Pump, Compressors & Pig Trap Design

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IBC
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Pump, compressor and pig trap design

- **This is subdivided into**

- **Pumps and pump design**
- **NPSH**
- **Pump curves**
- **Pump types**
- **Compressors**
- **Pig trap design**

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Pumps and compressors

- **Pumps are liquid service, compressors for gas.**
- **Pump performance is commonly quoted in metres head, sometime in m head water.**
- **This head figure remains the same independent of fluid pumped. The value that does change is the pressure that this head of liquid develops. This is dependent on density and gravity.**

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Pump and compressor design

- **Density of liquids and gas can change markedly with temperature and it is important to check the extremes of density with regard to the limits of pressure generated by different fluids.**
- **Booster pumps need to accommodate start-up inlet pressures and control outlet pressure**
- **Start-up may need control valves to control maximum flow rate or pressure – pumps and compressors**

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Pump Definitions

- **To convert metres head (m) to pressure in barg (p)**

$$\text{pressure (barg)} = \frac{m \times SG \times 9.81}{100} \; ; \; m = \frac{P \times 100}{SG \times 9.81}$$

- **Pump power can be expressed in a number of ways**
- **Hydraulic power – liquid power**
- **Shaft power – liquid power divided by pump efficiency (typically varies between 60 to 75%)**
- **Electrical power – shaft power divided by motor efficiency (typically 0.9 to 0.95)**

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Pump Definitions

$$\text{Hydraulic power (kW)} = \frac{\text{m X density X g X flow } (m^3/hr)}{3.6 \times 10^6}$$

m – metres head of fluid

Density - kg/m^3

g – 9.81 m/sec2

$$\text{Shaft power (kW)} = \frac{\text{m X SG X flow } (m^3/hr)}{\text{367 X pump eff (0-1)}}$$

A fixed speed Electric motor will take *whatever* power it needs to try to maintain that fixed speed.

Power (HP) = P kw / 0.746

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Pump NPSH

- **NPSH is a value used to note a liquid pumps limit on inlet head.**
- **Important for the initial pump in a system.**
- **Main line pumps generally need minimum 2 bar**
- **Does not indicate cavitation limit – allow 1 to 2m above NPSH limit.**
- **Becomes an issue with high temperature, high altitude, volatile fluids, height differential between tank and pump or long delivery lines.**
- **NPSHR is found by testing when differential head across a pump reduces by 3%**

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Pump NPSH

- **Calculation**
- **NPSHA = Pa + Hd – Hf – Vp**
- **Pa - Atmospheric pressure (varies with altitude)**
- **Hd - Head difference from centre of pump to liquid level (El liquid – El pump)**
- **Hf - Frictional losses in pipe work**
- **Vp - Reid Vapour Pressure (varies with temp and product)**

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Pump types available for pipeline use

- **Centrifugal:**
- **Wide power and pump capacity range**
- **Relatively compact**
- **No pressure pulsation**
- **No flow pressure 10 - 15% above normal pumping (recirculation not required)**
- **Normally requires flooded / pressurised suction**
- **Flow varies with pressure outlet**
- **Valid for viscosities up to 300 cP**
- **Aim for duty point within 85% of BEP**

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Centrifugal pump

Basic single stage centrifugal pump – open impellor with inlet screw

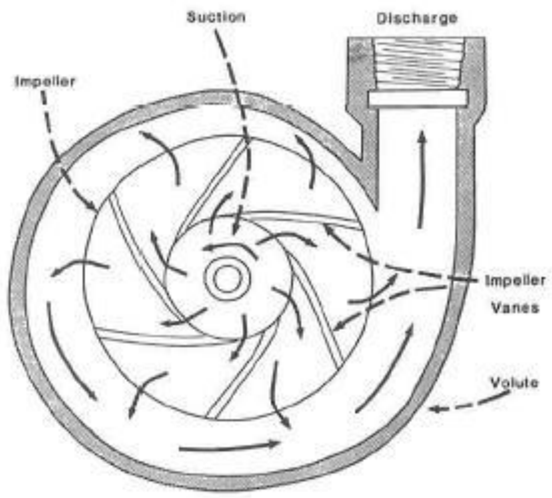

Figure 10-1. Radial flow pump.

