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Born on Aruba (Carribean) in 1963
School and College in the Netherlands
Resident in Romania - Bucharest
Mechanical Engineer (3 years) at Stork
Instrument Engineer (7 years) at MW Kellogg
Metering Engineer (17 years) at Polar Systems / Imtech Systems
Metering Consultant (4 years) at SGS - Kuwait
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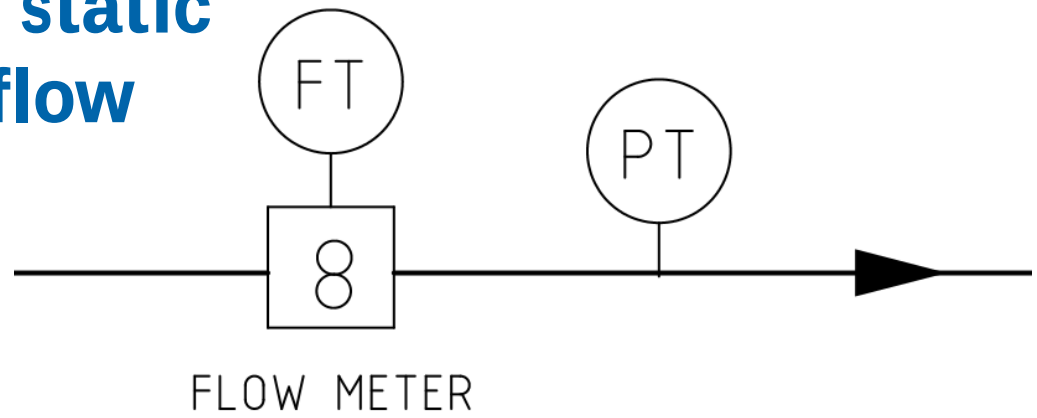
Back Pressure on Liquid Flow Measurement

Sharing experience regarding back pressure control with flow metering:

- Back Pressure theory
- Aspects during engineering
- Aspects during commissioning

What is Back Pressure and why is it addressed for liquid flow metering:

- Back Pressure of the flow meter is the static pressure of the fluid downstream the flow meter



- To ensure that the liquid in the flow meter stays liquid, and cavitation and flashing does not occur

Requirement for Minimum Back Pressure for liquid flow metering

- The equation can be found in many Standards for flow metering and is an estimation
- The vapor pressure of the fluid at line conditions (Temperature) shall be used

$$BP = (2 \times \Delta P) + 1.25\ Vp$$

Where: BP = Minimum back pressure
ΔP = Pressure drop at maximum flow rate
VP = Absolute vapor pressure at operating temperature

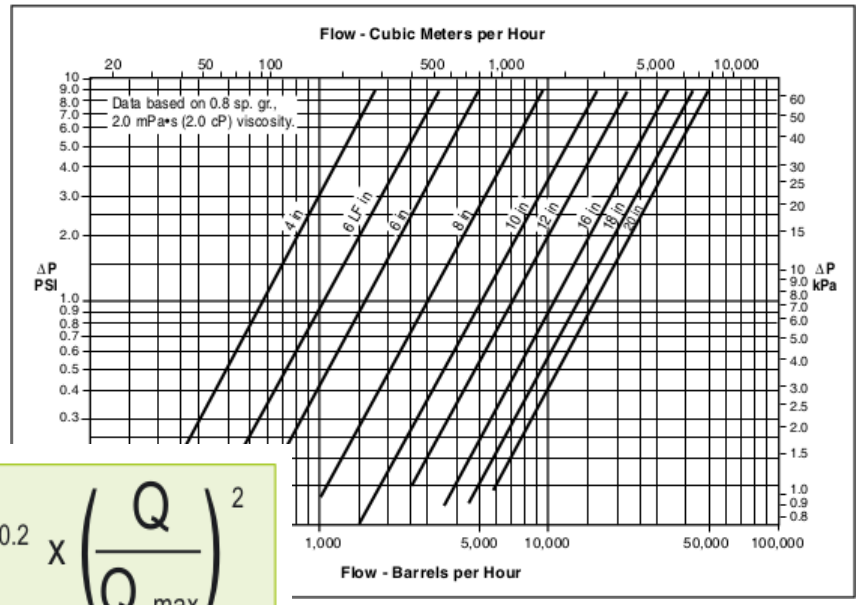
Back Pressure on Liquid Flow Measurement

From where do we obtain the meter pressure drop Δp:

Depends on the type of flow meter

- **Some manufacturer provides a pressure drop chart and/or an equation**
- **Always consult the manufacturer for special applications (low specific gravity)**

