 6 | 6 |
| 3/16 | — | — | — | 8 | 8 |
| 1/4 | 8 | — | — | 10 | 10 |
| 3/8 | 10 | — | — | 12 | 12 |
| 1/2 | 15 | 12.7 & 13 | 12 | 15 | 15 |
| 5/8 | — | — | — | 18 | 18 |
| 3/4 | 20 | — | — | 22 | 20 |
| 1 | 25 | 25 | 25 & 25.4 | 28 | 25 |
| 1 1/4 | 32 | — | 33 | 35 | 32 |
| 1 1/2 | 40 | 45 | 38 & 38.1 | 42 | 40 |
| 2 | 50 | 50 & 50.8 | 51 | 54 | 50 |

# STEEL PIPE THICKNESS

A schedule number indicates the approximate value of the expression

$$1000\,P/S$$

,where
***P*** is the service pressure and
***S*** is the allowable stress.

Higher schedule number means the thicker pipe.

[SEE TABLE E2.1 IN PIPING HANDBOOK]

# STEEL PIPE TABLE

| DN (mm) | Schedule | | $d_o$ (mm) | $t$ (mm) | $d_i$ (mm) | $m_{pipe}$ (kg/m) | $m_{water}$ (kg/m) | $I$ ($cm^4$) | $z$ ($cm^3$) |
|---|---|---|---|---|---|---|---|---|---|
| 20 | — | 5S | 26.67 | 1.651 | 23.368 | 1.016 | 0.429 | 1.02 | 0.765 |
| | — | 10S | 26.67 | 2.108 | 22.454 | 1.273 | 0.396 | 1.236 | 0.927 |
| | Std | 40 | 26.67 | 2.87 | 20.93 | 1.68 | 0.344 | 1.541 | 1.156 |
| | XS | 80 | 26.67 | 3.912 | 18.846 | 2.19 | 0.279 | 1.864 | 1.398 |
| | — | 160 | 26.67 | 5.537 | 15.596 | 2.878 | 0.191 | 2.193 | 1.645 |
| | XXS | — | 26.67 | 7.823 | 11.024 | 3.626 | 0.095 | 2.411 | 1.808 |
| 25 | — | 5S | 33.401 | 1.651 | 30.099 | 1.289 | 0.712 | 2.081 | 1.246 |
| | — | 10S | 33.401 | 2.769 | 27.863 | 2.086 | 0.61 | 3.151 | 1.887 |
| | Std | 40 | 33.401 | 3.378 | 26.645 | 2.494 | 0.558 | 3.635 | 2.177 |
| | XS | 80 | 33.401 | 4.547 | 24.307 | 3.227 | 0.464 | 4.396 | 2.632 |
| | — | 160 | 33.401 | 6.35 | 20.701 | 4.225 | 0.337 | 5.208 | 3.119 |
| | XXS | — | 33.401 | 9.093 | 15.215 | 5.436 | 0.182 | 5.846 | 3.501 |

[SEE APPENDIX ข.8]

# STANDARD DIMENSION RATIO

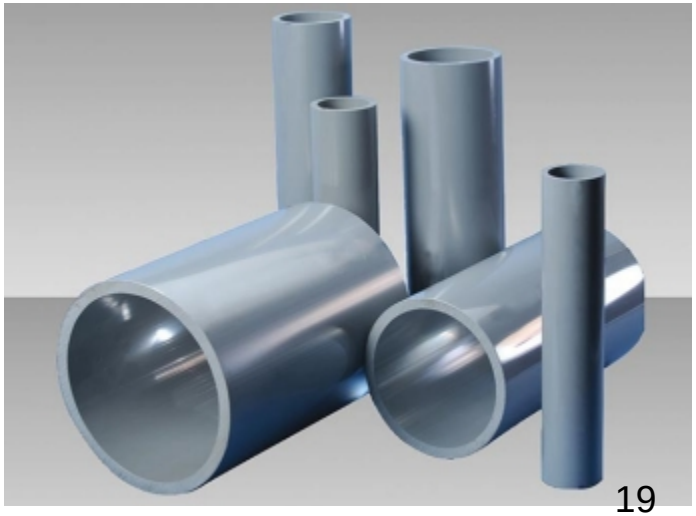
SDR = Outside diameter / Thickness

SDR is used mostly in plastic pipes .

For comparison; a DN100 sch.40 steel pipe → SDR = 114.3/6.02 = 19

Examples

⅛"–24" Schedule 40/80
½"–8" Schedule 120
¾"–8" SDR 21
1"–24" SDR 26
18"–24" SDR 41



# PRESSURE RATING

| Class | 150 | 300 | 400 | 600 | 900 | 1500 | 2500 |
|---|---|---|---|---|---|---|---|
| PN | 20 | 50 | 68 | 110 | 150 | 260 | 420 |

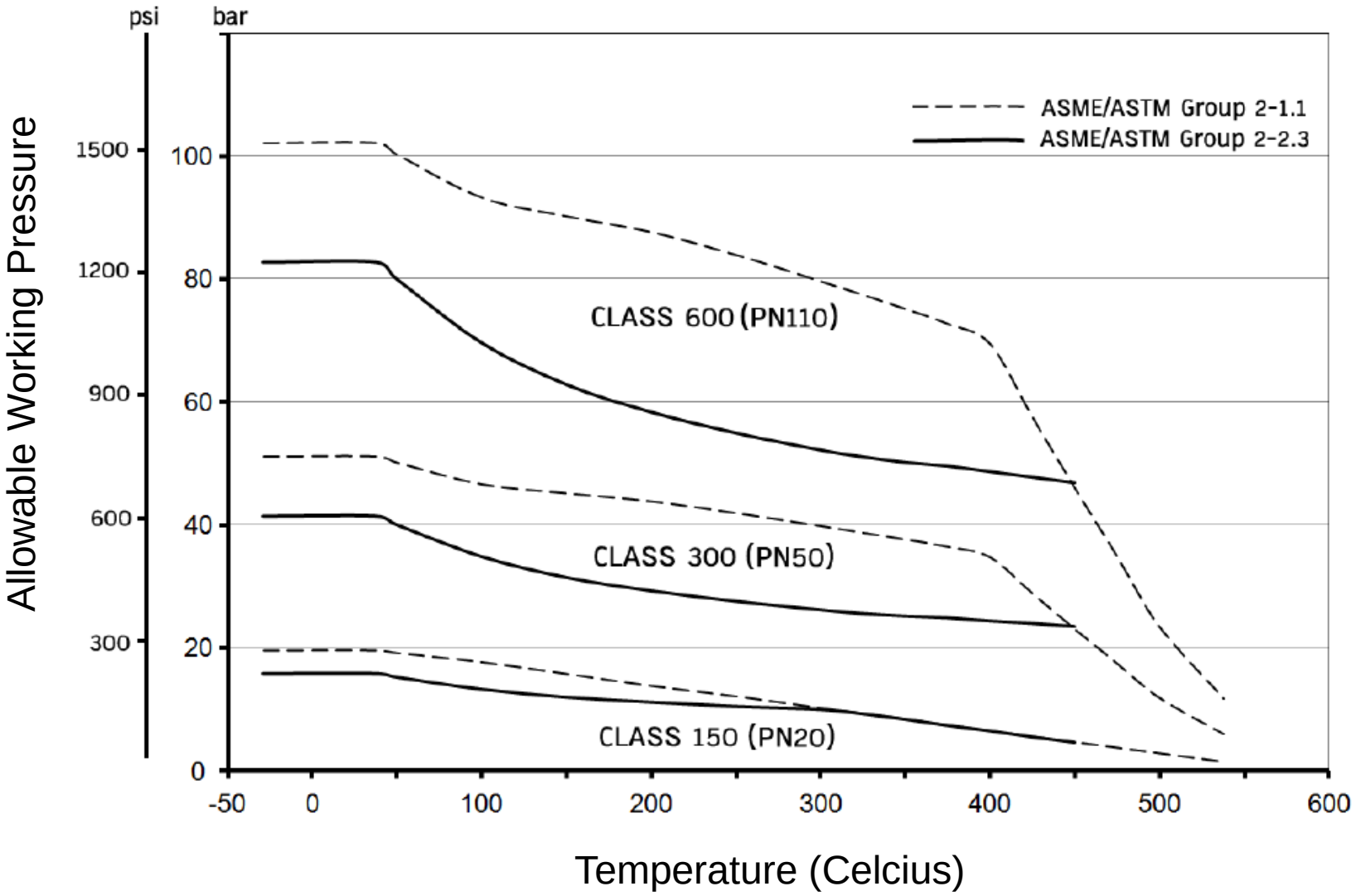
***Notes:***

1. Pressure-temperature ratings of different classes vary with the temperature and the material of construction.
2 For pressure-temperature ratings, refer to tables in ASME B16.5, or ASME B16.34.

Class – PSIG
PN – BARS

Actual allowable working pressures depend on MATERIAL and TEMPERATURE

# PRESSURE RATING



# PIPE MATERIALS

| Materials | Density ($kg/m^3$) | Yield Strength (MPa) | Ultimate Strength (MPa) | Elastic Modulus (GPa) | Coefficient of Thermal Expansion ($10^{-6}$ $K^{-1}$) | Thermal Conductivity (W/m.K) | Specific Heat (J/kg.K) | Melting Point (°C) |
|---|---|---|---|---|---|---|---|---|
| **Metal** | | | | | | | | |
| Aluminum | 2,800 | 72 | 97 | 72 | 22.5 | 192 | 910 | 660 |
| Copper | 8,940 | 69 | 220 | 110 | 16.5 | 398 | 385 | 1,082 |
| Brass | 8,530 | 75 | 303 | 110 | 20 | 110 | 337 | 905 |
| Titanium | 4,510 | 240 | 330 | 107 | 9 | 17 | 720 | 1,668 |
| Stainless Steel | 8,000 | 193 | 552 | 207 | 16 | 16 | 490 | 1,510 |
| Med. Carb. Steel | 7,850 | 350 | 520 | 207 | 11.3 | 52 | 490 | 1,425 |
| **Plastic** | | | | | | | | |
| ABS | 1,080 | 40 | 55 | 2.5 | 95 | 0.26 | 1,400 | 105 |
| PVC | 1,400 | 41 | 47 | 3.4 | 100 | 0.18 | 2,400 | 80 |
| HDPE | 950 | 27 | 30 | 3 | 225 | 0.42 | 2,000 | 130 |

Notes: All values are approximated. Some thermal properties vary with temperature.

# CARBON STEEL PIPES

TYPES:
SEAM/SEAMLESS
BLACK/GALVANIZED

JOINTS:
THREADED
WELDED
FLANGED

APPLICATIONS:
GENERAL PRESSURE PIPING

**Usually come in 6-meter length.**

# CARBON STEEL PIPES ASTM A53A


Min yield strength 205 MPa
Min tensile strength 330 MPa

# CARBON STEEL PIPES TIS276-2562
# GALVANZED STEEL PIPE TIS277-2532

ความต้านแรงดึงและความยืด

ท่อเหล็กต้องมีความต้านแรงดึงไม่น้อยกว่า 320 เมกะพาสคัล และมีความยืดไม่น้อยกว่าร้อยละ 20 การทดสอบให้ปฏิบัติตามมาตรฐานผลิตภัณฑ์อุตสาหกรรม การทดสอบเหล็กและเหล็กกล้า เล่ม 6 การทดสอบท่อเหล็กกล้าโดยการดึง มาตรฐานเลขที่ มอก.244 เล่ม 6

ประเภท ให้แสดงด้วยแถบสีกว้างประมาณ 50 มิลลิเมตร ดังนี้

| | |
|---|---|
| ประเภท 1 สีน้ำตาล | ท่อเหล็กแบบมีตะเข็บ ผนังท่อบาง |
| ประเภท 2 สีน้ำเงิน | ท่อเหล็กแบบมีตะเข็บและแบบไม่มีตะเข็บ ผนังท่อหนาปานกลาง |
| ประเภท 3 สีแดง | ท่อเหล็กแบบมีตะเข็บและแบบไม่มีตะเข็บ ผนังท่อหนา |
| ประเภท 4 สีเขียว | ท่อเหล็กแบบมีตะเข็บและแบบไม่มีตะเข็บ ผนังท่อหนาพิเศษ |

# STRUCTURAL STEEL PIPES TIS107-2561

มอก. 107–2561

**JIS G3444**

ตารางที่ 4 ความต้านแรงดึง ความเค้นคราก การดัดโค้ง และการกดแบน สำหรับท่อแบบกลม

(ข้อ 5.3.1.1 ข้อ 5.3.1.2 และข้อ 5.3.1.3)

| รายการที่ | สมบัติทางกล | เกณฑ์ที่กำหนด ชั้นคุณภาพ | | | | |
|---|---|---|---|---|---|---|
| | | STK290 | STK400 | STK490 | STK500 | STK540 |
| 1 | ความต้านแรงดึง (เมกะพาสคัล) ไม่น้อยกว่า | 290 | 400 | 490 | 500 | 540 |
| 2 | ความเค้นคราก (เมกะพาสคัล) ไม่น้อยกว่า | - | 235 | 315 | 355 | 390 |
| 3 | การดัดโค้ง (เฉพาะขนาดเส้นผ่านศูนย์กลางภายนอกไม่เกิน 50 mm) มุมของการดัดโค้ง (องศา) | 90 | 90 | 90 | 90 | 90 |
| | รัศมีภายในของการดัดโค้ง (มิลลิเมตร) | 6D | 6D | 6D | 6D | 6D |
| 4 | การกดแบน (เฉพาะขนาดเส้นผ่านศูนย์กลางภายนอกมากกว่า 50 mm) ระยะห่างแผ่นกด (H) (มิลลิเมตร) | (2/3) D | (2/3) D | (7/8) D | (7/8) D | (7/8) D |

*หมายเหตุ* D คือ ขนาดเส้นผ่านศูนย์กลางภายนอกท่อ

# STAINLESS STEEL PIPES

Stainless steel pipes have Cr, Ni and Mo content.

1. Ferric type: resist corrosion, magnitic response, cannot be harden: ASTM 430
2. Austenitic: corroded under chloride, non-magnetic response: ASTM 304 – Most popular, ASTM 316, general purpose: food-drug, chemical, etc.
3. Superaustenitic: high corrosion resistance
4. Martensitic: high temperature applications, magnitic response: ASTM 410
5. Duplex (1+2)

# CAST IRON PIPES

TYPES:

CAST IRON/DUCTILE CAST IRON

PLAIN/COATED

JOINTS:

CAULKED

APPLICATIONS

SOIL, WASTE, DRAIN

# COPPER PIPES

TYPES:

HARD (ANNEALED) / SOFT (DRAWN)

THICKNESS: K (THICK), L, M (THIN)

JOINTS:

SOLDERED

FLARED

FLANGED

APPLICATIONS:

COMPRESSED GAS, MEDICAL GAS

Copper pipes don’t like ammonia

# OTHER METAL PIPES

**ALUMINUM – Light weight, low thermal inertia**

**BRASS (Cu+Zn) – General sanitary pipe, valves.**

**LEAD – Radioactive waste**

# PLASTIC PIPES

## ADVANTAGES

**1.** Resistance to a very wide range of sanitary and chemical effluents
**2.** Resistance to aggressive soils
**3.** Availability in long lengths
**4.** Light weight
**5.** Low resistance to fluid flow
**6.** Generally low initial cost

## DISADVANTAGES

**1.** Poor structural stability requiring additional support
**2.** Susceptibility of some types of plastics to physical changes resulting from exposure
to sunlight
**3.** Generally low resistance to solvents
**4.** Poor fire resistance

# MAJOR TYPES

PVC, CPVC
PP, PP-R
PE, HDPE, PB


# PVC PIPES

## มอก 17 - 2561

แบ่งออกเป็น 5 ชั้นคุณภาพ ตามความดันที่ระบุดังตารางที่ 1

**ตารางที่ 1 ชั้นคุณภาพ**

(ข้อ 3.2)

| ชั้นคุณภาพ | ความดันระบุที่ 27 °C (MPa) |
|---|---|
| PVC 5 | 0.51 |
| PVC 7 | 0.70 |
| PVC 8.5 | 0.85 |
| PVC 10.5 | 1.08 |
| PVC 13.5 | 1.36 |

*หมายเหตุ 1 MPa = 9.869 23 bar*

*= 10.197 2 kgf/cm²*


**Usually come in 4-meter length.**

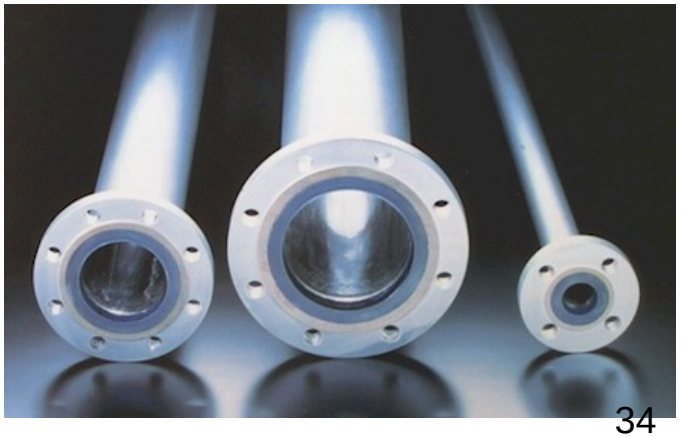
# OTHER PIPE MATERIALS

CONCRETE

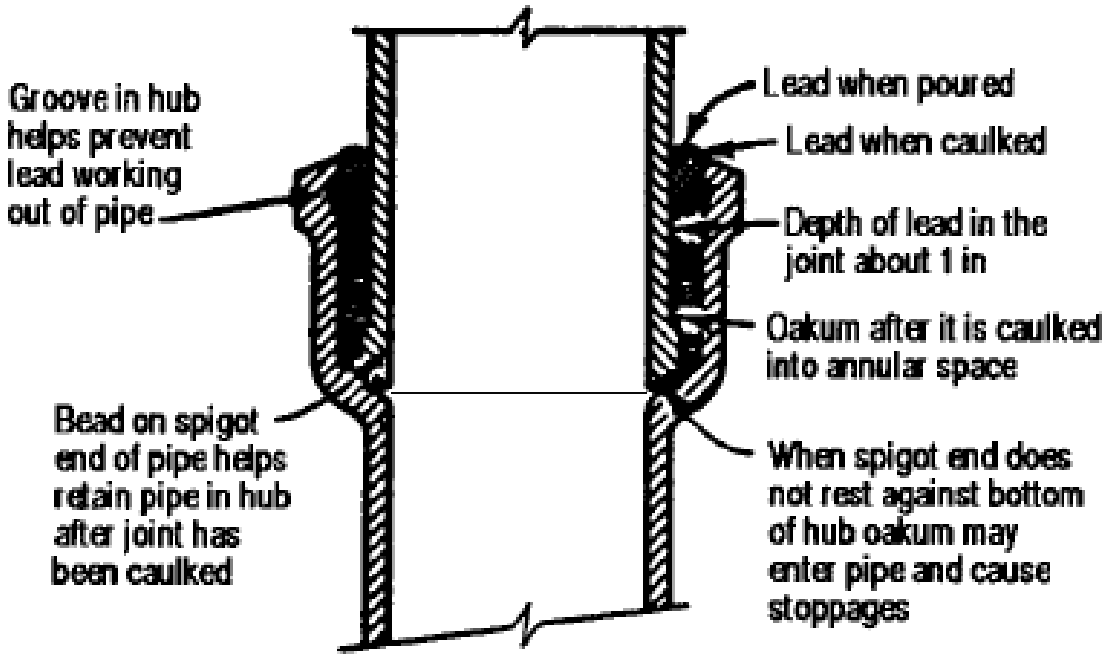
NON-REINFORCE/REINFORCE CLASS I TO 5
GENERAL WASTE AND DRAIN

GLASS

FOR CORROSIVE LIQUIDS i.e. ACIDS.