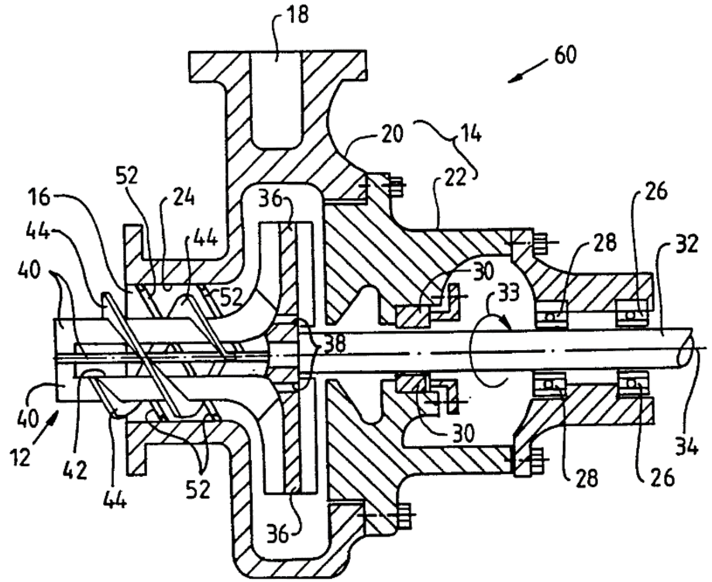

FIG. 3

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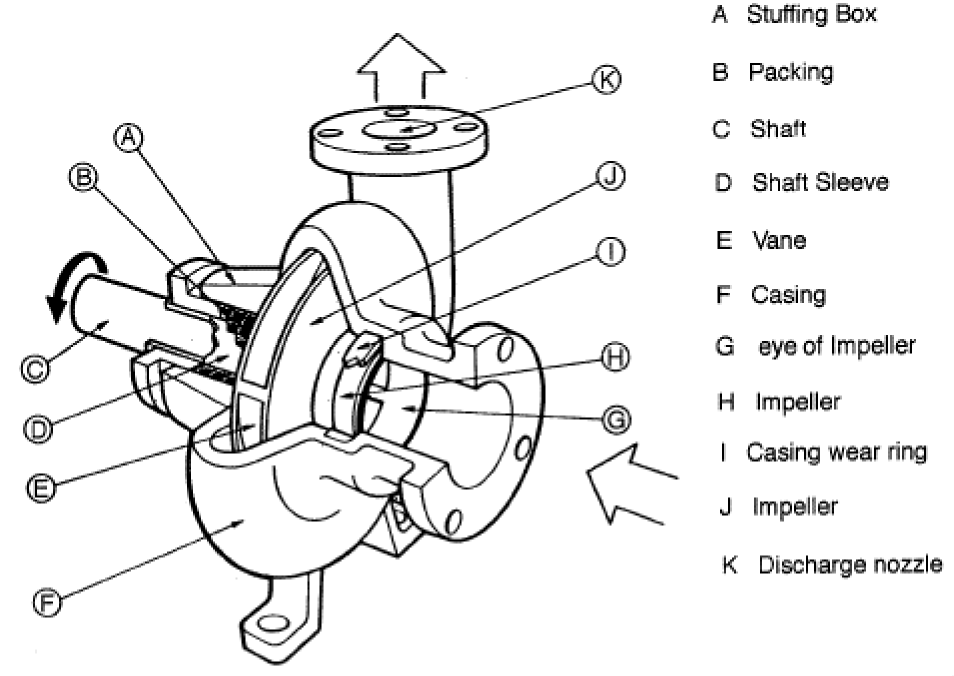
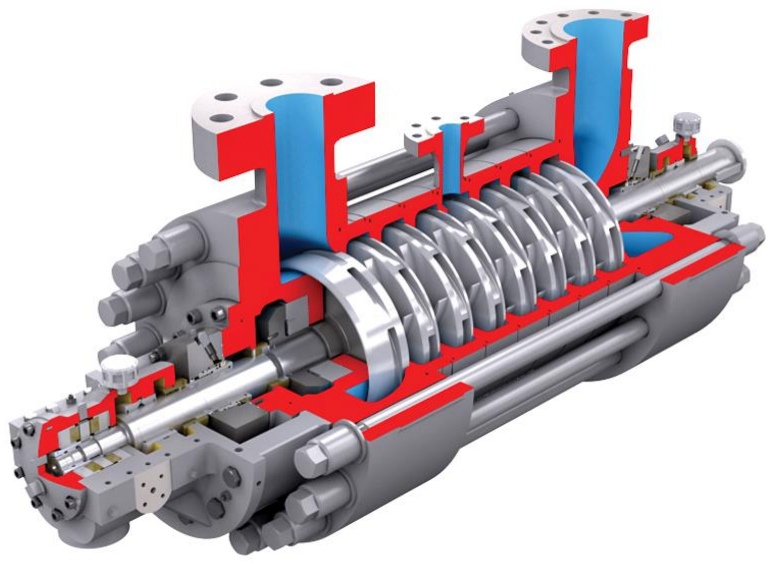
Centrifugal pump