Pressure Drop



$$\Delta P = 3.6 \times d \times \nu^{0.2} \times \left(\frac{Q}{Q_{max}}\right)^2$$

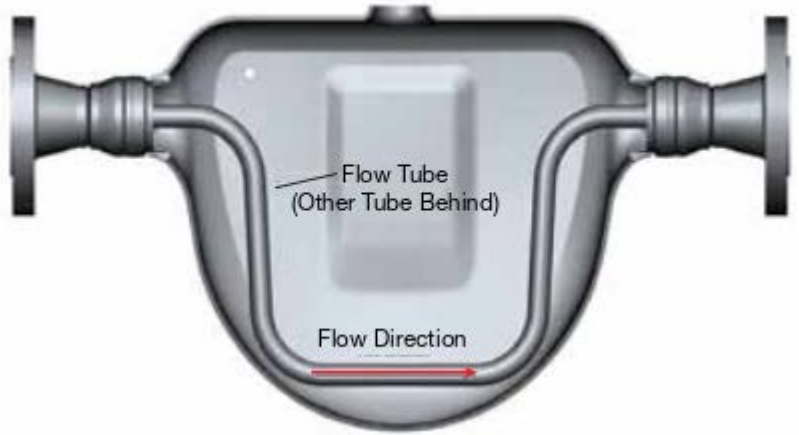
with:

P	: Pressure drop (PSI)
d	: Relative density
ν	: Kinematic viscosity (cSt)
Q	: Flowrate (Bbl/h)
Q_{max}	: Maximum flowrate (Bbl/h)

Coriolis meter Back Pressure:

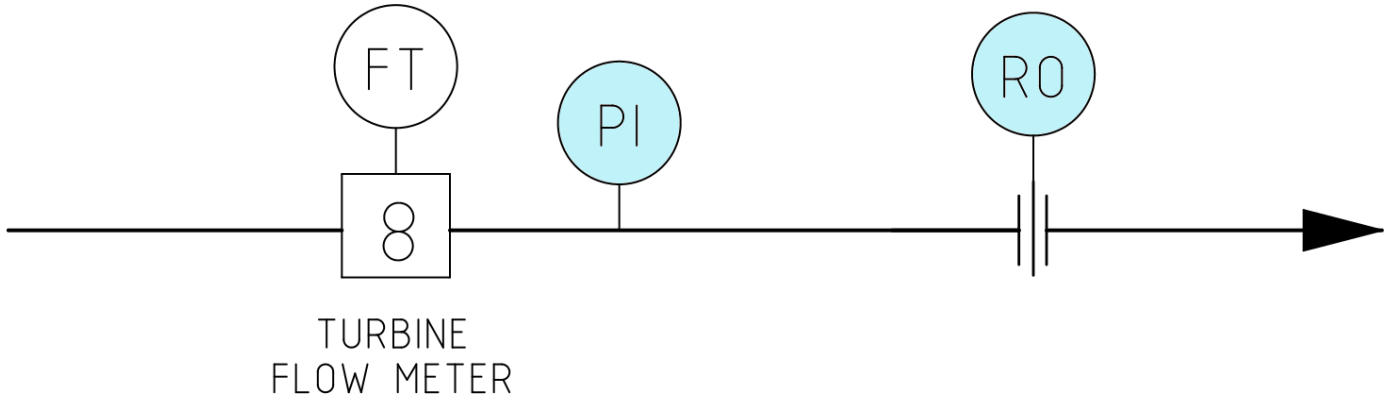
- Small diameter tubes causes higher velocities, and as a consequence a lower static pressure (Bernoulli)

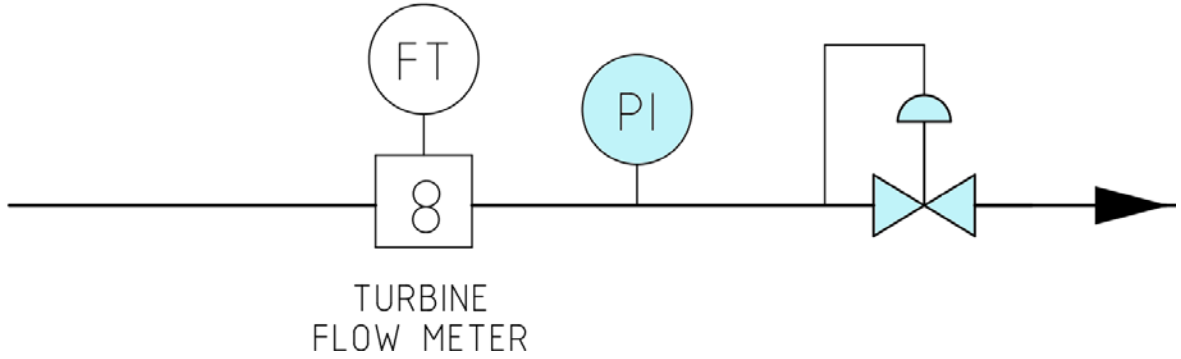
- Beside the conventional Back Pressure Equation, also manufacturer calculation (sizing and selection tool) of static pressure inside the tube is a requirement.