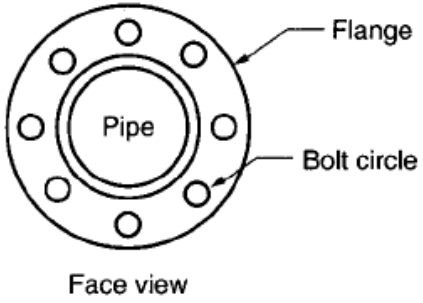


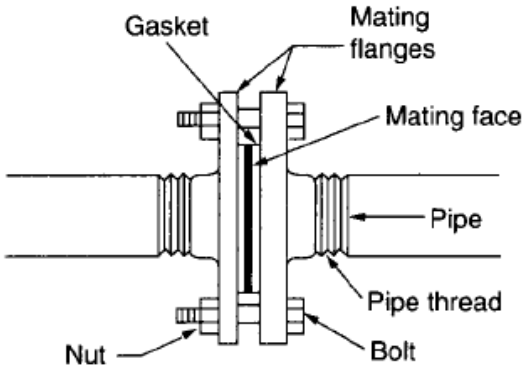
# JOINTS



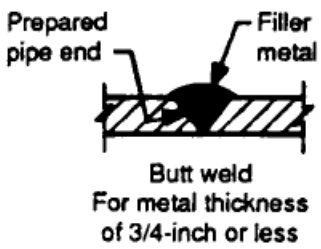

CAULKED JOINT FOR CAST IRON PIPES

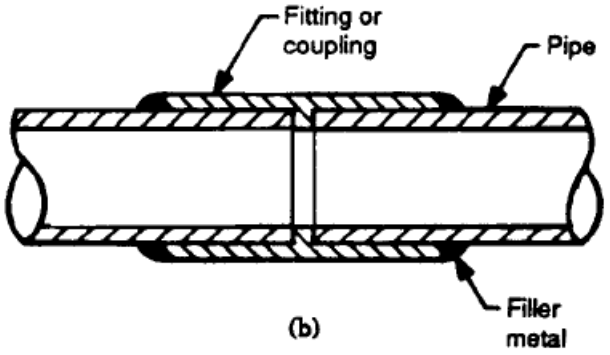
# JOINTS FOR STEEL PIPES




FLANGED

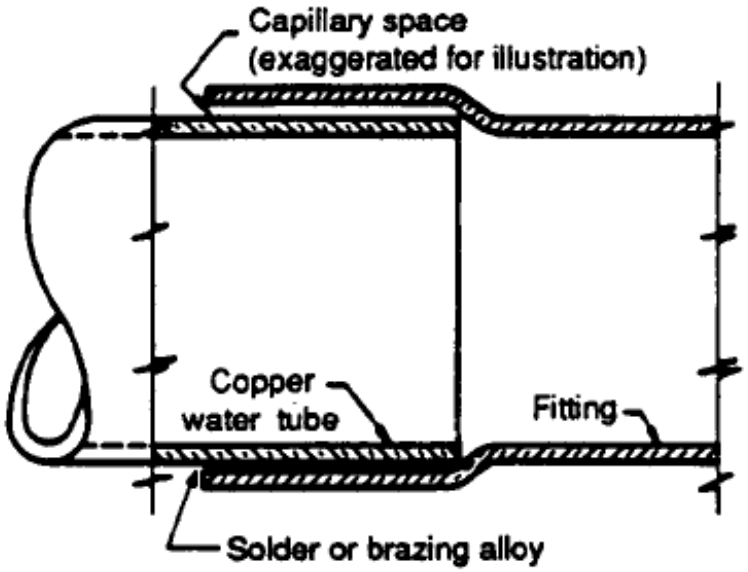


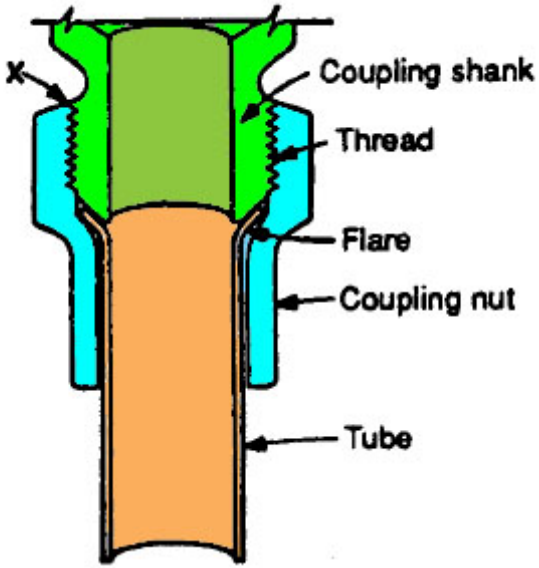

WELDED

# FLANGES

# JOINTS FOR COPPER TUBES

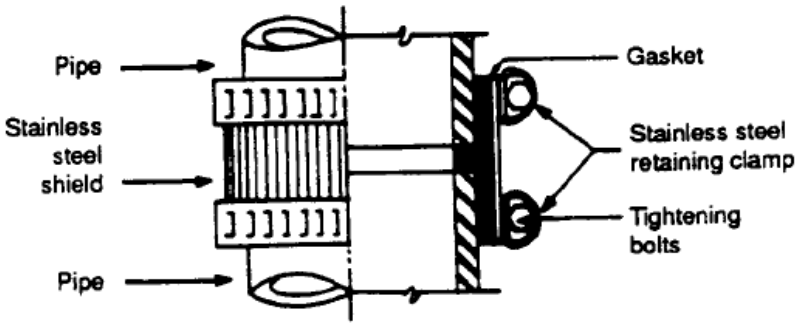


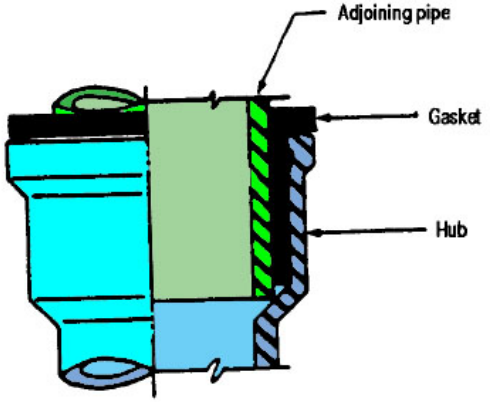

SOLDERED OR BRAZED



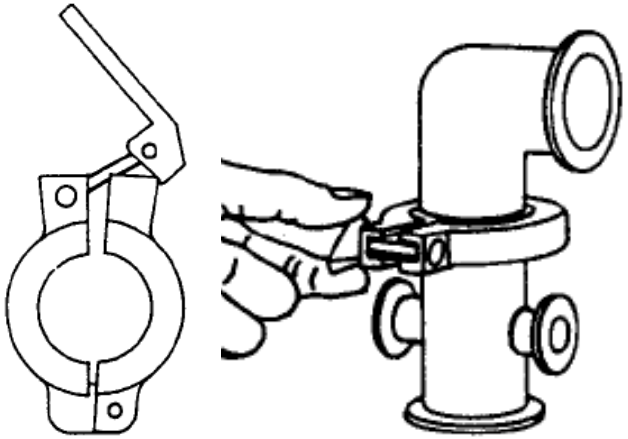

FLARED

# OTHER TYPES

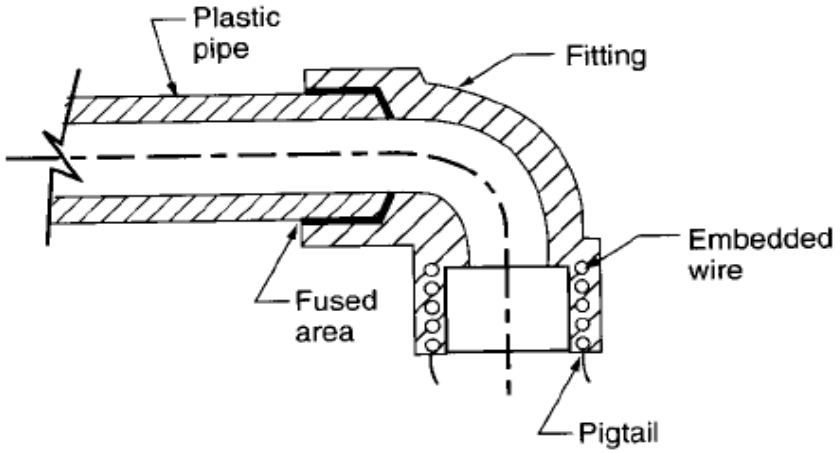

Pipe
Stainless steel shield
Pipe
Gasket
Stainless steel retaining clamp
Tightening bolts


Adjoining pipe
Gasket
Hub

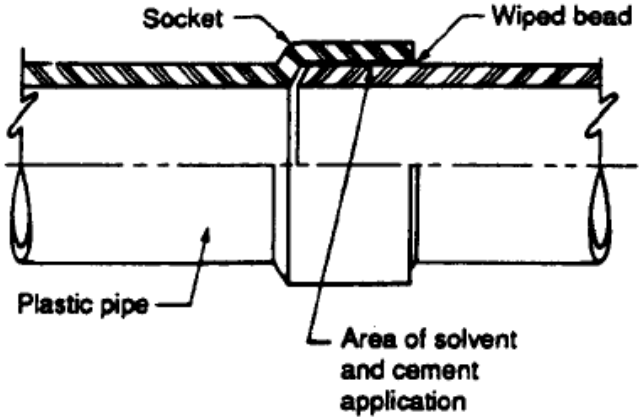

FERNCO
1056-44
4" CI/PLASTIC
TO
4" CI/PLASTIC



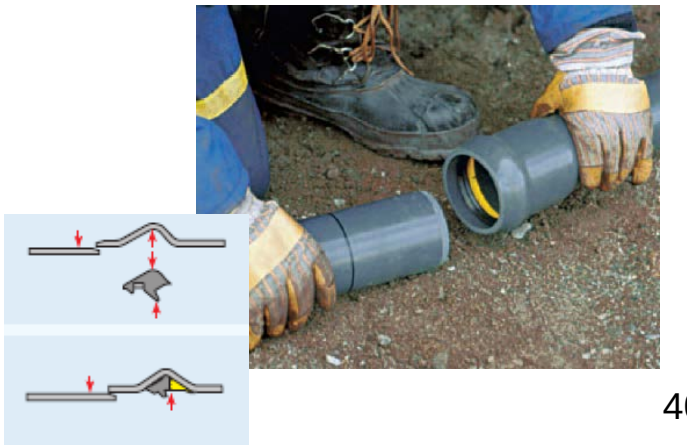
# JOINTS FOR PLASTIC PIPES



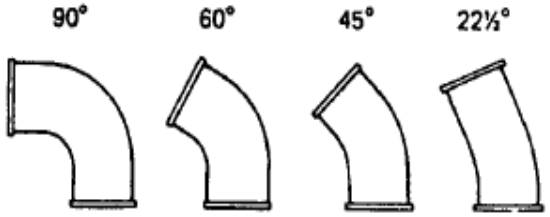

HEAT-FUSED JOINT



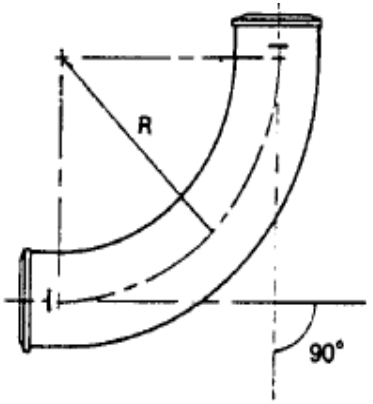

SOLVENT CEMENT JOINT

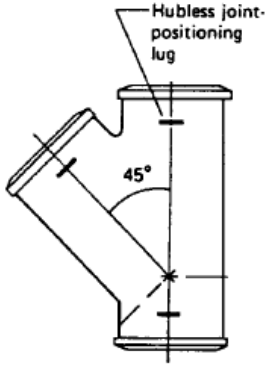


# FITTINGS

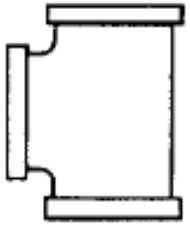



BEND



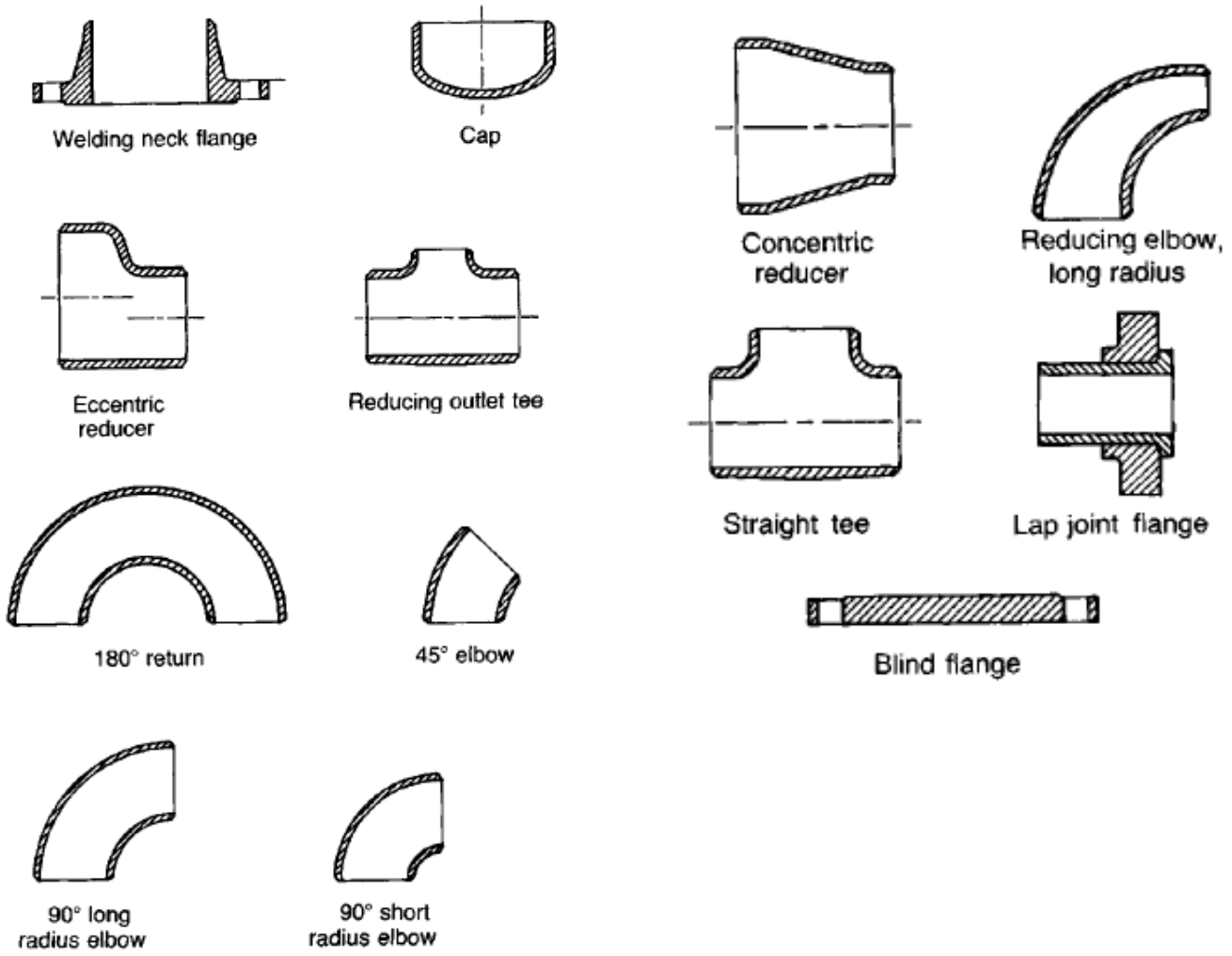

WYE



TEE

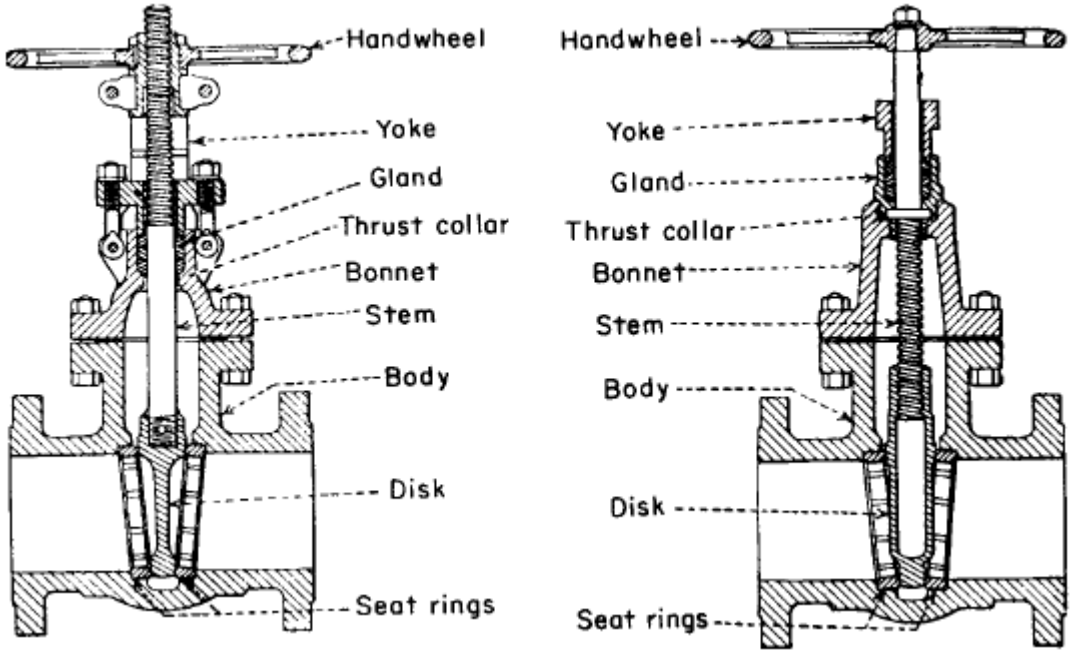
ELBOW

# FITTINGS (FOR WELDING)



# 2. VALVES


# GATE VALVES




**Advantages**

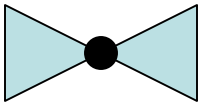
1. Good shutoff characteristics.
2. Bidirectional.
3. LOW pressure loss