Basic single stage OH centrifugal pump



Multi Stage BB pump



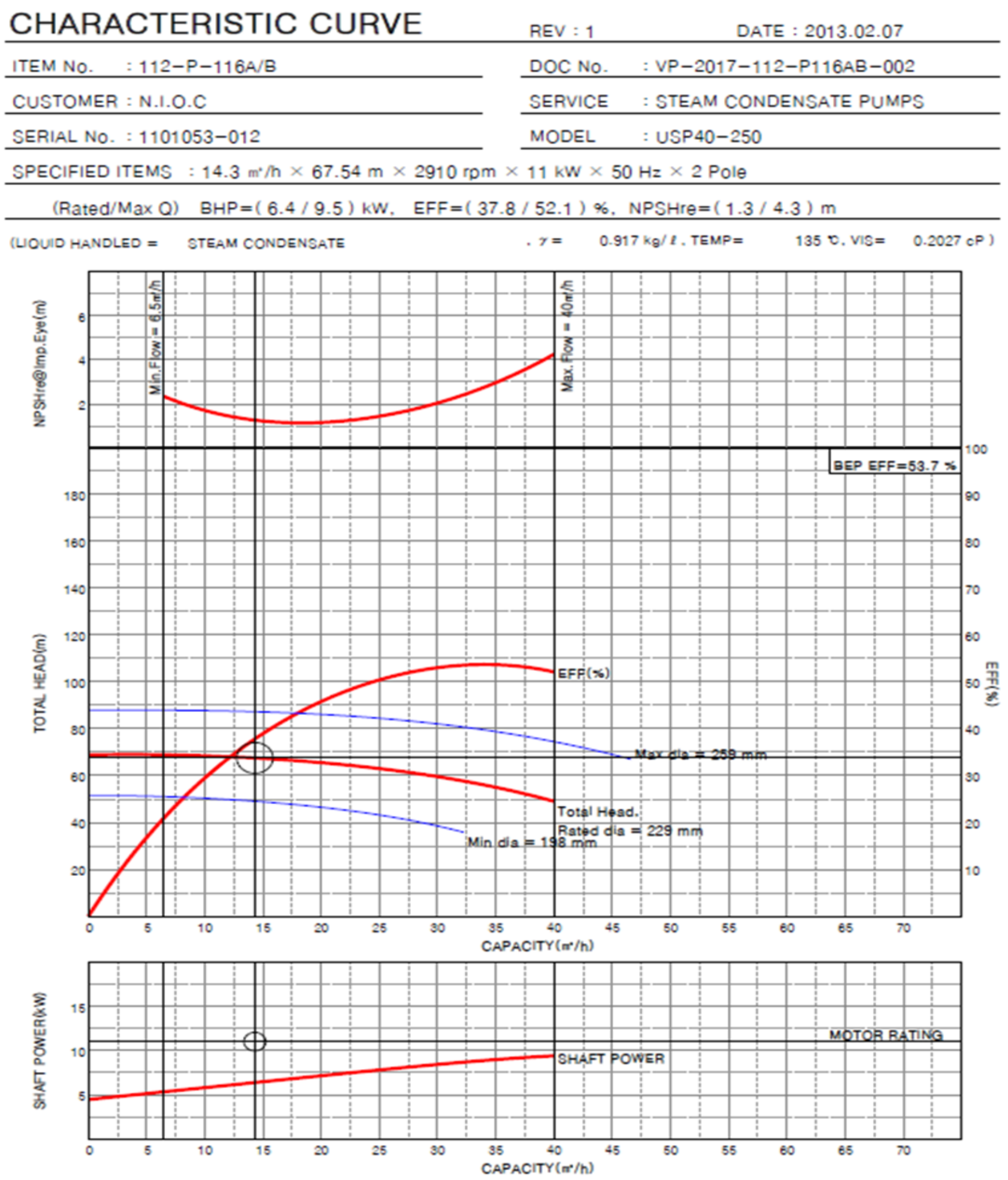
Pump curve

NPSH curve

Pump curve

Efficiency curve

Shaft power curve



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Variable speed pumps

- **Where flow rates and pressures can vary significantly or where multi-products are being pumped, Variable Speed Drives are often used to reduce power consumption.**
- **Can vary power by mechanical gearboxes or fluid drives or electrical frequency changes (VFD).**
- **Pumps need to work within 85% of BEP and have a good match to the system curve.**