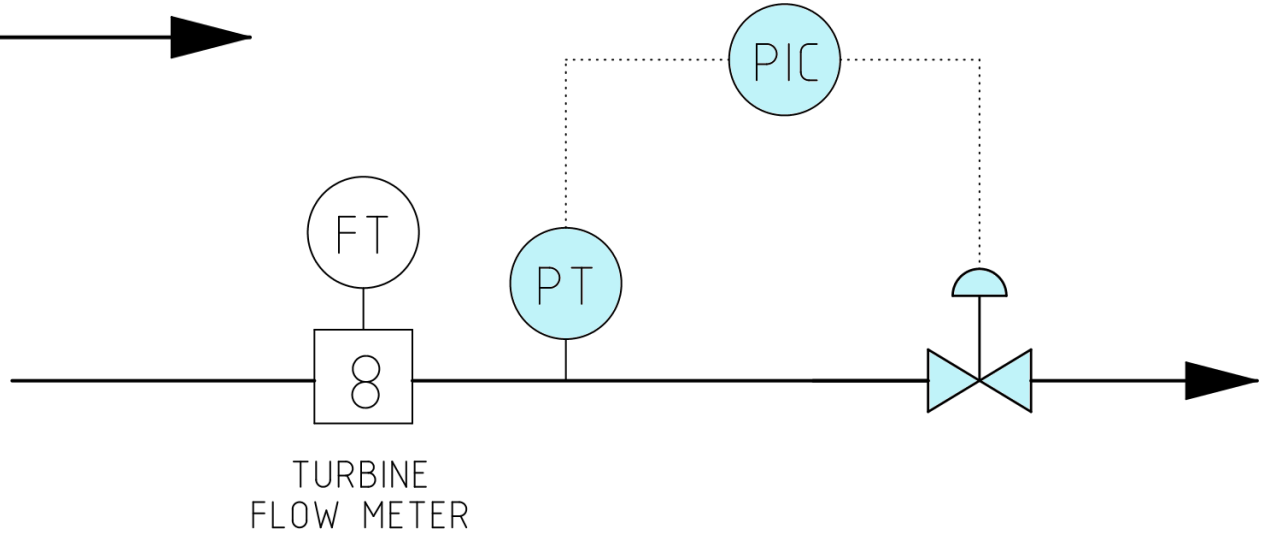


How to Control the Back Pressure

- Restrict the flow downstream the flow meter

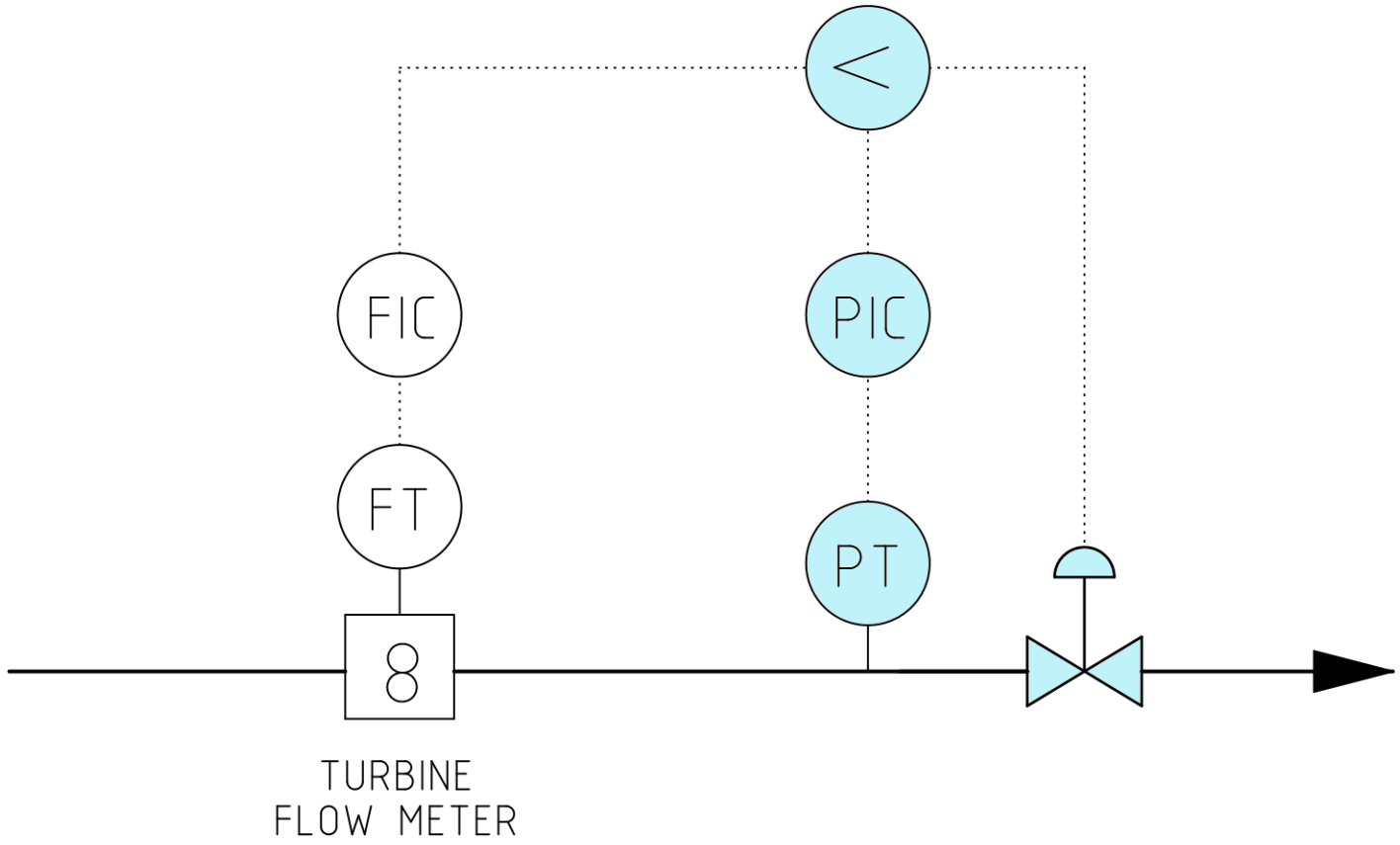






How to combine Back Pressure Control and Flow Control:

- Flow controller
- Pressure controller
- Low signal selector



Which type of liquid flow meters are subject for Back Pressure Control:

- All single phase liquid flow meters (e.g. Turbine, PD, Coriolis, Ultrasonic, Orifice)