**Disadvantages**

1. Not quick opening or closing valves.
2. Require large space
3. High-fluid velocities when near-fully-closed

# GATE VALVES

# GLOBE VALVES



**Advantages**

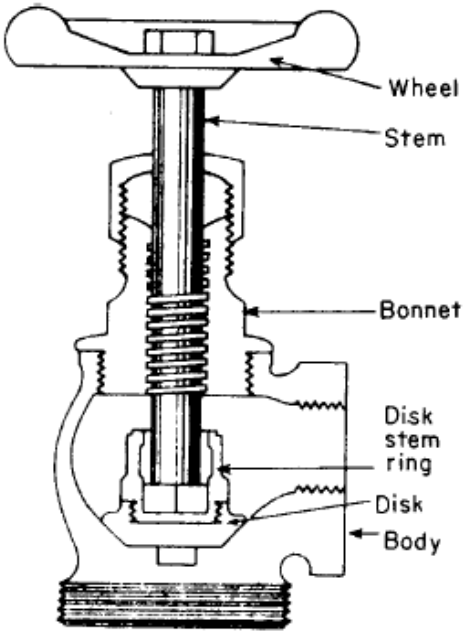
1. Good shutoff capability
2. Good throttling capability
3. Shorter stroke
4. Available in tee, wye, and angle patterns,
5. Easy to resurface the seats

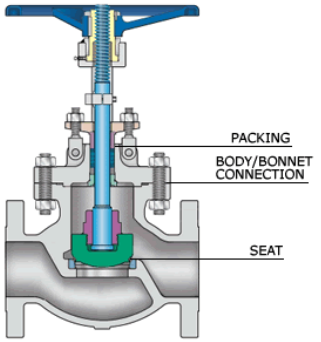
**Disadvantages**

1. Higher pressure drop
2. Requires greater force or a larger actuator to seat the valve (with pressure under the seat)

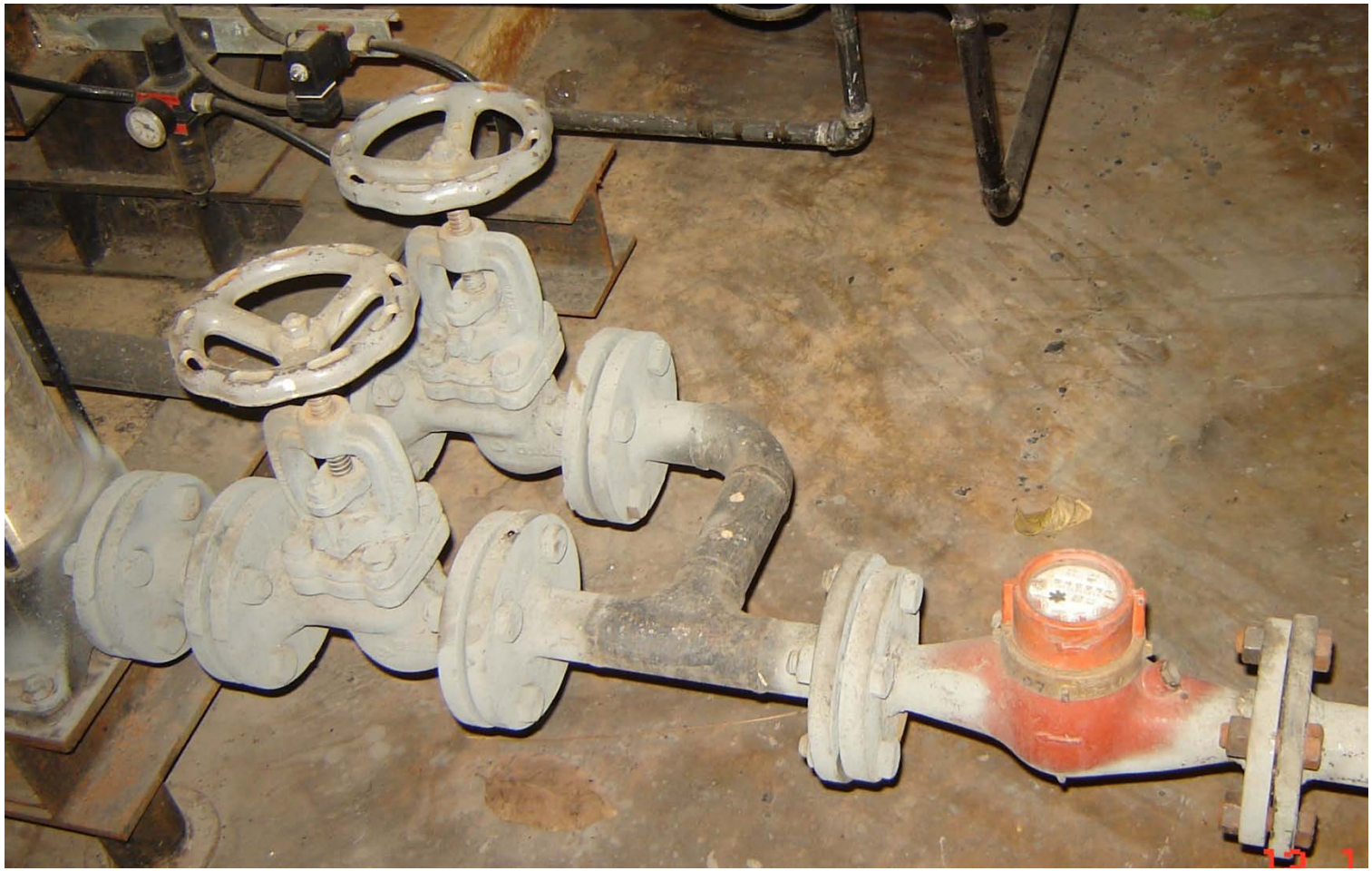
**Applications**

Flow regulation

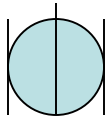


# GLOBE VALVES

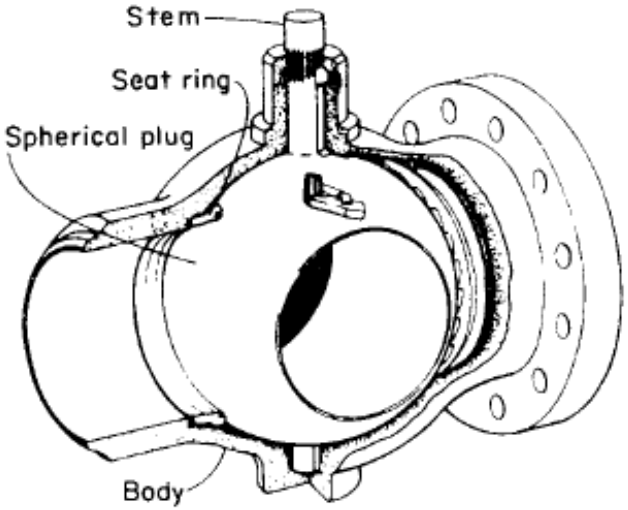


# BALL VALVES



**Advantages**

1. Provides bubble-tight service.
2. Quick to open and close.
3. Smaller in size than a gate valve.
4. Multiport design offers versatility
5. Required less actuated force




**Disadvantages**

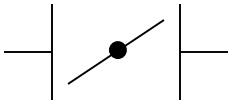
1. Not suitable for sustained throttling applications
2. Suspended particles can settle causing failure.
3. Small size

**Applications**

1. Air, gaseous, and liquid applications requiring bubble-tight service
2. Low-point drains and high-point vents
3. Instrument root valves
4. Cooling water and feedwater systems
5. Steam service

# BALL VALVES


# BUTTERFLY VALVES



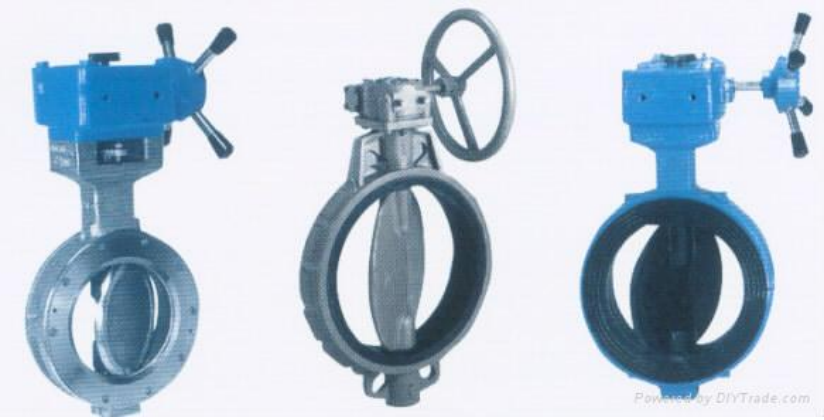
**Advantages**

1. Compact and light weight.
2. Quick acting (quarter-turn)
3. Available in large sizes: NPS 1½ (DN 40) to over NPS 200(DN 5000).
4. Low-pressure drop

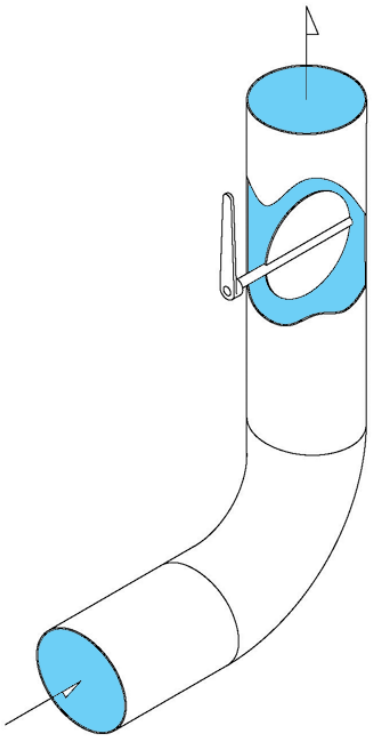
**Disadvantages**

1. Limited throttling (low differential pressure)
2. Must avoid turbulent:
   - Locate 4 to 6D downstream from turbulent source
   - **Orient valve stem carefully…How?**