- **They can be used for soft start**
- **Can introduce harmonics into the supply system and have losses of ~ 5% of power.**
- **Motors need insulated bearings**

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Variable speed pumps

- **Where a large static head is present compared to frictional losses or where the system curve is very steep or very flat, VFDs may not be suitable**
- **Affinity laws:**
- **Pump Flow α speed**
- **Pump head α speed^2**
- **Pump power α speed^3**

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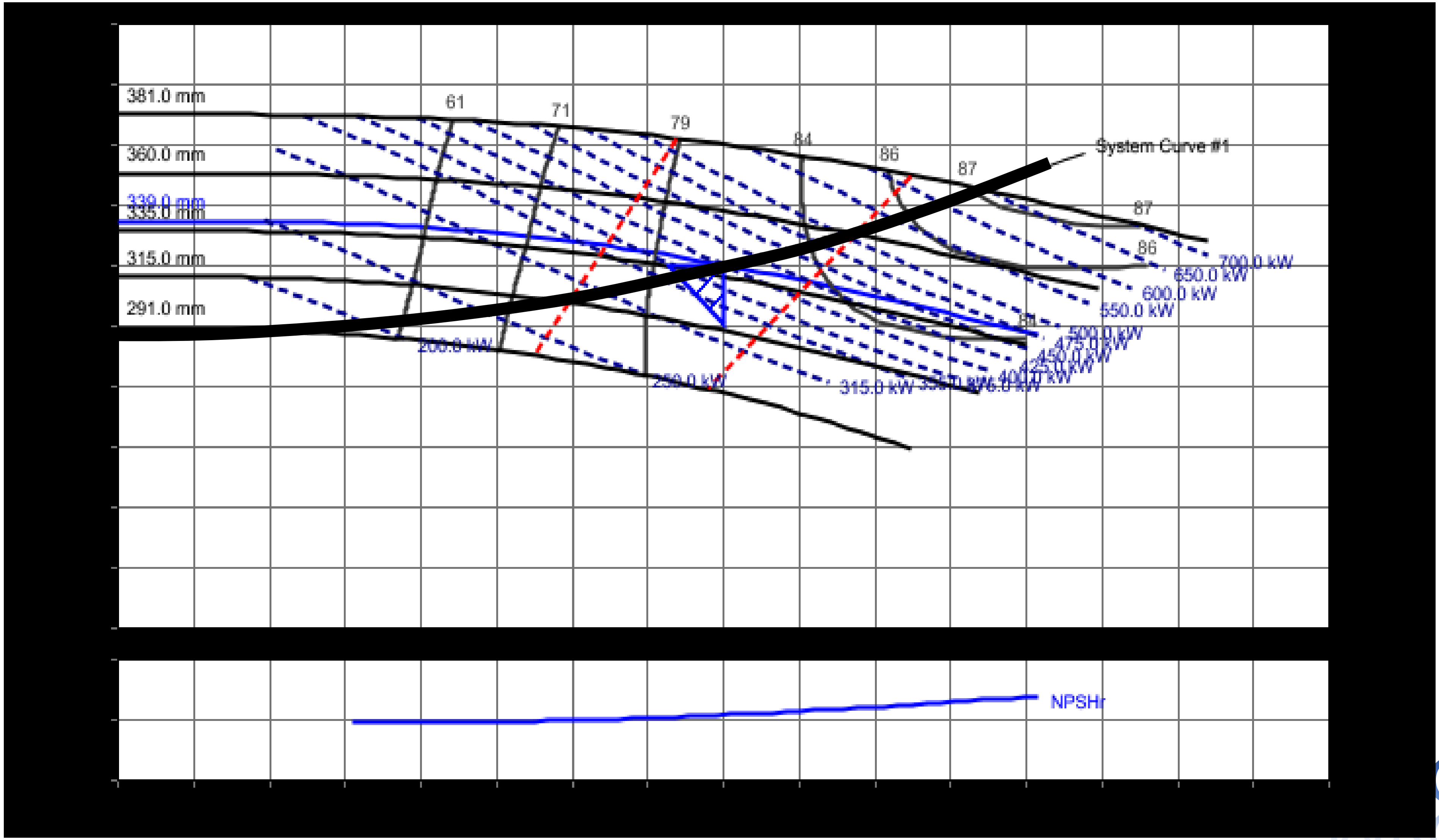
Variable speed pumps