- Ensure that all operating cases are calculated, i.e. minimum, normal, maximum, viscosity and specific gravity.

Back Pressure on Liquid Flow Measurement

When using a control valve for Back Pressure Control:

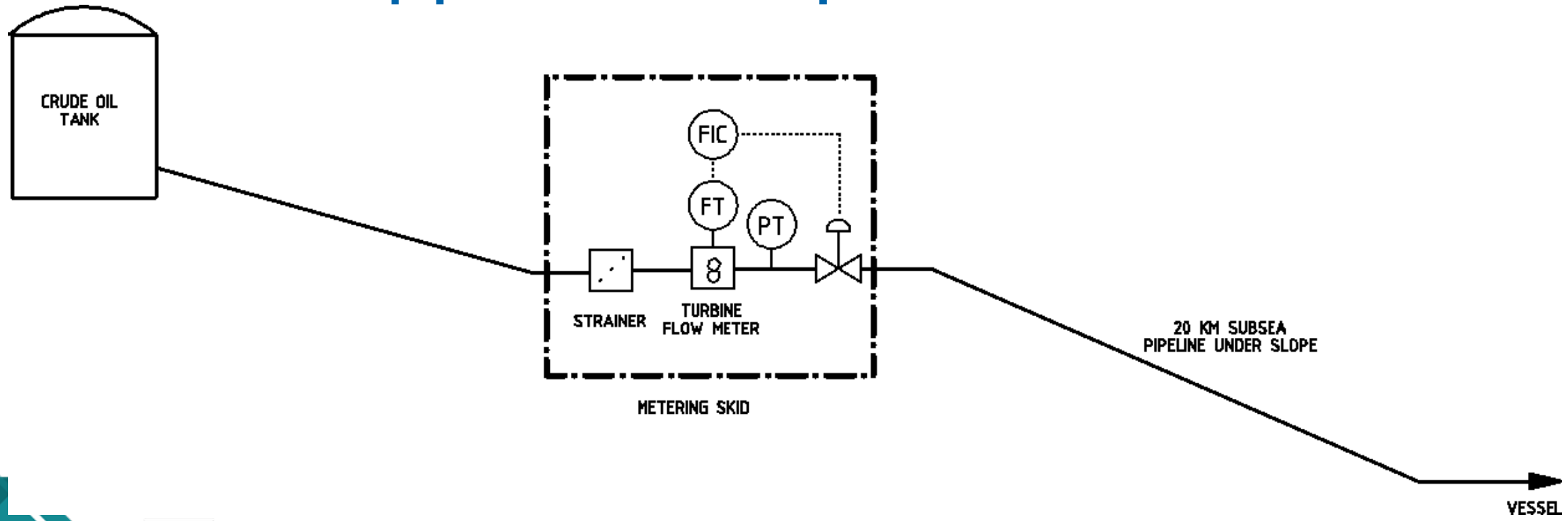
- Proper selection of the type of control valve
- Proper sizing of the control valve
- Actuator response time
- Hydraulic pipe loss calculation is essential to determine the pressure loss in the downstream piping system
- Back Pressure controller with fast response