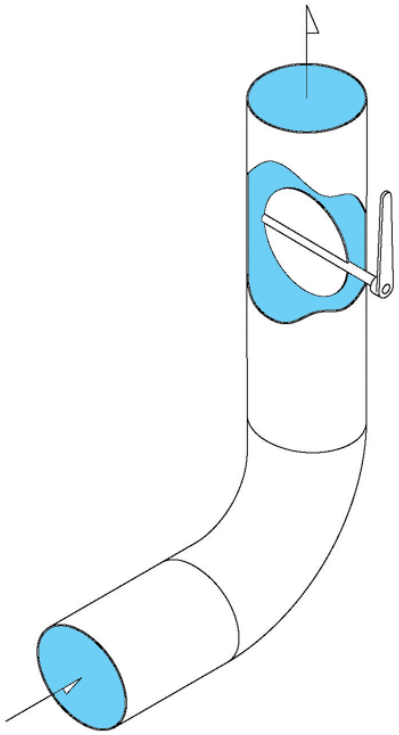
# BUTTERFLY VALVES



# ORIENTATION OF VALVE STEM



CORRECT

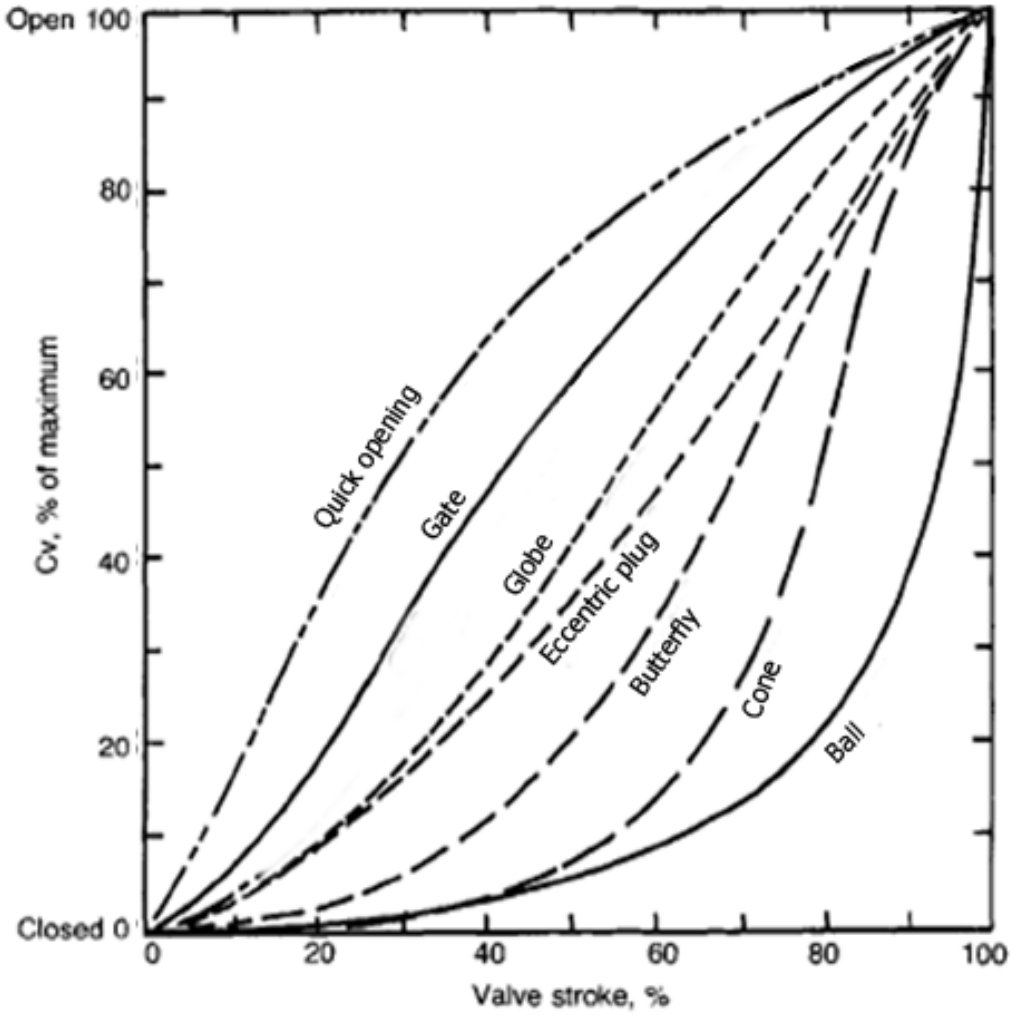


INCORRECT

# VALVE ACTUATORS


- Pneumatic
- Electric

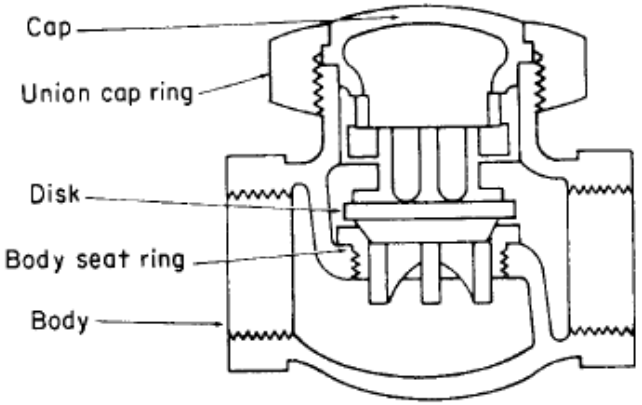
# VALVE PRESSURE DROP

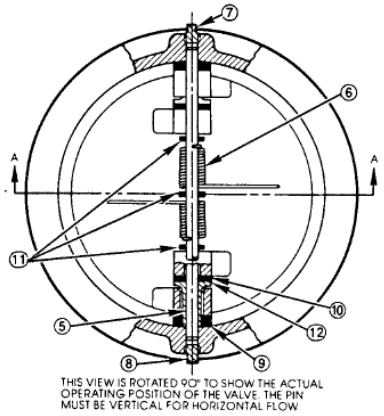


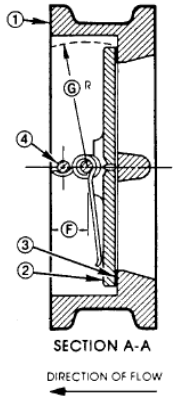

$$C_v = \frac{Q}{\sqrt{\Delta P}}$$

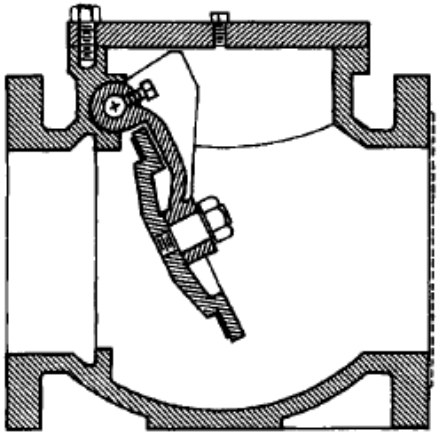
$Q$ IN GPM
$\Delta P$ IN PSI

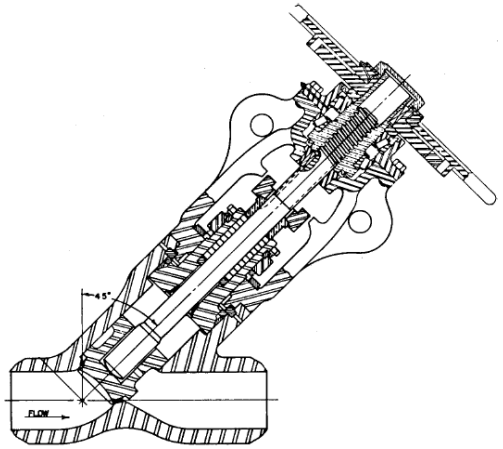
# CHECK VALVES



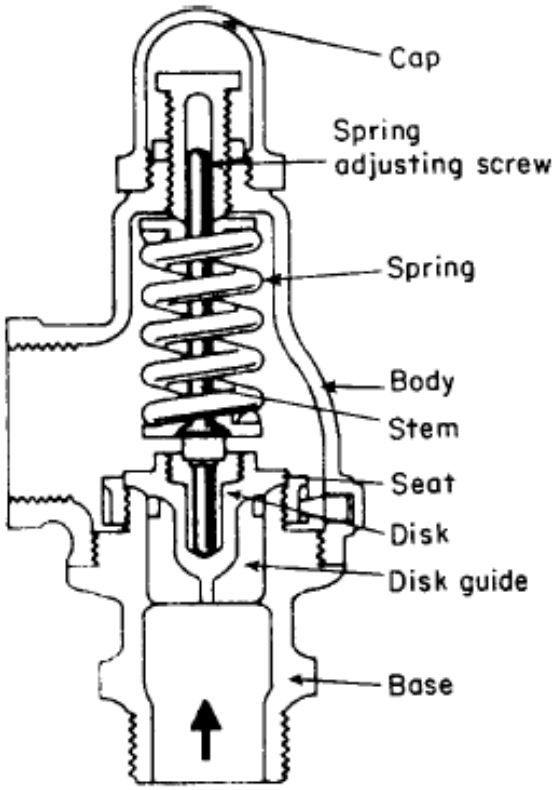



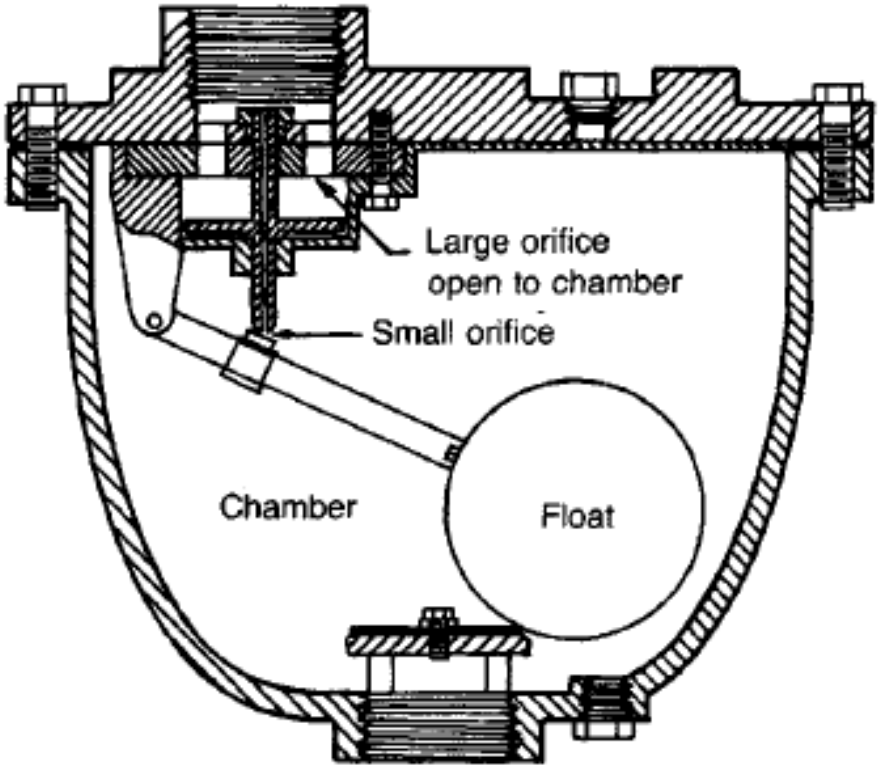


# CHECK VALVES


# RELEIF VALVES



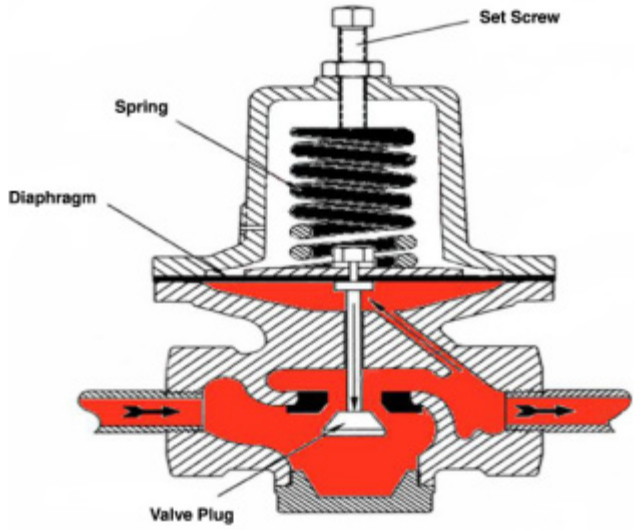
# AIR RELEASE VALVES



# PRESSURE REDUCING VALVES

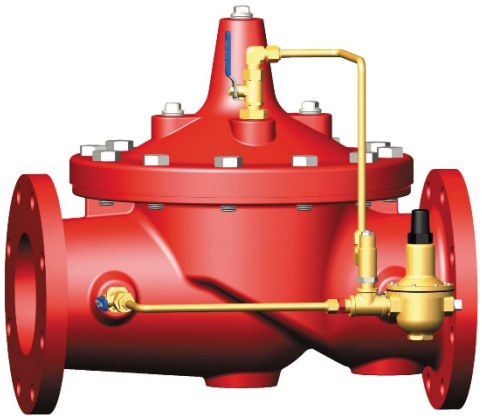
PRV, pressure regulator, pressure regulating valve, pressure control valve

Direct acting

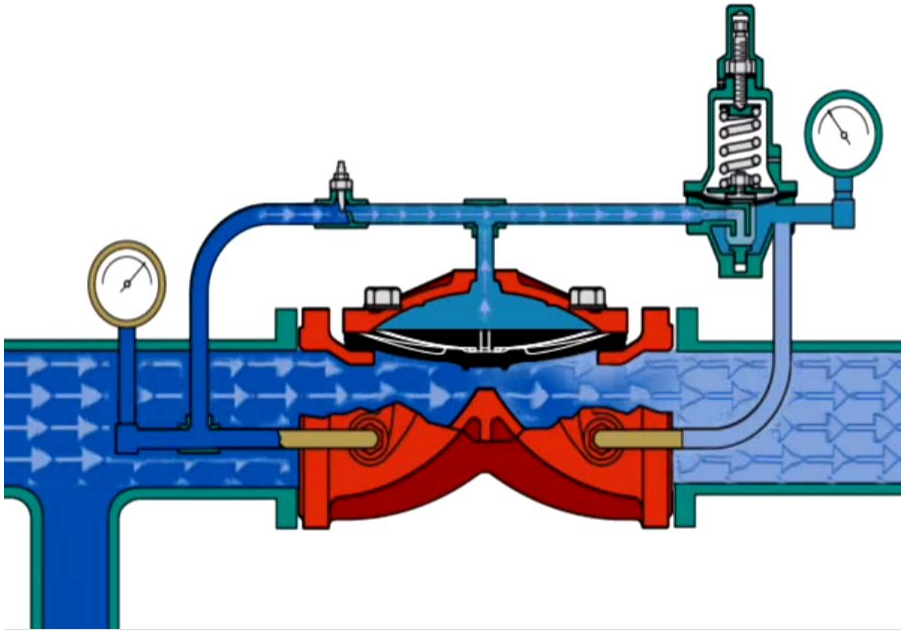


# PRESSURE REDUCING VALVES

PRV, pressure regulator, pressure regulating valve



Pilot operated



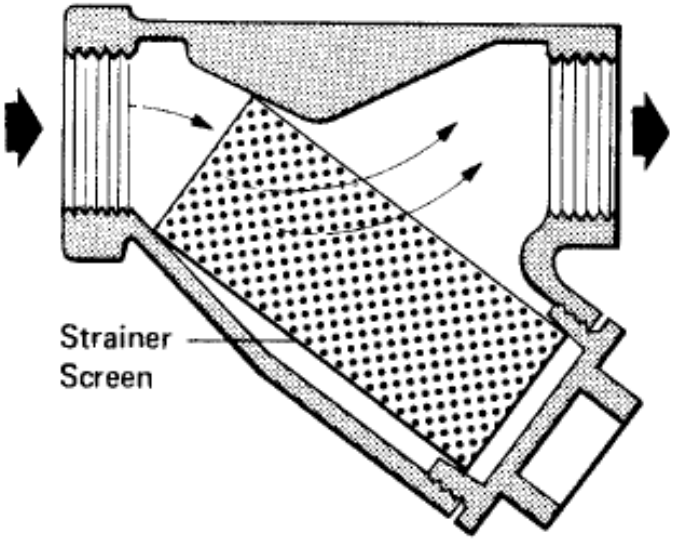
# OTHER VALVES

DIAPHRAGM VALVES
PLUG VALVES
NEEDLE VALVES

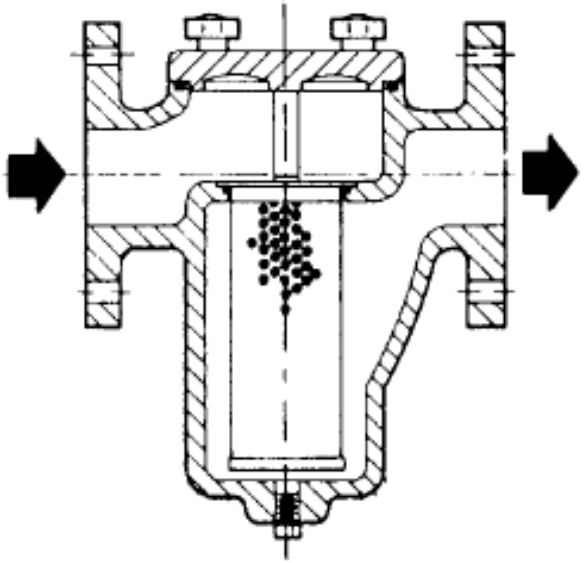
# 3. ACCESSORIES

Water hammer arresters
Strainer
Pressure guages
Flow meters
PIPE HANGERS
Etc.

# STRAINERS




WYE STRAINER



BUCKET STRAINER

# Y - STRAINERS

# PRESSURE GUAGE


Fig. 12.6.1 'C'-shaped (a) and coiled (b) Bourdon tubes

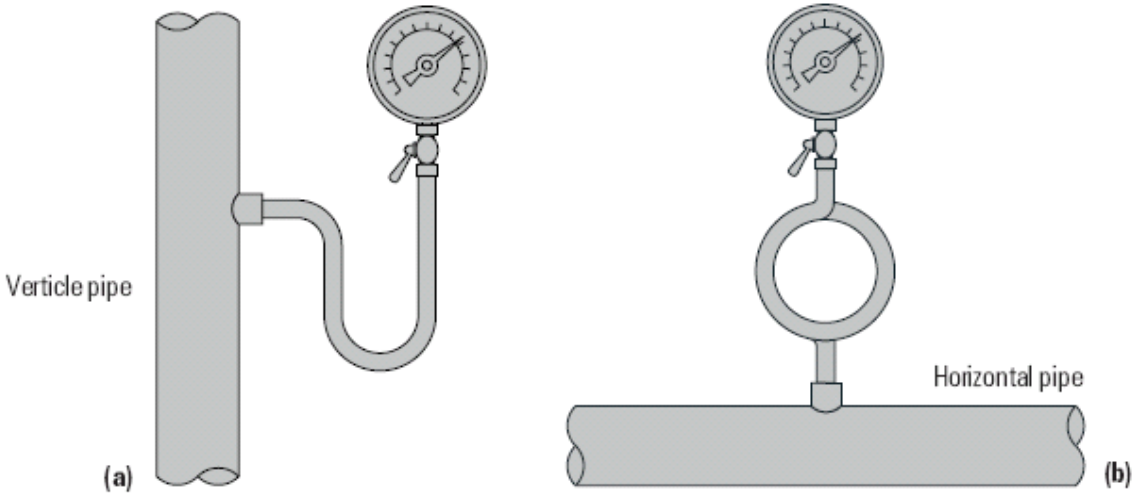
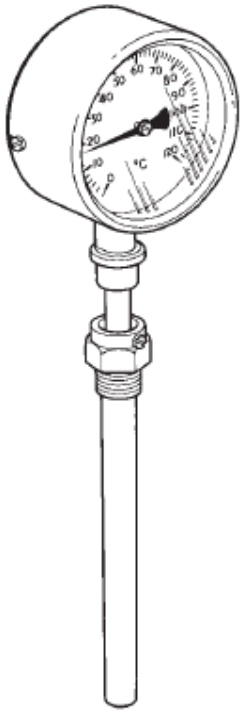



Fig. 12.6.2 'U' (a) and ring type (b) syphon tubes

# PRESSURE GUAGE (digital)


- Resistive
- Capacitive
- Piezoelectric
- Optical
- MEMS

# TEMPERATURE GUAGE



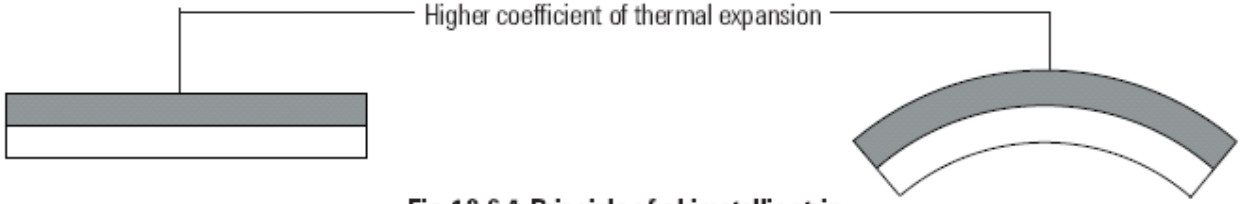
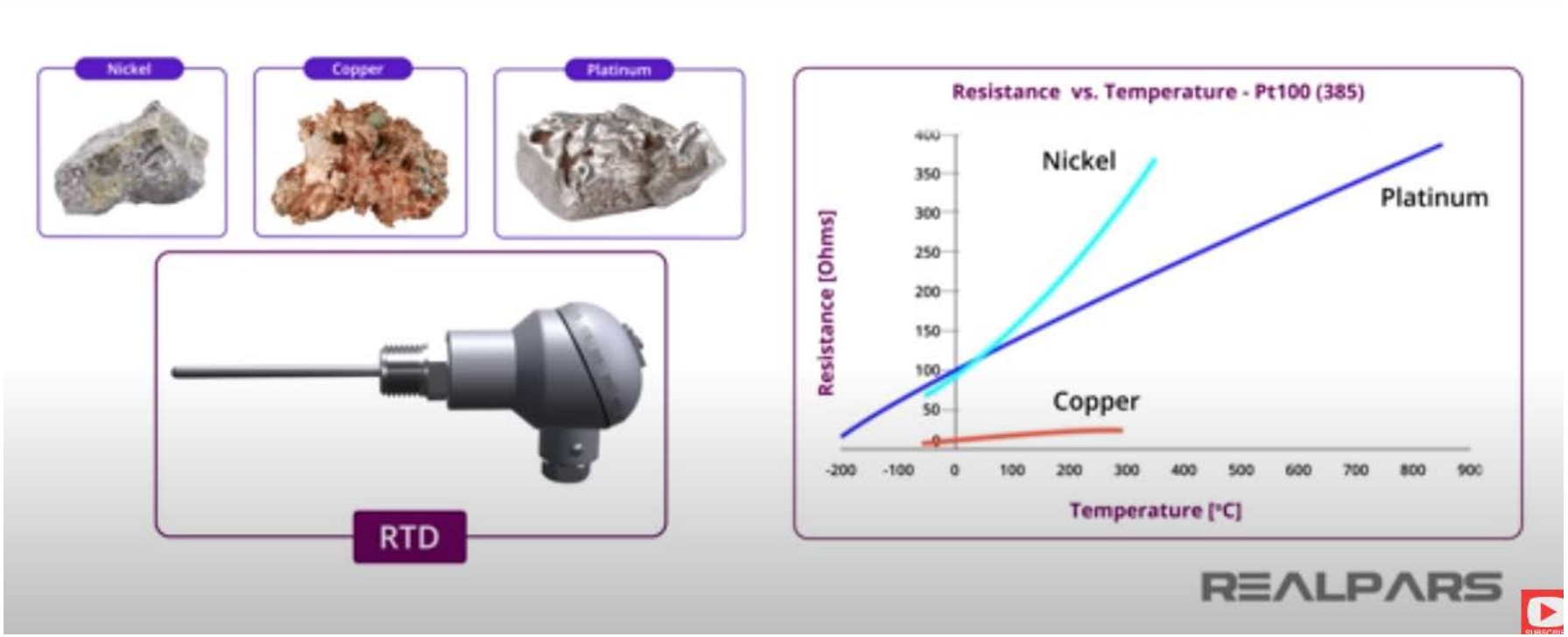



Fig. 12.6.4 Principle of a bimetallic strip

Bimetalic Strip – All Mechanic

# TEMPERATURE GUAGE (digital)

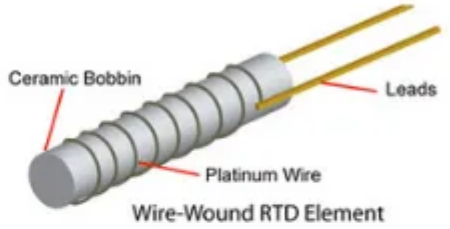
RTD (Resistant temperature detector) – Platinum Resistance Thermometer – PT100

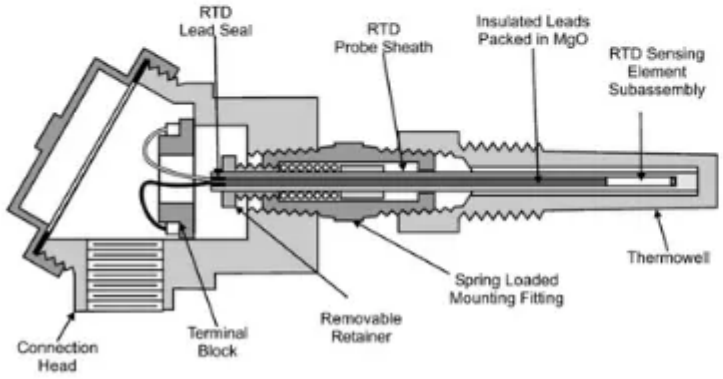


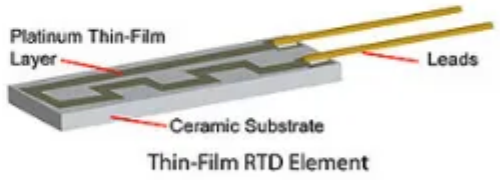

https://www.youtube.com/watch?v=3qDL_ipZxLg

# TEMPERATURE GUAGE (digital)

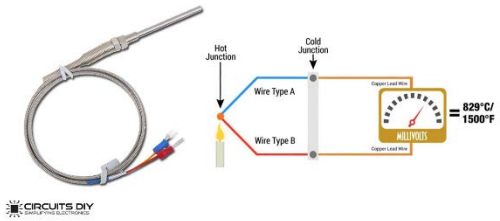
RTD (Resistant temperature detector) – Platinum Resistance Thermometer – PT100