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Other pumps

All positive displacement

Piston

Screw

Progressive cavity

Vane pumps

Diaphragm pumps

Lobe

Gear

Axial piston

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Compressors

Compressors for pipeline service are commonly powered by gas turbine units using fuel gas from the pipeline due to large power demands and remote location of many units.

Pressure ratio normally limited to range 1.5 to 2.2. Multiple compressor trains required for oilfield compression (350-500 barg).

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Compressors

Compressors require re-circulation lines for start-up and surge protection at low flow to avoid stalling of compressor.

Use of after coolers or interstage coolers often required and can be hydraulically advantageous

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Pig traps

- **Design codes**
- **Definitions**
- **Design issues**
- **Launcher / Receiver**

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Pig traps

- **Safety critical item**
- **Deliberate full bore opening**
- **High potential for incorrect operation**
- **Part of pipeline design**

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Pig traps

Design code

Pig traps should be part of the pipeline design.

Design code should be the pipeline code and not a pressure vessel or piping code.

Pressure Vessel and piping codes can significantly reduce the ID - Need to check INTERNAL diameter versus pipeline to avoid large reduction.

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Pig traps

Definitions

Major Barrel – Place where pig is inserted / removed, normally 2 pipe sizes bigger than the pipeline nominal size

Minor barrel – smaller pipe attached to the pipeline. Needs to allow for maximum pig length to avoid fouling valves

Throat – reducer from Major Barrel to minor barrel – bottom flat

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Pig traps

Bypass – Piping which allows flow around the pig trap

Balancing Line – Essential to prevent trapped gas from blowing pig out of trap.

Kicker line – connecting pipes to flow in or out of the pig trap during use. Size min 30% of pipeline size, 50% preferred.

End closure – Normally quick acting opening purpose designed to pressure vessel codes (ASME VIII). Specify type (e.g. Bandlock 2)