Commissioning aspects with Back Pressure:

- Proper tuning of the pressure controller. The control action should be fast.
- Trending of static pressure and control valve signal to investigate issues.
- Verify that the actual pressure corresponds with the pressure on the data sheet
- Sometimes you have to think out of the box

Case 1 (Fractured Pig)

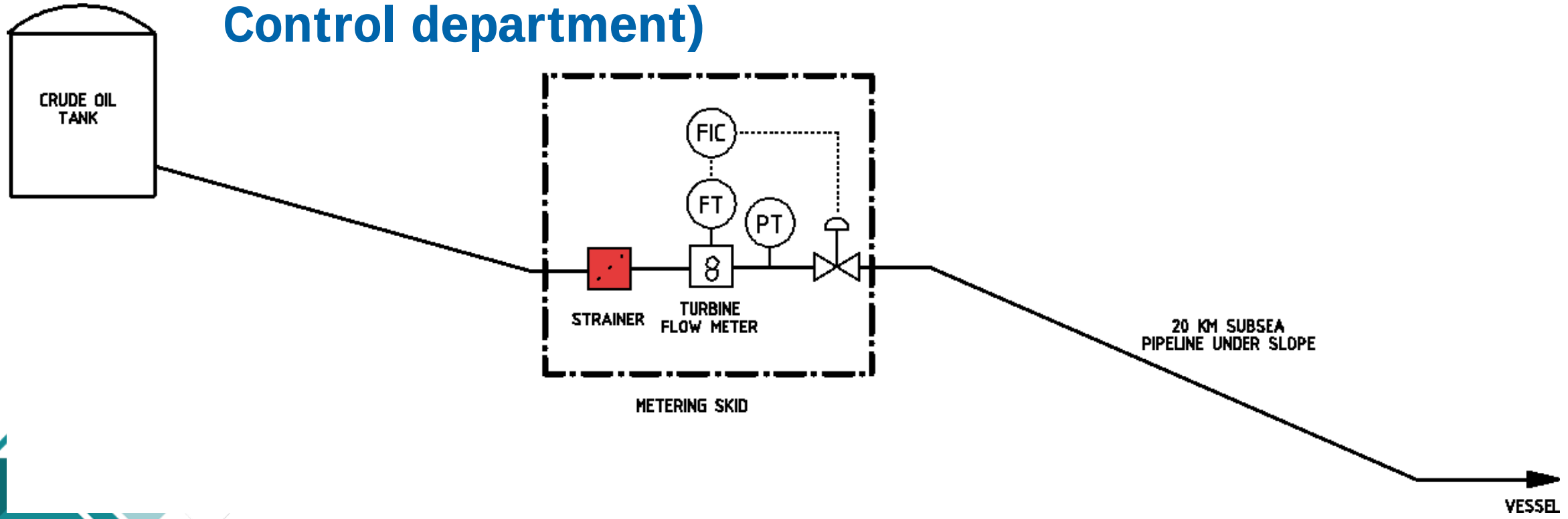
- Crude Oil Metering Skid in Kuwait for vessel loading
- Subsea pipeline under slope to vessel