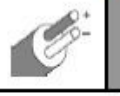



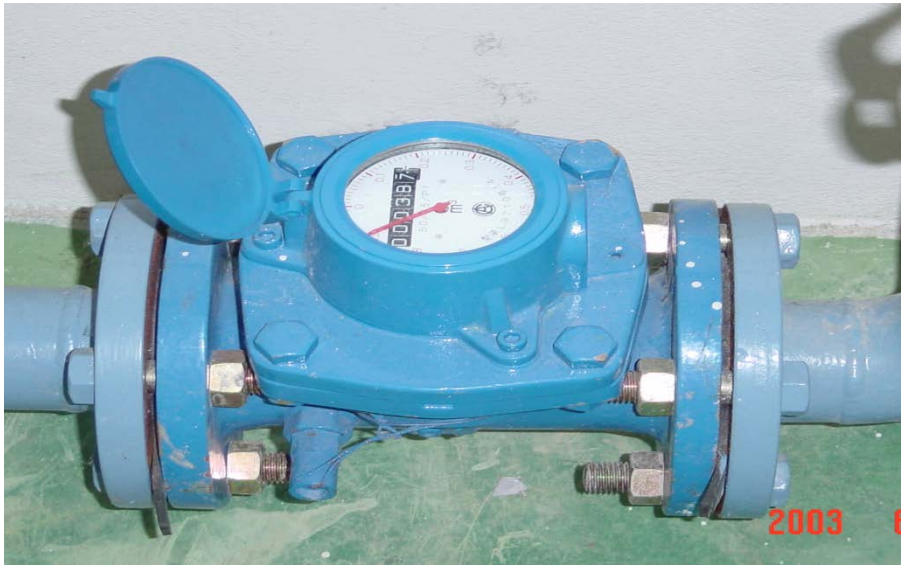

# TEMPERATURE GUAGE (digital)




| ANSI Code | ANSI MC 96.1 Color Coding | | Alloy Combination | | Maximum T/C Grande temp. range | EMF(mv)Over Max.temp.range | IEC 584-3 Color Coding | IEC Code |
|---|---|---|---|---|---|---|---|---|
| | Thermocouple | Extension | + Lead | - Lead | | | | |
| K |  |  | NICKEL-CHROMIUM Ni-Cr | NICKEL-ALUMINUM Ni-Al | -270 to 1372°C -454 to 2501°F | -6.458 to 54.886 |  | K |
| J |  |  | IRON Fe (magnetic) | CONTANTAN COOPER-NICKEL Cu-Ni | -210 to 1200°C -346 to 2193°F | -8.095 to 69.553 |  | J |
| T |  |  | COPPER Cu | CONTANTAN COOPER-NICKEL Cu-Ni | -270 to 400°C -454 to 752°F | -6.258 to 20.872 |  | T |
| E |  |  | NICKEL-CHROMIUM Ni-Cr | CONTANTAN COOPER-NICKEL Cu-Ni | -270 to 1000°C -454 to 1832°F | -9.835 to 76.373 |  | E |
| N |  |  | NICROSIL Ni-Cr-Si | NISIL Ni-Si-Mg | -270 to 1300°C -450 to 2372°F | -4.345 to 47.513 |  | N |
| S | NONE ESTABLISHED |  | PLATINUM-10% RHODIUM Pt-10%Rh | PLATINUM Pt | -50 to 1768°C -58 to 3214°F | -0.236 to 18.693 |  | S |
| R | NONE ESTABLISHED |  | PLATINUM-13% RHODIUM Pt-13%Rh | PLATINUM Pt | -50 to 1768°C -58 to 3214°F | -0.226 to 21.101 |  | R |
| B | NONE ESTABLISHED |  | PLATINUM-30% RHODIUM Pt-30%Rh | PLATINUM-6% RHODIUM Pt-6%Rh | 0 to 1820°C 32 to 3308°F | 0 to 13.820 |  | B |

Thermocouple
(voltage changes with temperature)

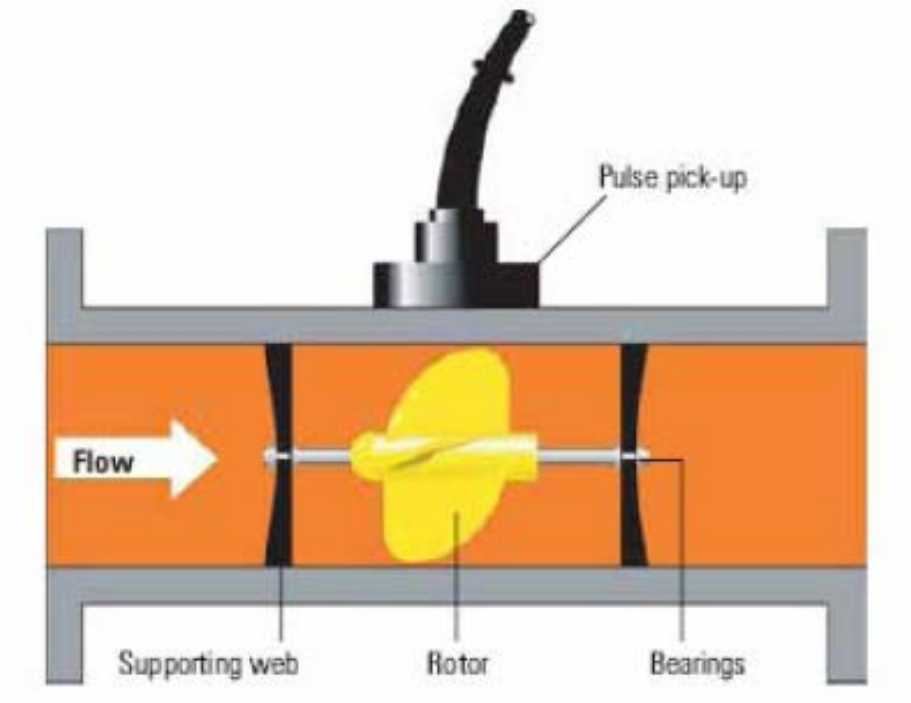
# FLUID FLOW METER



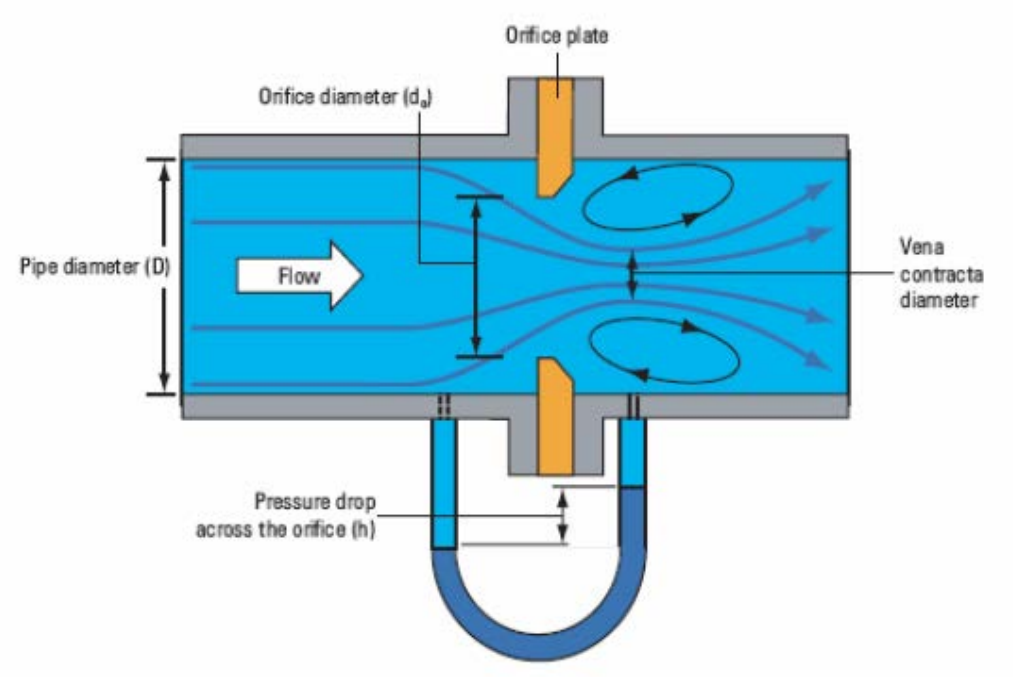

Rotameter

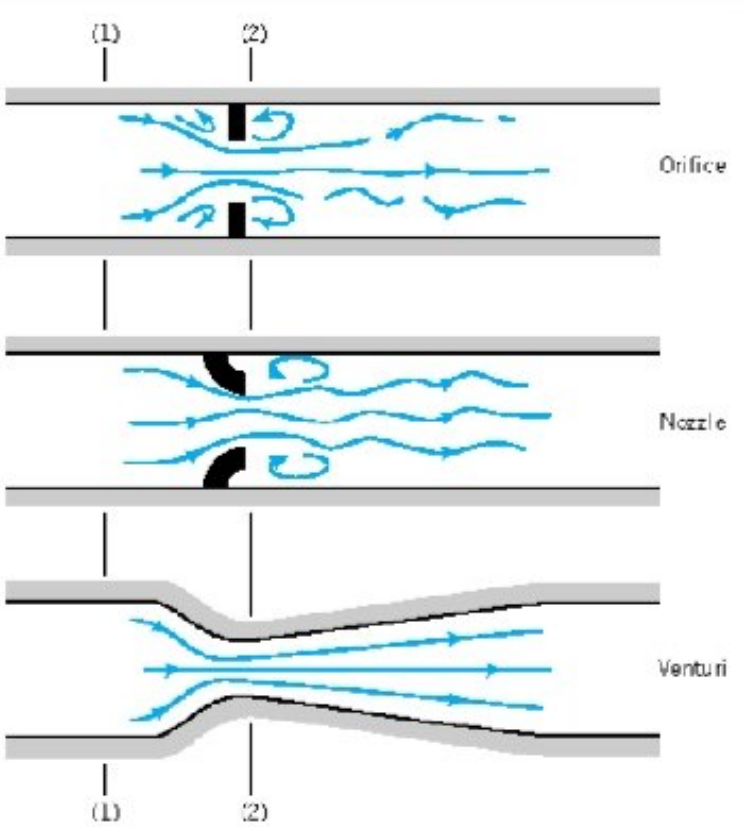
Propeller/turbine
Differential head-Pitot tube
Deflection
Variable area (rotameter)
Magnetic
Ultrasonic
Etc.

# TURBINE FLOW METER



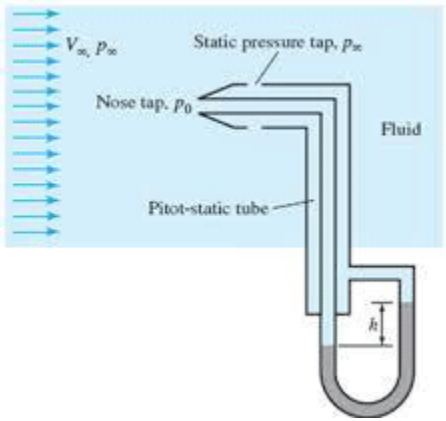
# DIFFERENT PRESSURE FLOW METER



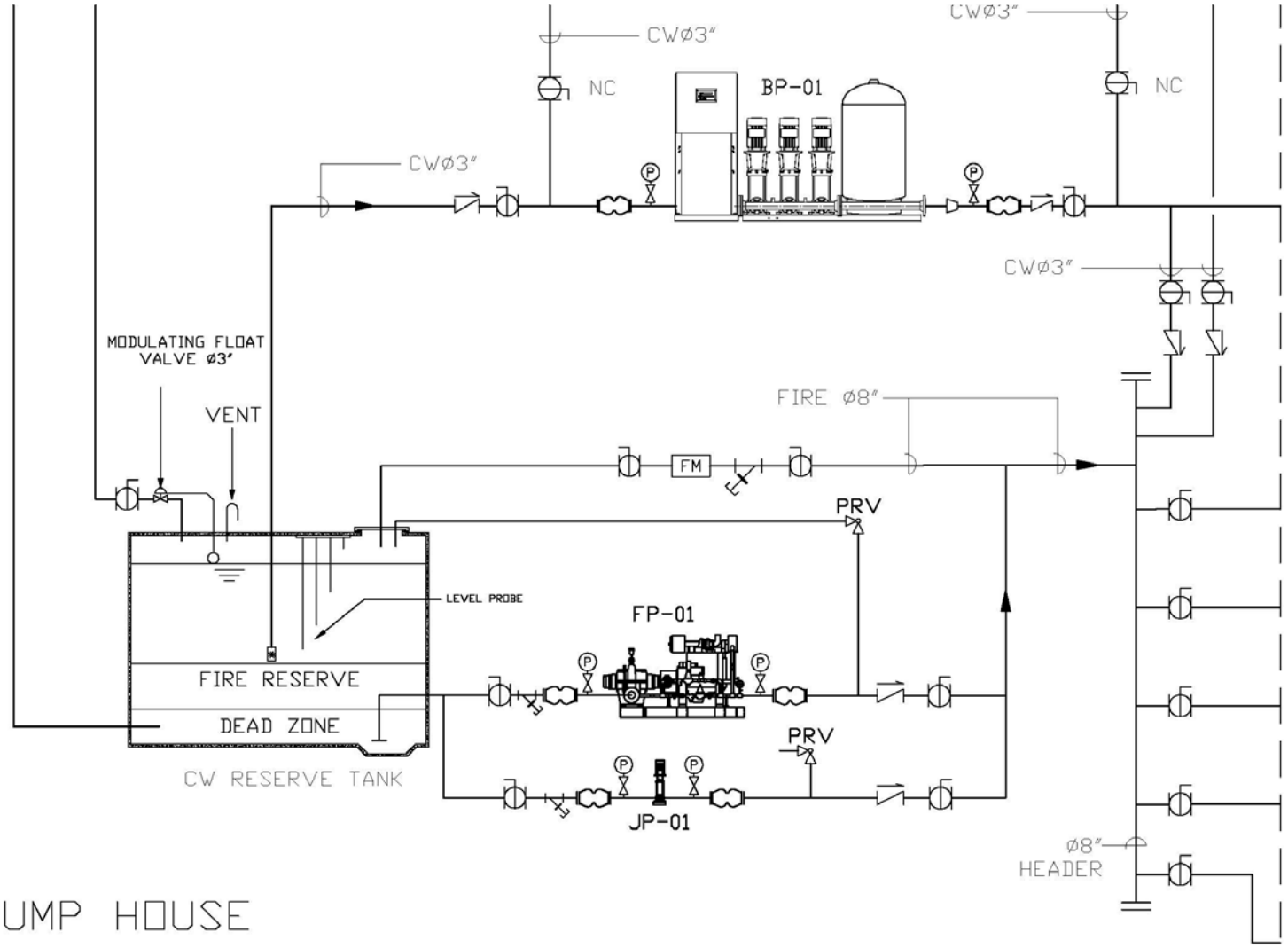



# FLOW MEASUREMENT TECHNOLOGY

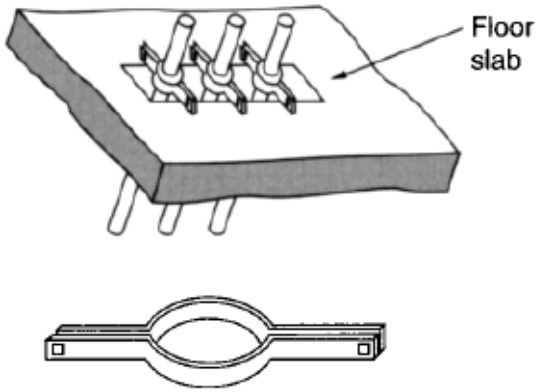
- Pitot tube
- Hot wire
- Ultrasonic
- Coriolis
- …



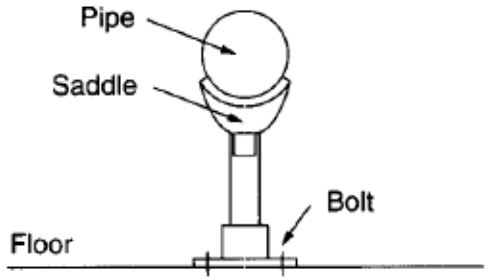

# WATER TANK ACCESSORY



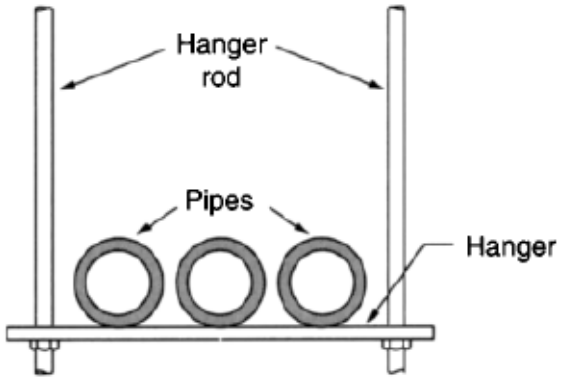
# PIPE HANGERS & SUPPORTS



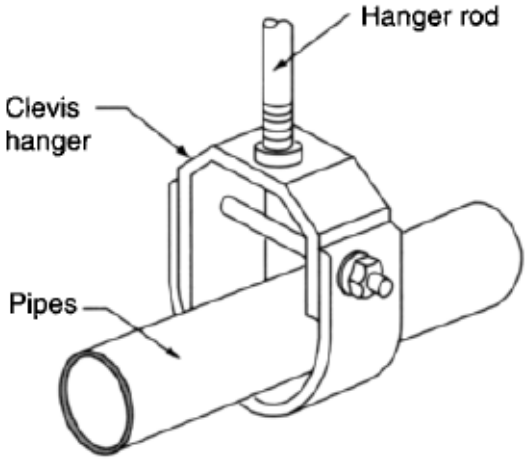

(a)




(b)




(c)




(d)

# PIPE HANGERS SPACING

## ASME B31.1

**Table 121.5 Suggested Steel Pipe Support Spacing**

| Nominal Pipe Size, NPS | Diameter Nominal, DN | Suggested Maximum Span | | | |
|---|---|---|---|---|---|
| | | Water Service | | Steam, Gas, or Air Service | |
| | | ft | m | ft | m |
| 1 | 25 | 7 | 2.1 | 9 | 2.7 |
| 2 | 50 | 10 | 3.0 | 13 | 4.0 |
| 3 | 80 | 12 | 3.7 | 15 | 4.6 |
| 4 | 100 | 14 | 4.3 | 17 | 5.2 |
| 6 | 150 | 17 | 5.2 | 21 | 6.4 |
| 8 | 200 | 19 | 5.8 | 24 | 7.3 |
| 12 | 300 | 23 | 7.0 | 30 | 9.1 |
| 16 | 400 | 27 | 8.2 | 35 | 10.7 |
| 20 | 500 | 30 | 9.1 | 39 | 11.9 |
| 24 | 600 | 32 | 9.8 | 42 | 12.8 |

GENERAL NOTES:

(a) Suggested maximum spacing between pipe supports for horizontal straight runs of standard and heavier steel pipe at maximum operating temperature of 750°F (400°C).

(b) Does not apply where span calculations are made or where there are concentrated loads between supports, such as flanges, valves, specialties, etc.

(c) The spacing is based on a fixed beam support with a bending stress not exceeding 2,300 psi (15.86 MPa) and insulated pipe filled with water or the equivalent weight of steel pipe for steam, gas, or air service, and the pitch of the line is such that a sag of 0.1 in. (2.5 mm) between supports is permissible.