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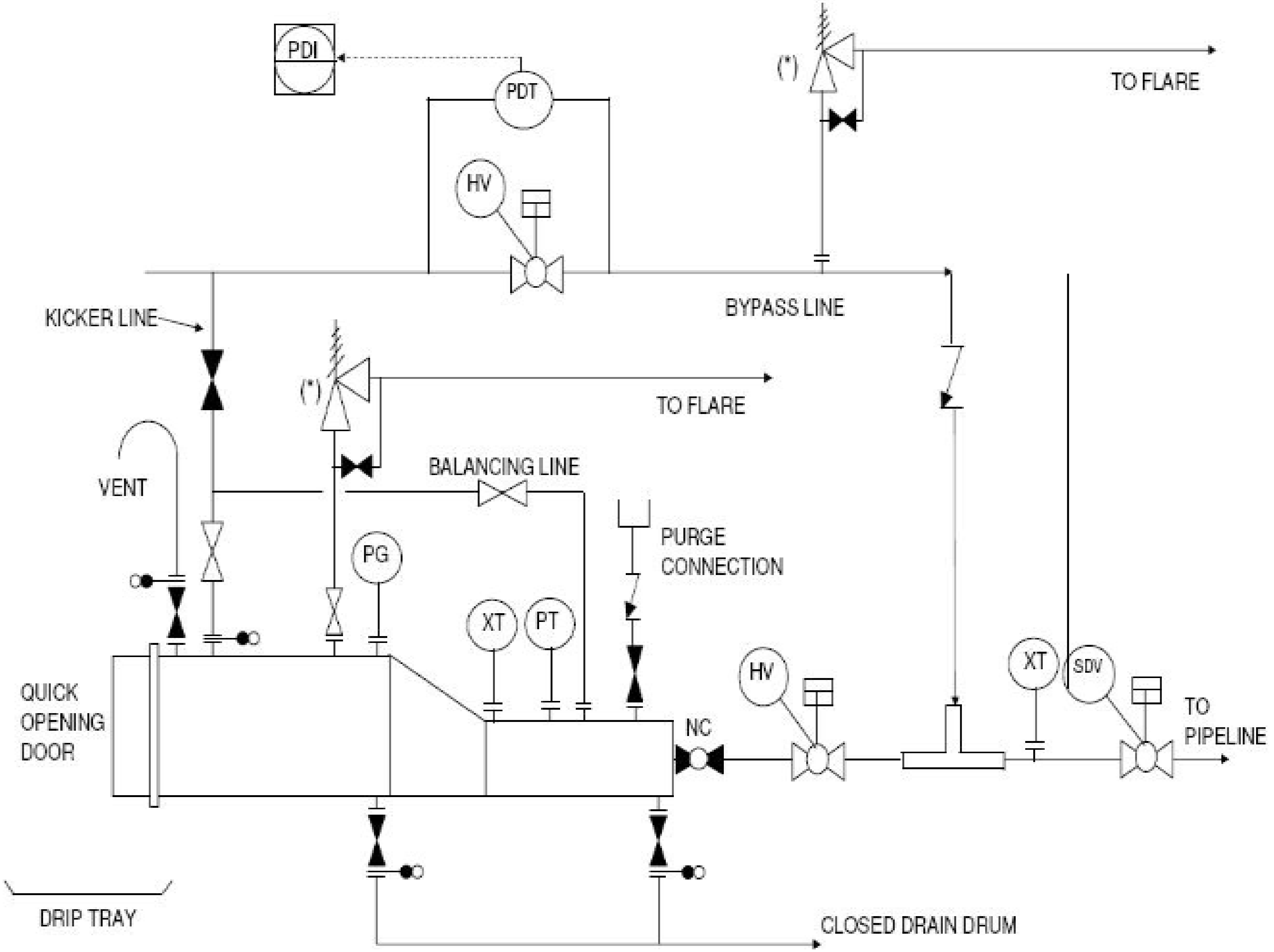
PDI
PDT
(*)
TO FLARE
HV
KICKER LINE
BYPASS LINE
(*)
TO FLARE
VENT
BALANCING LINE
PURGE
CONNECTION
PG
XT
PT
HV
XT
SDV
TO
PIPELINE
QUICK
OPENING
DOOR
NC
DRIP TRAY
CLOSED DRAIN DRUM

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Design issues for pig traps

Design issues

- **Orientation – Flat**
- **Length – Intelligent pigs**
- **Balancing line**
- **Isolation and safety interlocks**
- **Drain and vent sizes (min 4”)**
- **End closures**
- **Pig signallers**

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Pig traps

- **Launcher**
  - **Short minor barrel**
  - **Kicker line at rear of major barrel**
- **Receiver**
  - **Minor barrel equal to length of largest pig**
  - **Kicker line towards throat**
  - **Larger drains**
- **Multi use**
  - **Long minor barrel**
  - **Mid point location of kicker line**

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Summary

Pump design

Pump types

Compressors

Pig trap design

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Thank You

Any questions?

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