Back Pressure on Liquid Flow Measurement

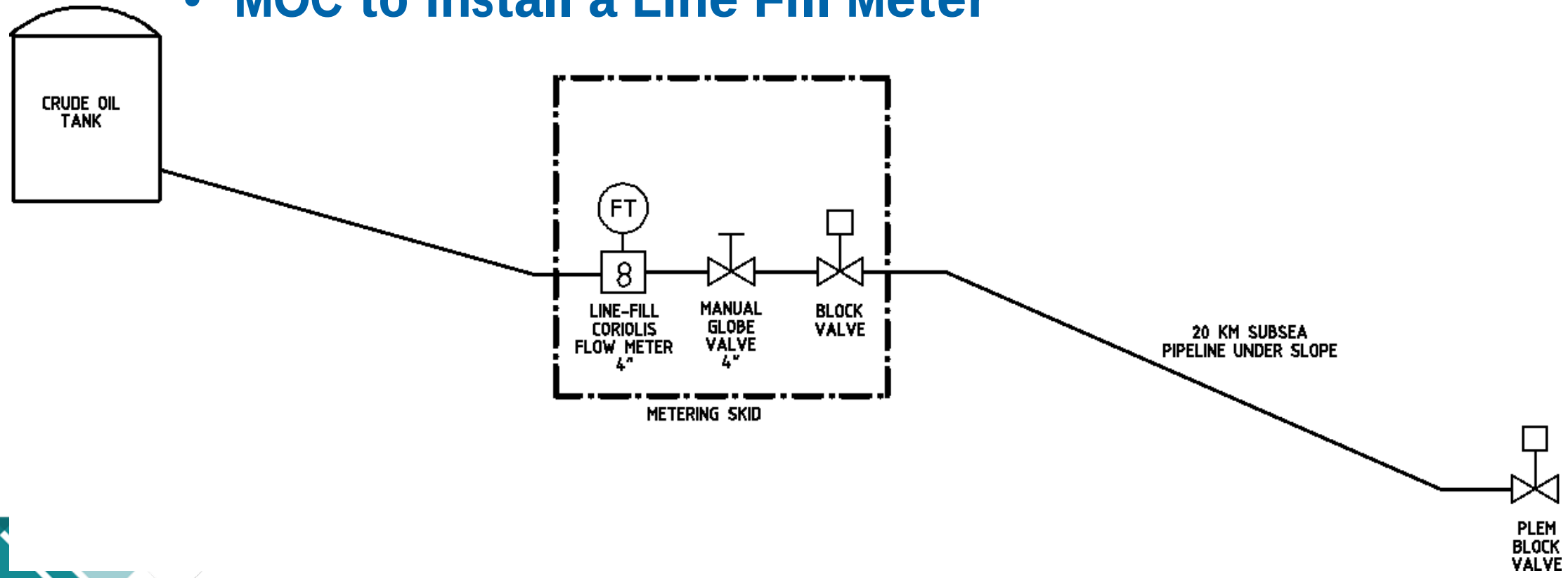
Case 1: Fractured pig between crude oil tank and metering skid.

- Strainer almost blocked
- Cavitation in the turbine flow meter
- Bill of laden with higher figures (Addressed by our Loss Control department)



Case 2 (Line Fill Coriolis Meter)

- Subsea pipeline which require Line Fill Meter
- Existing skid without Line Fill Meter (16” Turbine Meters)
- MOC to install a Line Fill Meter



Case 2 (Line Fill Meter)

Engineering Criteria

- Very Low pressure in the subsea pipeline due to shrinkage
- Coriolis Meter selected: sensitive for back pressure!!