## ASHRAE

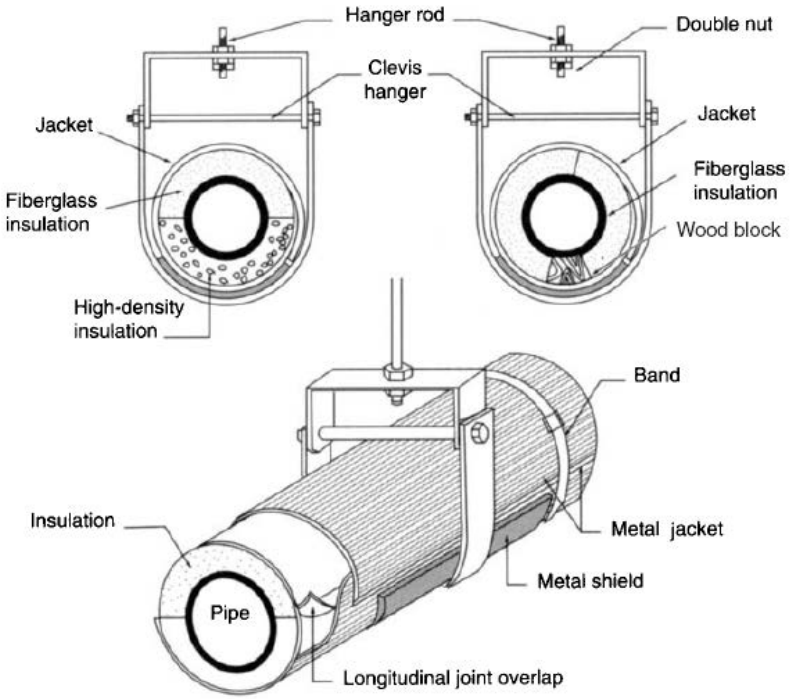
**Table 6 Suggested Hanger Spacing and Rod Size for Straight Horizontal Runs**

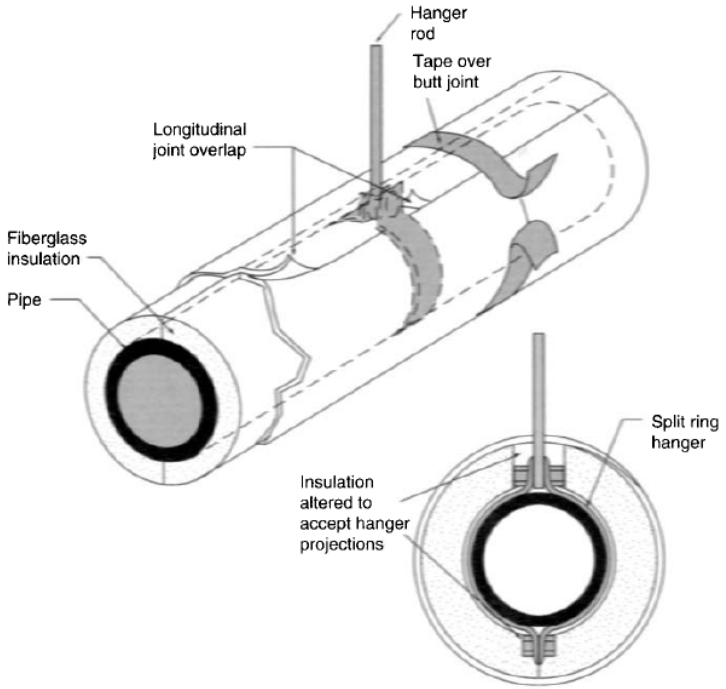
| Nominal O.D., mm | Hanger Spacing, m | | | Rod Size, mm |
|---|---|---|---|---|
| | Standard Steel Pipe[a] | | Copper Tube | |
| | Water | Steam | Water | |
| 15 | 2.1 | 2.4 | 1.5 | 6.4 |
| 20 | 2.1 | 2.7 | 1.5 | 6.4 |
| 25 | 2.1 | 2.7 | 1.8 | 6.4 |
| 40 | 2.7 | 3.7 | 2.4 | 10 |
| 50 | 3.0 | 4.0 | 2.4 | 10 |
| 65 | 3.4 | 4.3 | 2.7 | 10 |
| 80 | 3.7 | 4.6 | 3.0 | 10 |
| 100 | 4.3 | 5.2 | 3.7 | 13 |
| 150 | 5.2 | 6.4 | 4.3 | 13 |
| 200 | 5.8 | 7.3 | 4.9 | 16 |
| 250 | 6.1 | 7.9 | 5.5 | 19 |
| 300 | 7.0 | 9.1 | 5.8 | 22 |
| 350 | 7.6 | 9.8 | | 25 |
| 400 | 8.2 | 10.7 | | 25 |
| 450 | 8.5 | 11.3 | | 32 |
| 500 | 9.1 | 11.9 | | 32 |

*Source*: Adapted from MSS *Standard* SP-69

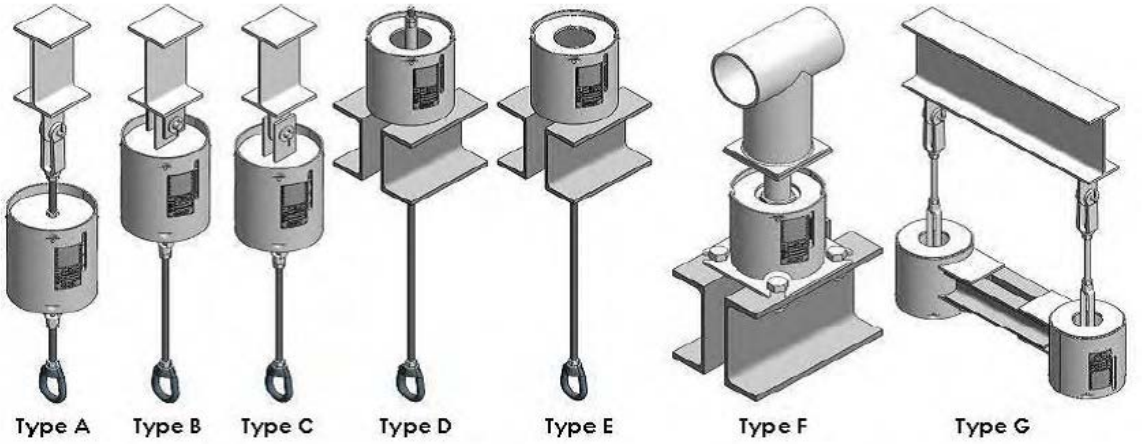
[a] Spacing does not apply where span calculations are made or where concentrated loads are placed between supports such as flanges, valves, specialties, etc.

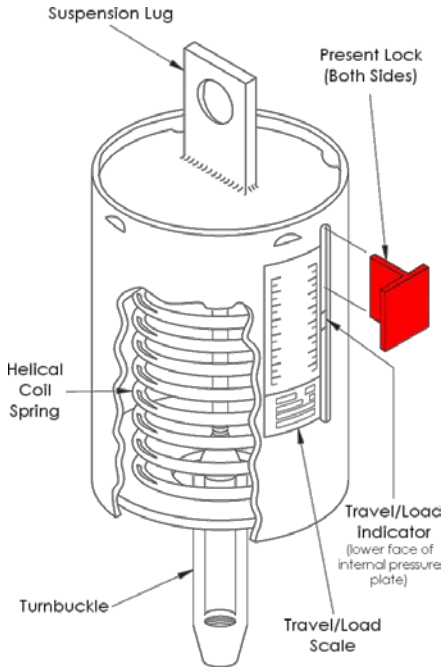
# HANGING INSULATED PIPES



# SPRING HANGERS



# 4. PUMPS

## DISPLACEMENT PUMPS

RECIPROCATING

ROTARY

High head

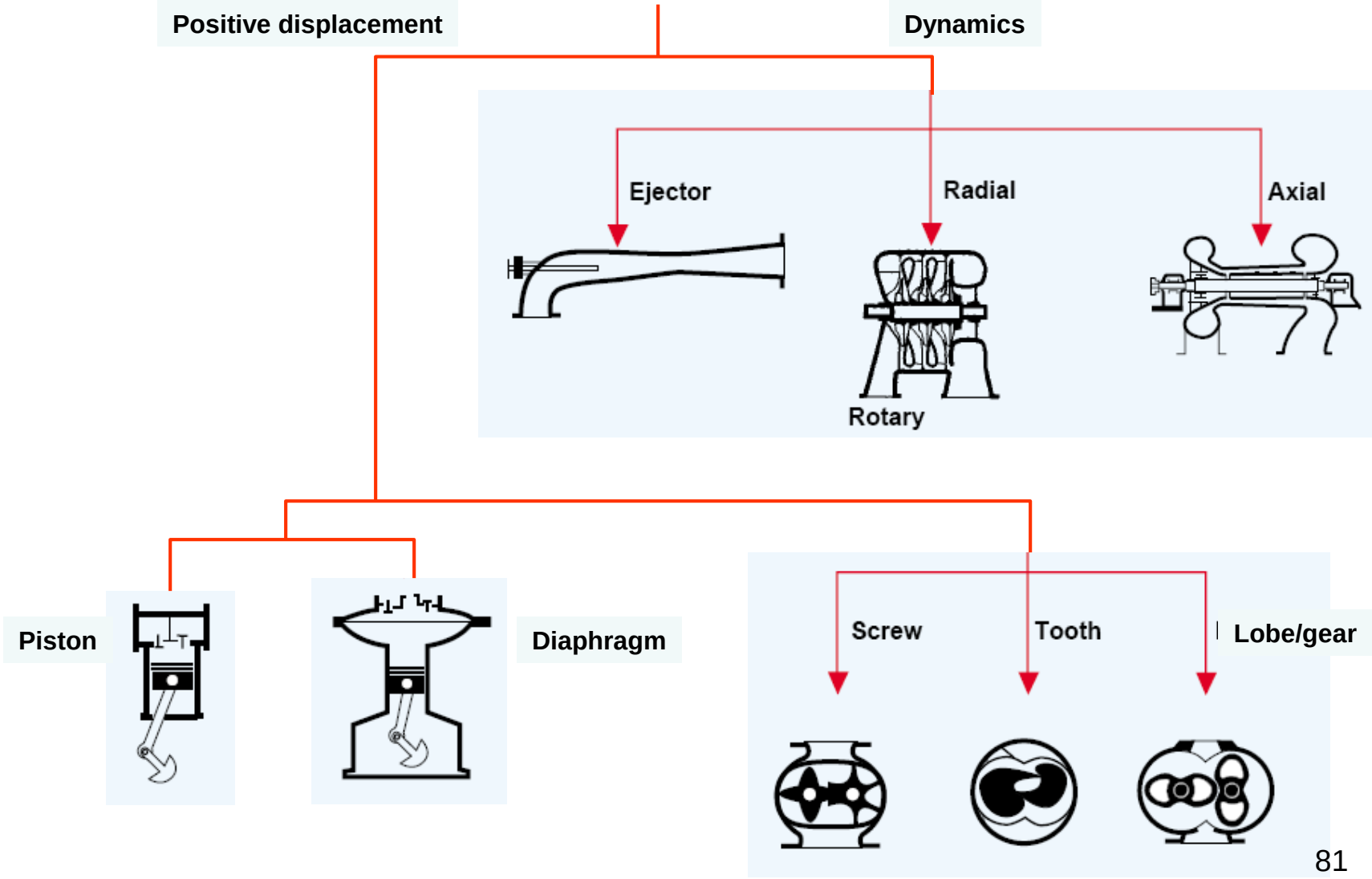
## DYNAMICS PUMPS

TURBINE

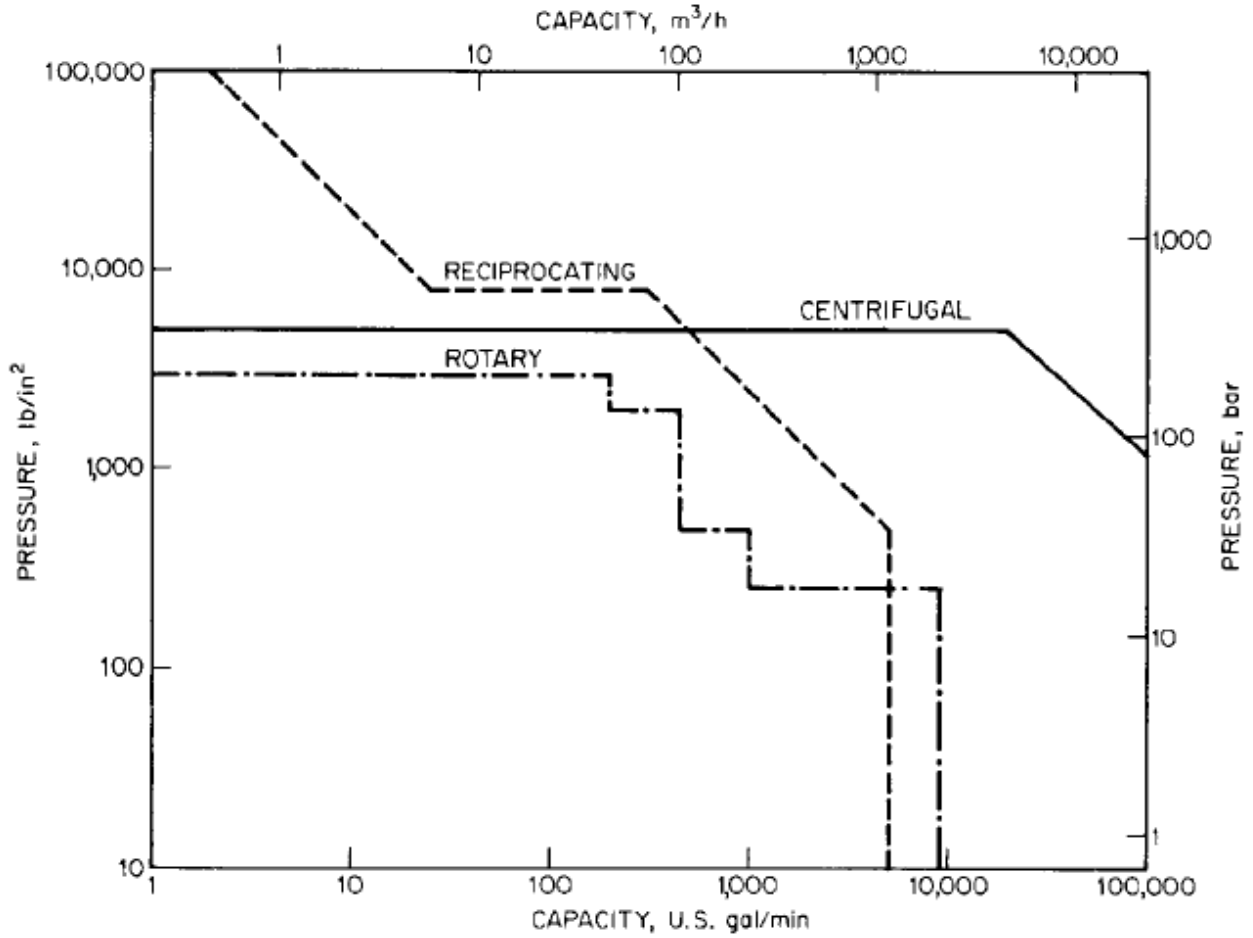
CENTIFUGRAL

High flow

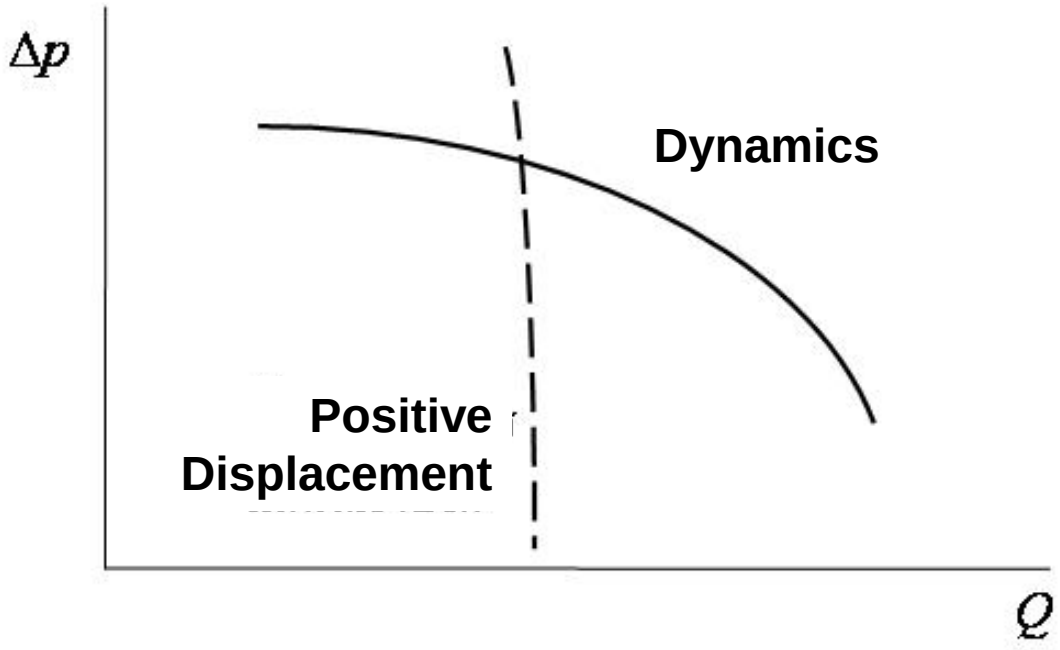
# TYPES


Positive displacement
Dynamics
Ejector
Radial
Axial
Rotary
Piston
Diaphragm
Screw
Tooth
Lobe/gear

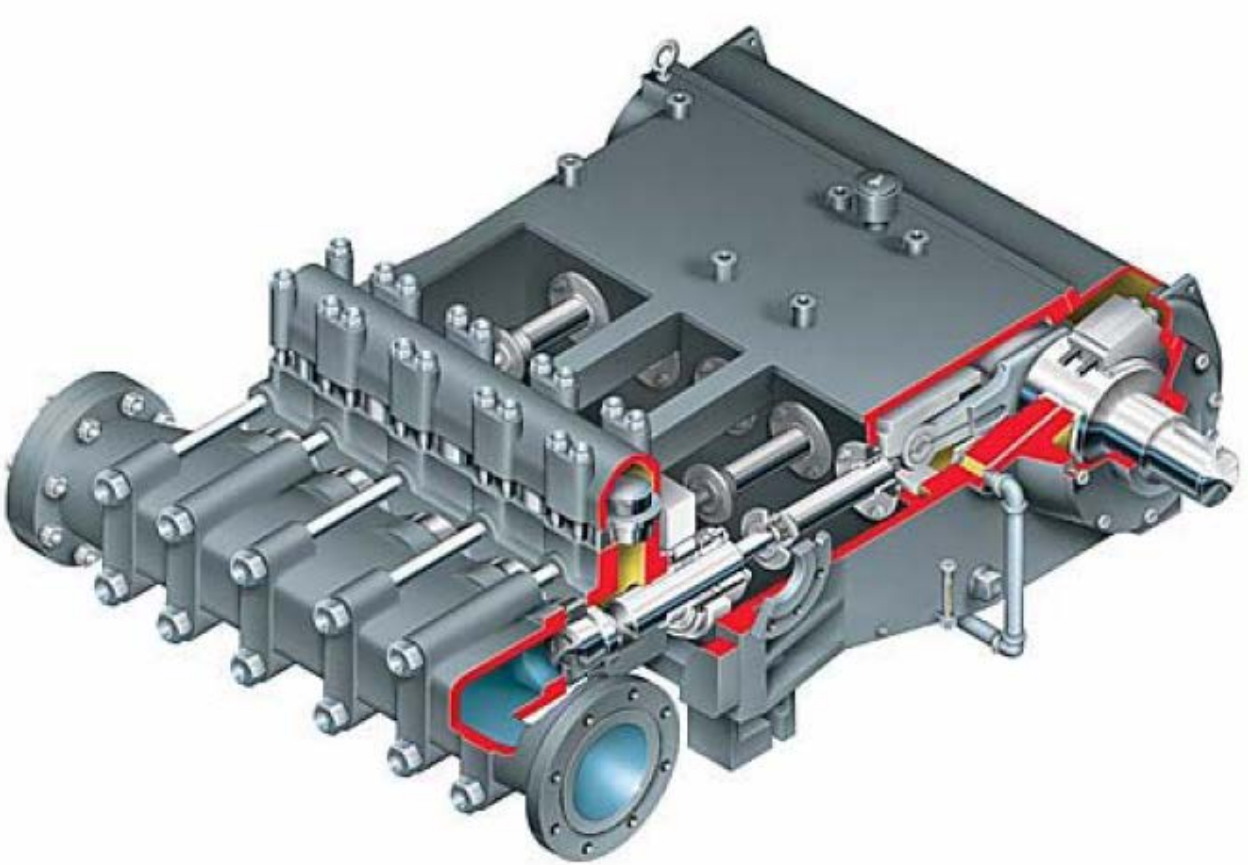
# RANGE


CAPACITY, m³/h
1
10
100
1,000
10,000
100,000
10,000
1,000
100
10
RECIPROCATING
CENTRIFUGAL
ROTARY
PRESSURE, lb/in²
PRESSURE, bar
1,000
100
10
1
1
10
100
1,000
10,000
100,000
CAPACITY, U.S. gal/min

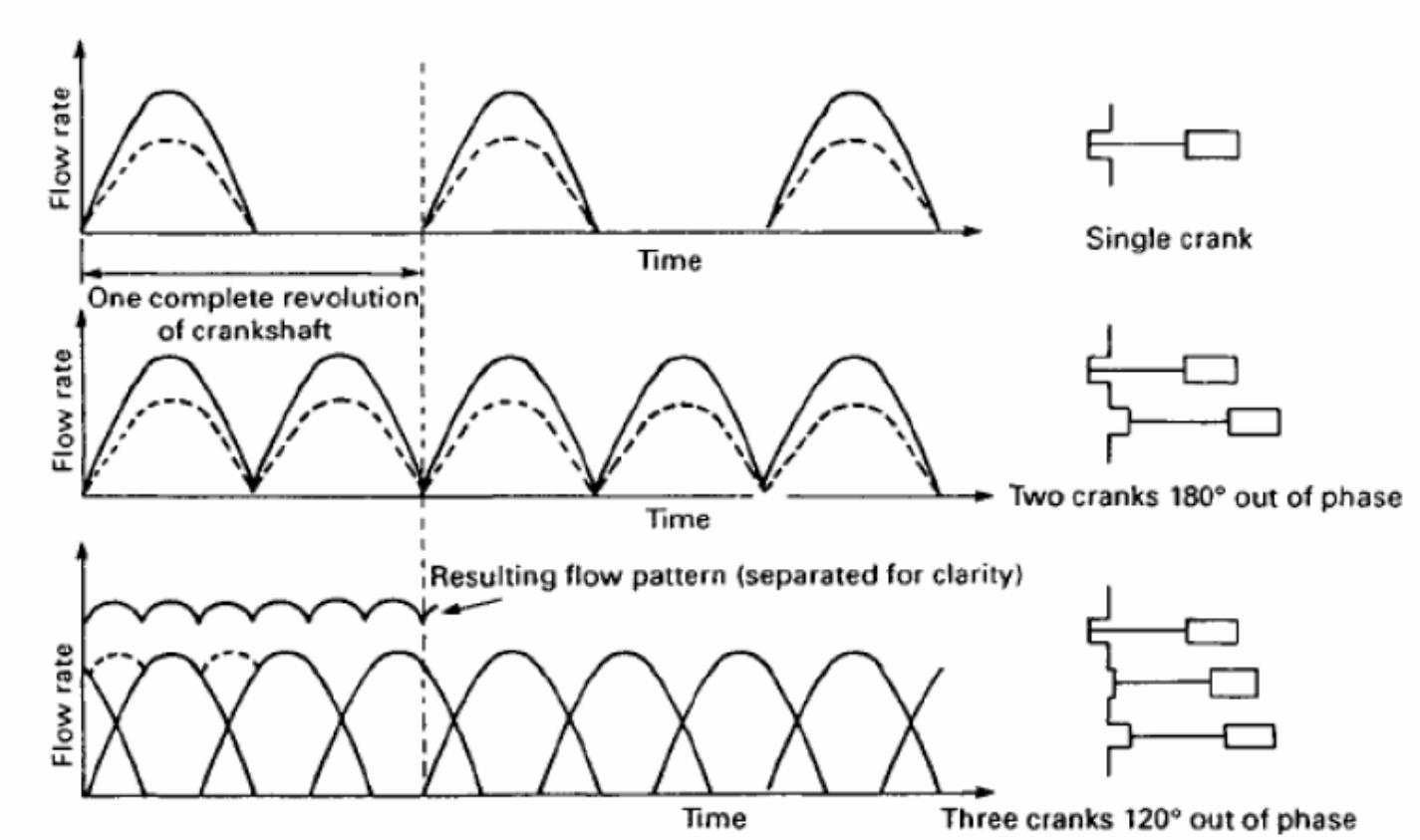
# CHARACTERISTICS



# PISTON PUMP

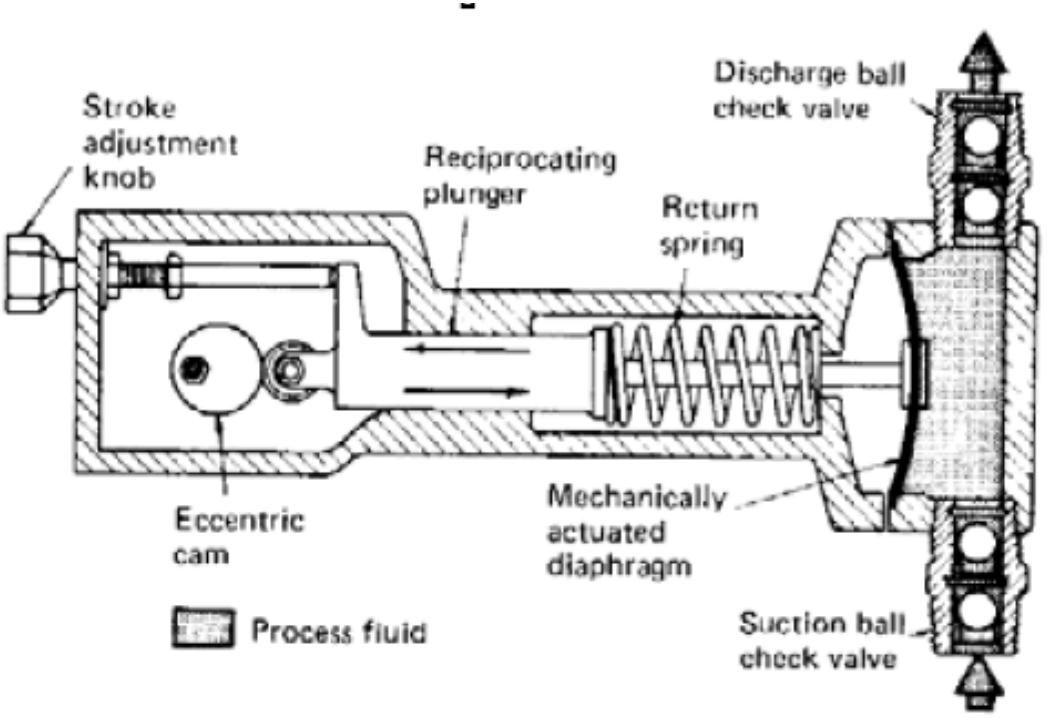


# FLOW FLUCTUATION



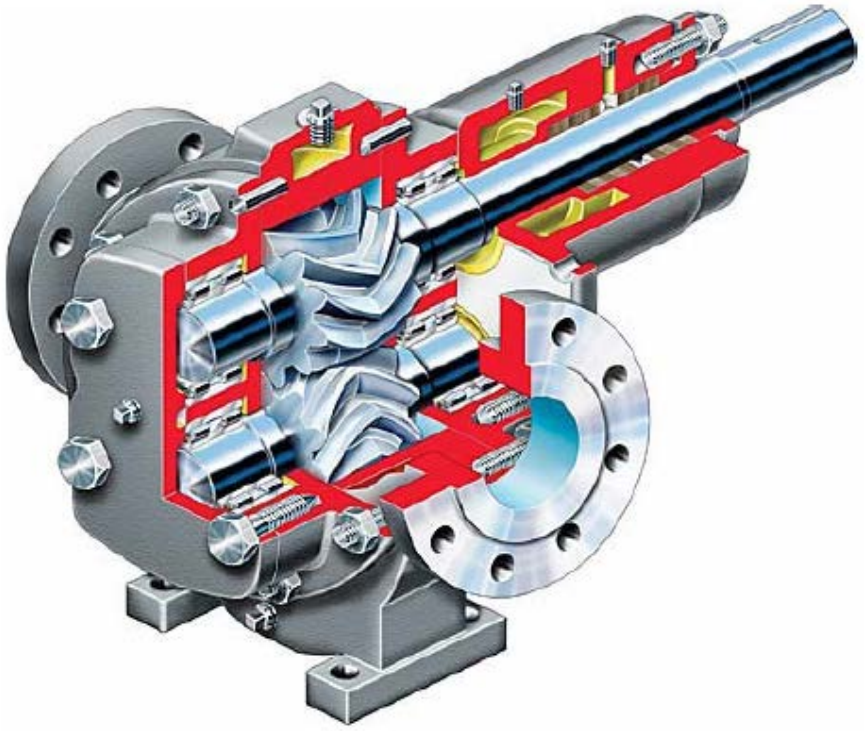

Install receiver tank to reduce fluctuation

# DIAPHARGM PUMP



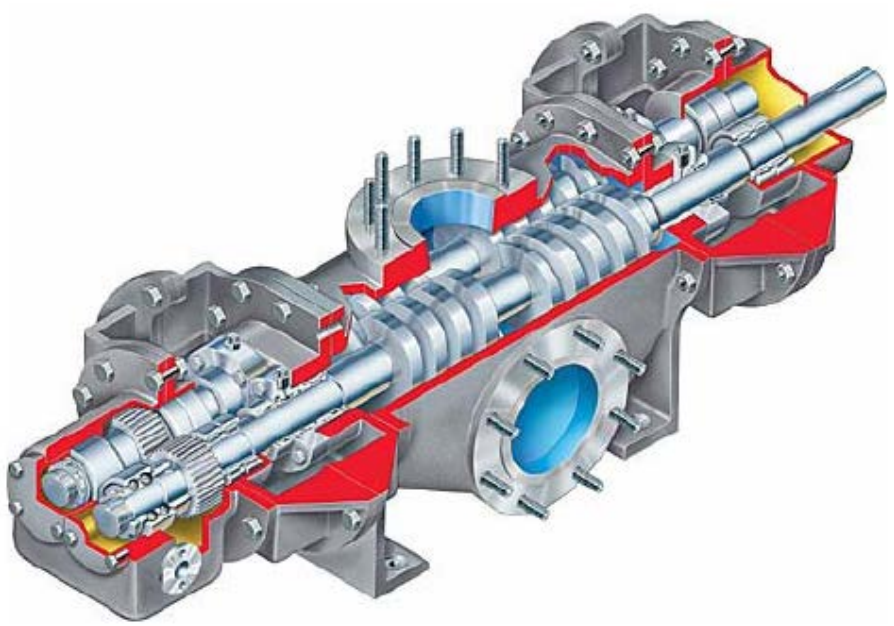

Avoid contact between fluid and pump mechanism

# ROTARY GEAR PUMP



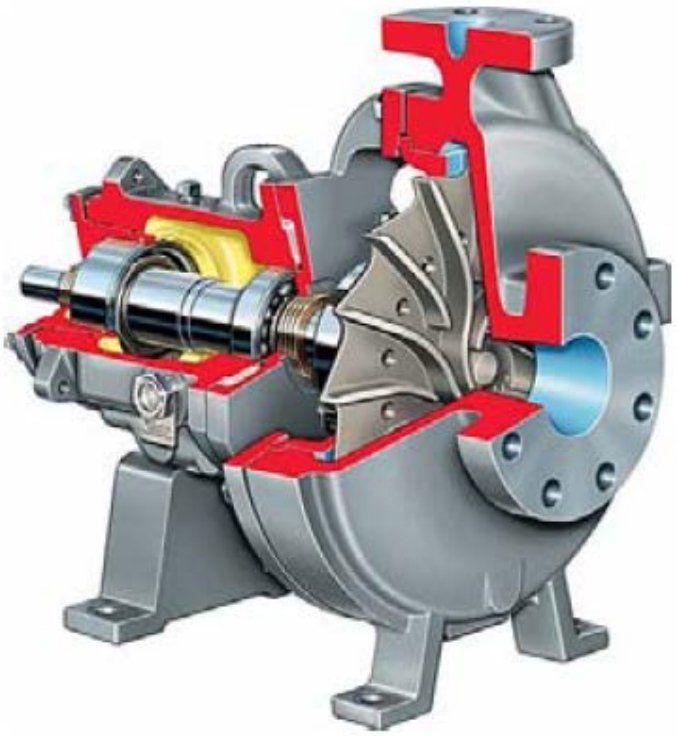
For high viscosity fluid

# ROTARY SCREW PUMP

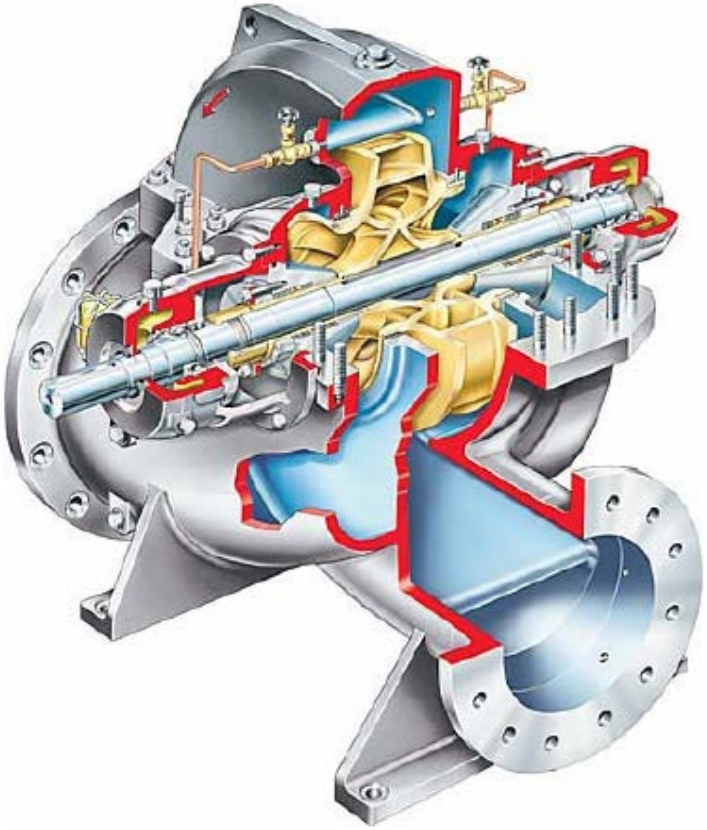


For very high viscosity fluid

# CENTRIFUGAL PUMP

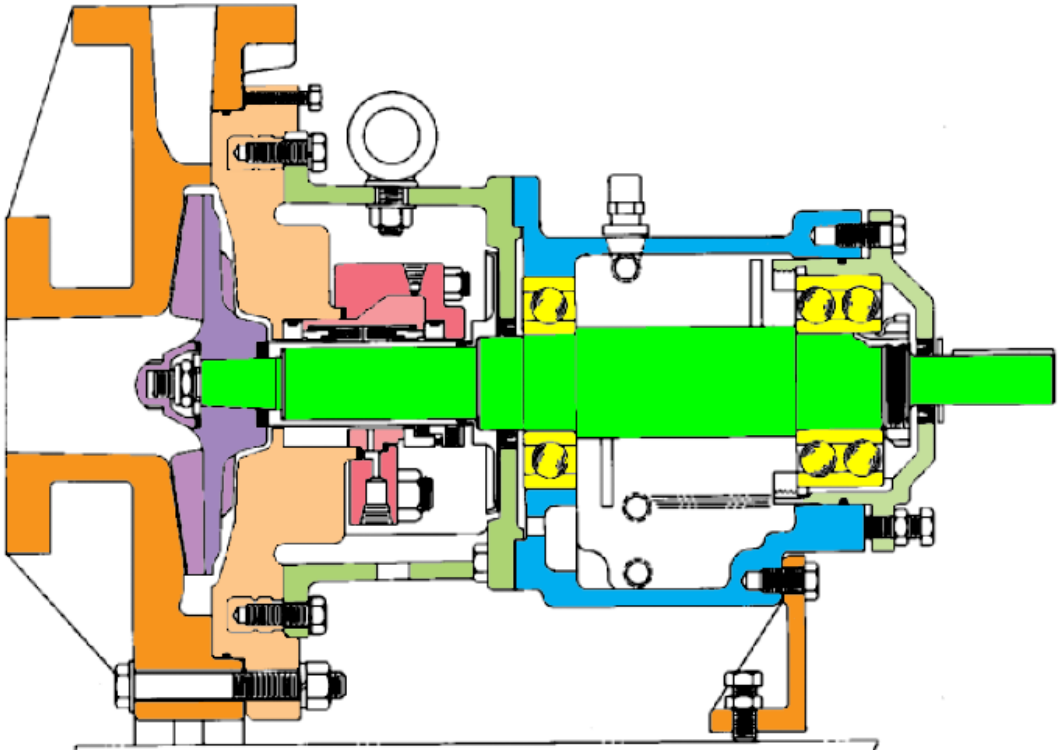


End suction

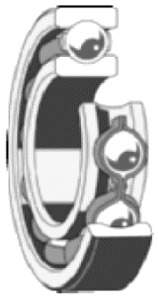


Split-case

# CENTRIFUGAL PUMP CONSTRUCTION

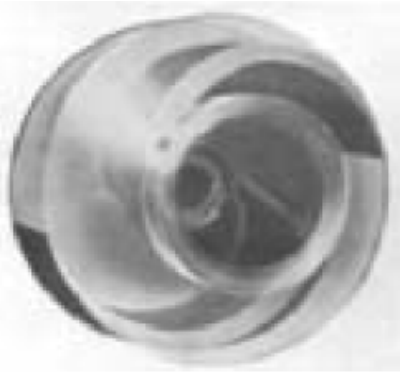


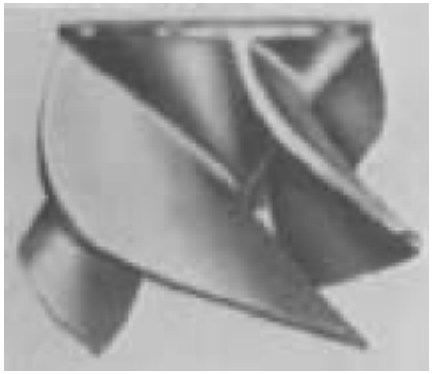
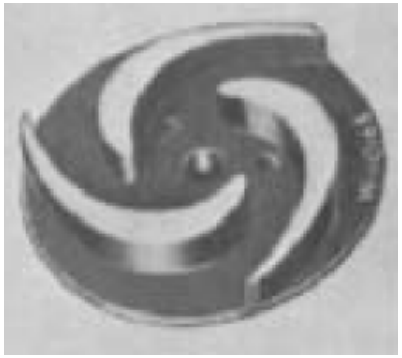
End suction pump



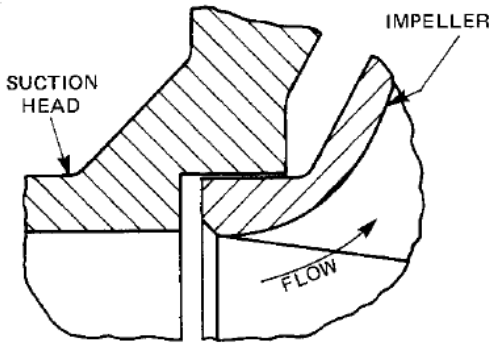
# DEMONSTRATION UNITS

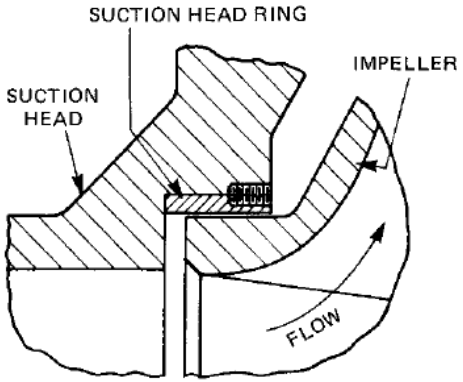

# IMPELLERS

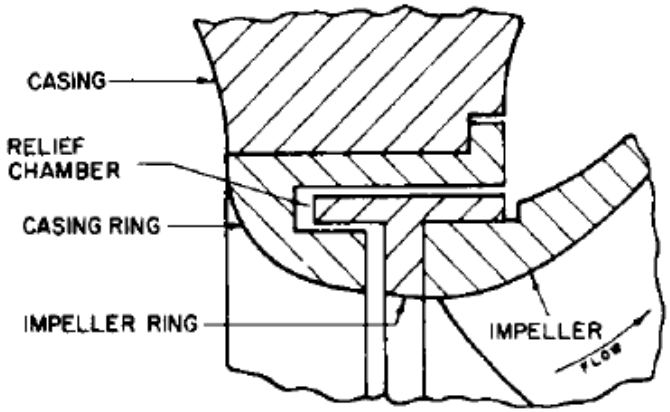



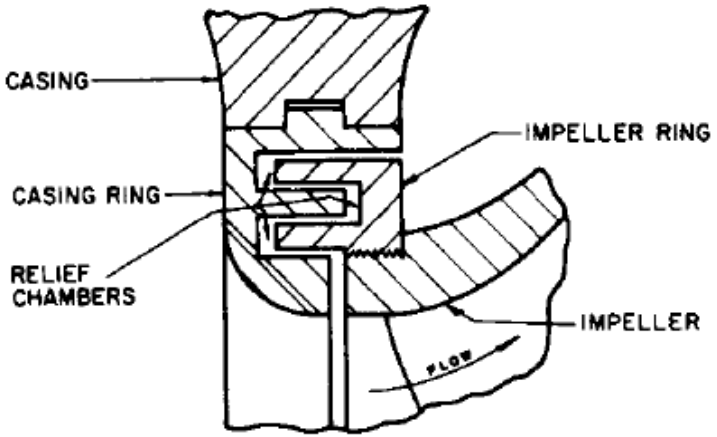




# LEAKAGE JOINTS

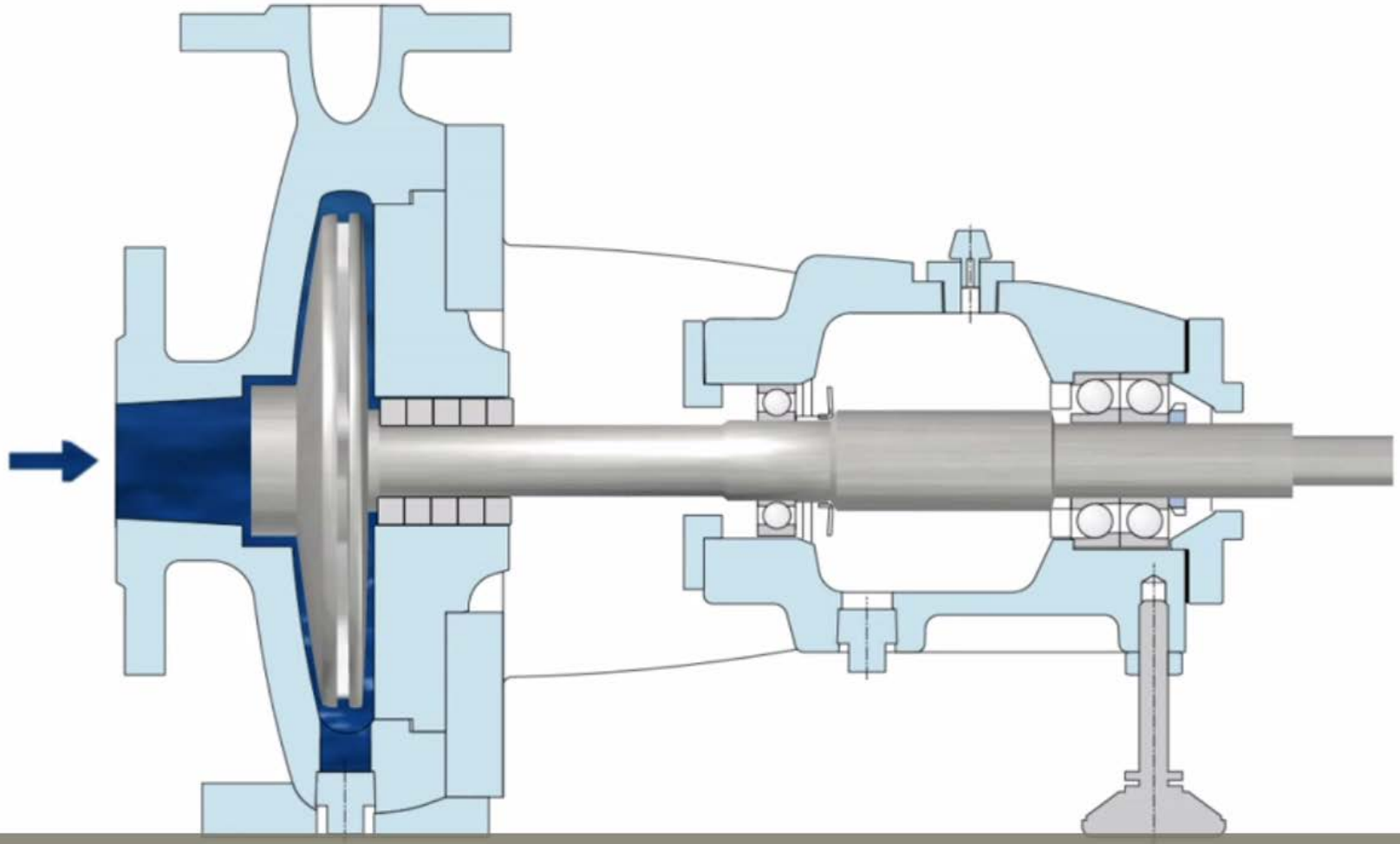


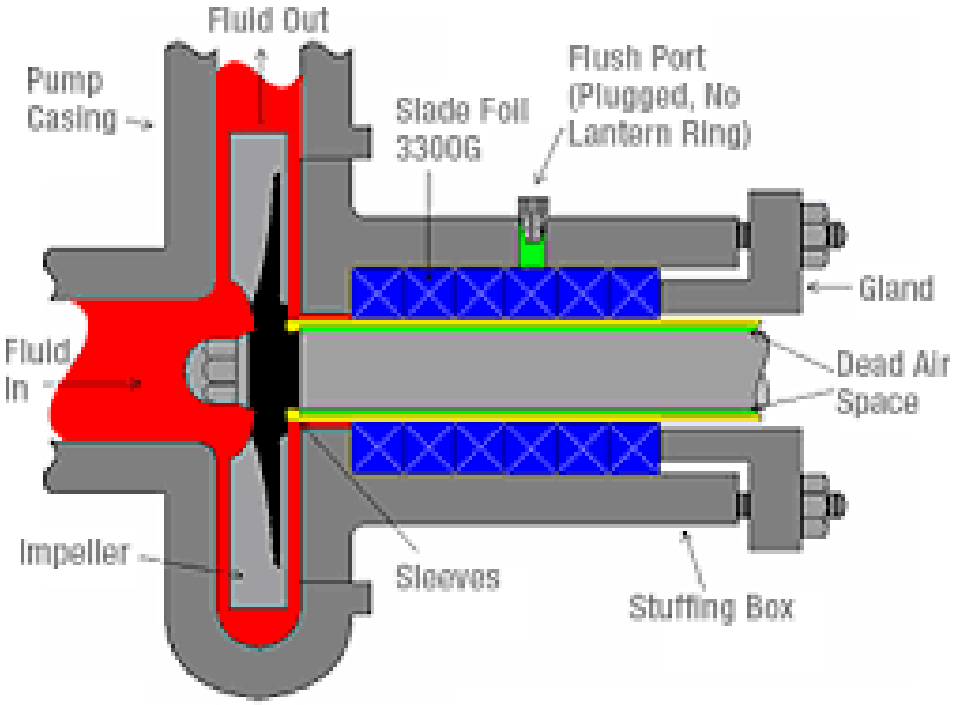



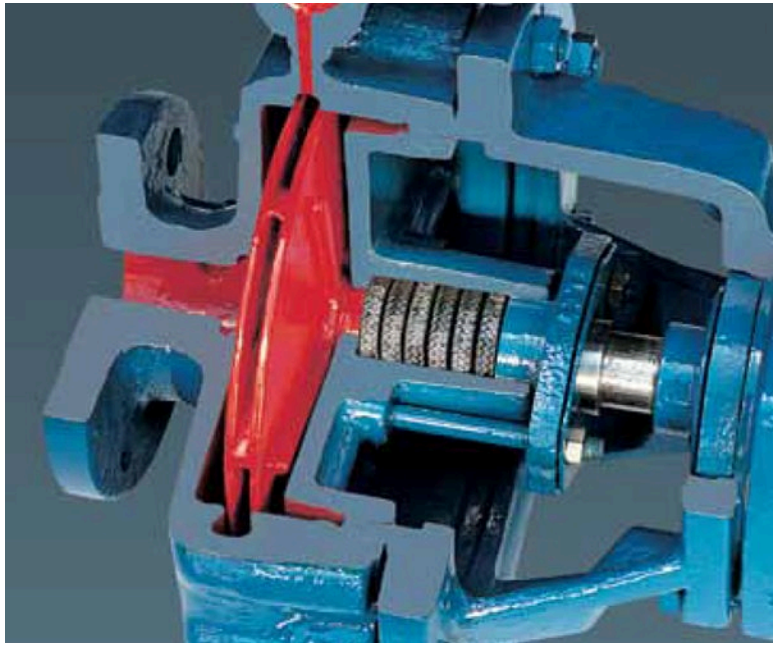
# SHAFT SEALING

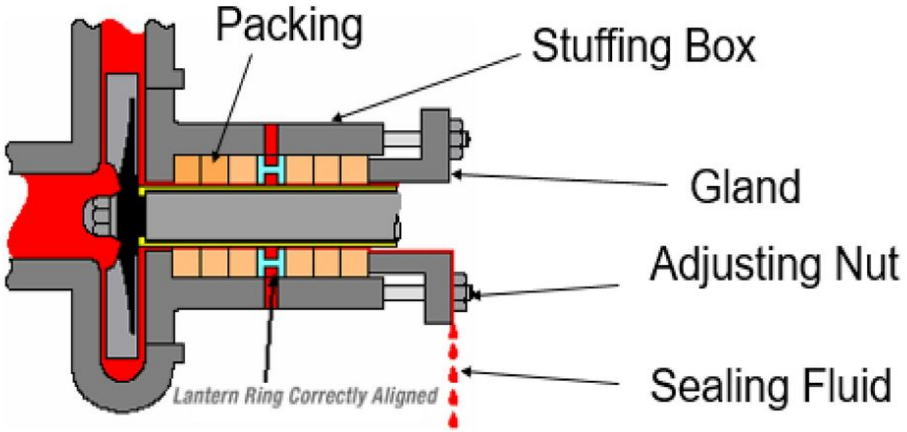


# GLAND PACKING SEAL

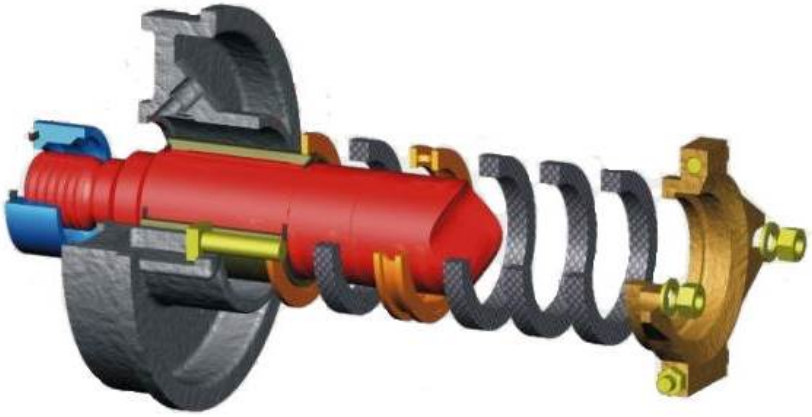


# GLAND PACKING SEAL

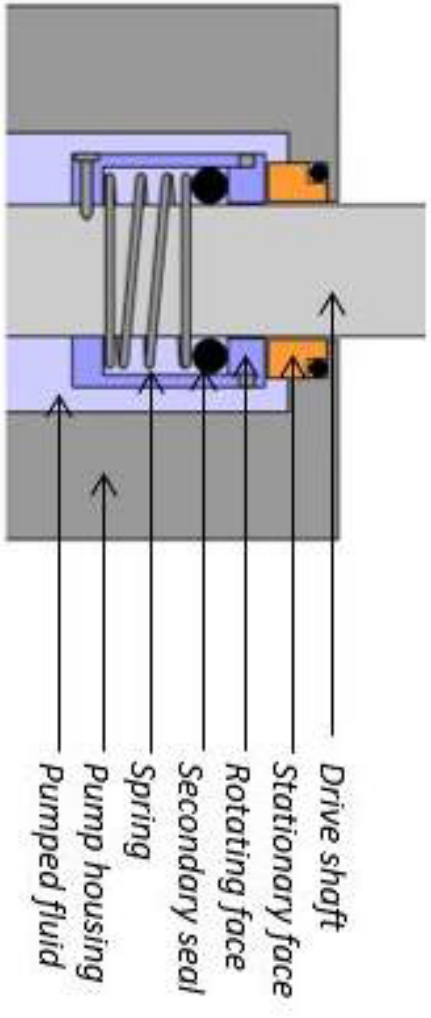




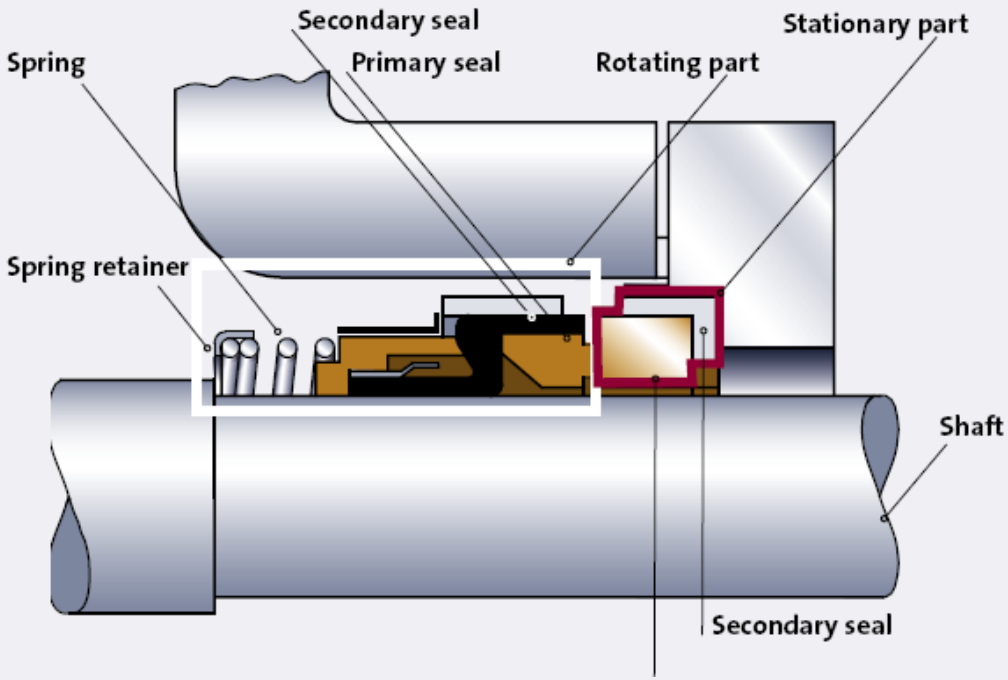

GLAND PACKING



# MECHANICAL SEAL




# MECHANICAL SEAL




| Mechanical shaft seal | Designation |
|---|---|
| Rotating part | Seal face (primary seal) |
| | Secondary seal |
| | Spring |
| | Spring retainer (torque transmission) |
| Stationary part | Seat (seal faces, primary seal) |
| | Static seal (secondary seal) |

# HOME PUMP

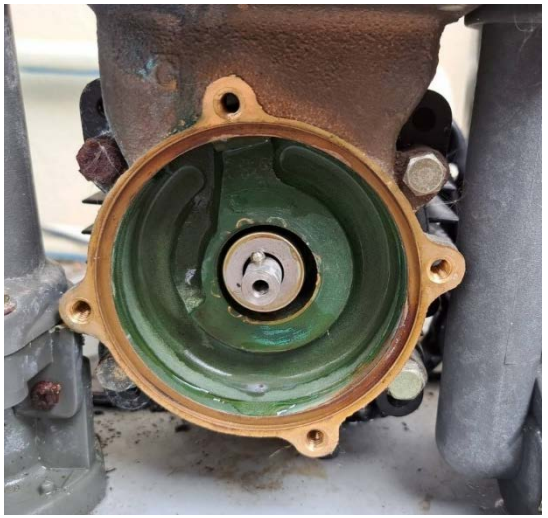

MITSUBISHI ELECTRIC
CONSTANT PRESSURE WATER PUMP
EP-155R


HITACHI
GX
SERIES
WT-P
100GX2
JAPAN
HITACHI


FUJIKA
FUJIKA


HITACHI
GX
SERIES
WT-P
150GX2
JAPAN
HITACHI

# HOME PUMP

# INDUSTRIAL PUMP

# INSTALLATION

# NEXT SESSION

- Pipe drawing. Symbols.
- Cost estimation.
- Theory of flow in pipes.
- Calculation of pressure drop in pipes.
- Energy balance in fluid flow.

# HOMEWORK 2

1) **Locate one of automatic air vents in Thammasat university. Take a photo and explain the reason for having it in such location.**

2) **Compare weight per meter of a DN150 sch40 and sch80 steel pipe filled with water. Find percentage of the different base on sch40.**