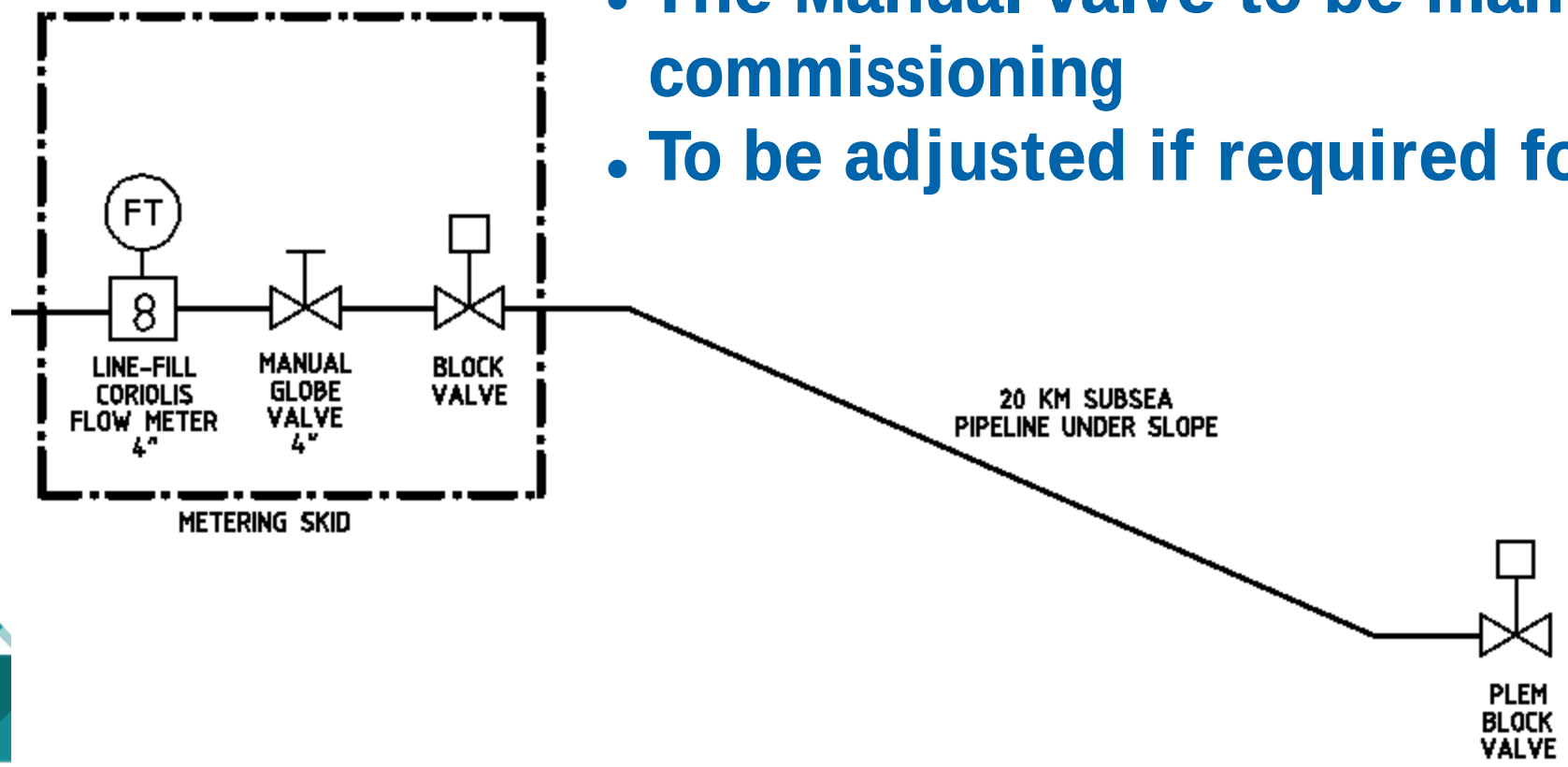
Design Criteria for Back Pressure:

- Manual Valve with fixed setting
- Sizing of manual valve (high diff. pressure → Cavitation)
- Proper sizing of manual valve

Case 2 (Coriolis Line Fill Meter)

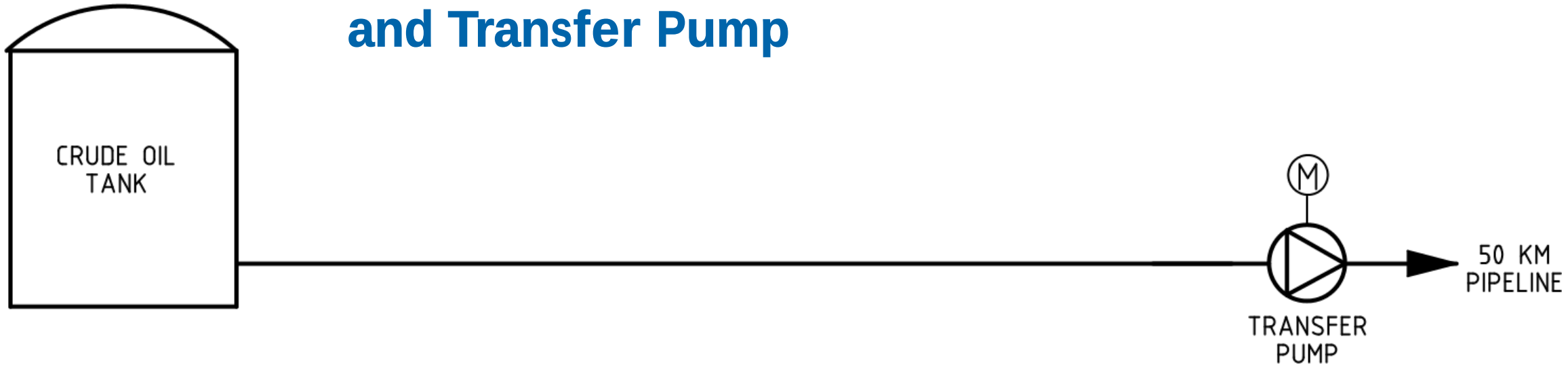
Commissioning/Operation:

- The Manual valve to be manually set during commissioning
- To be adjusted if required for viscosity



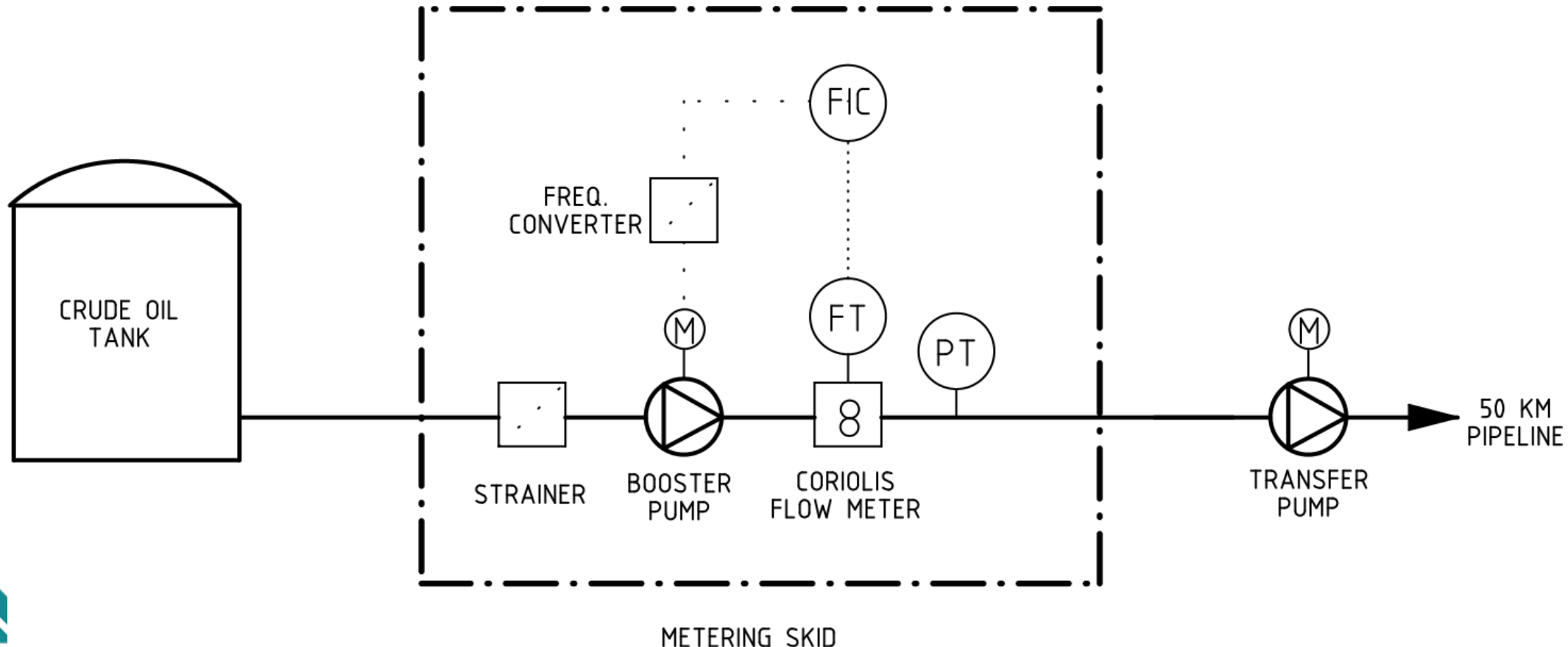
Case 3: New Crude Oil Metering Skid

- Coriolis flow meter to be installed in an existing installation in Romania (EU)
- Mandatory installation between Crude Oil Tank and Transfer Pump



Case 3

Skid contained a booster pump to compensate for the pressure loss in the strainer and Coriolis meter



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Case 3 (Commissioning)

Case 3 (Commissioning)

Frequency controlled pump too slow when starting the transfer pump.

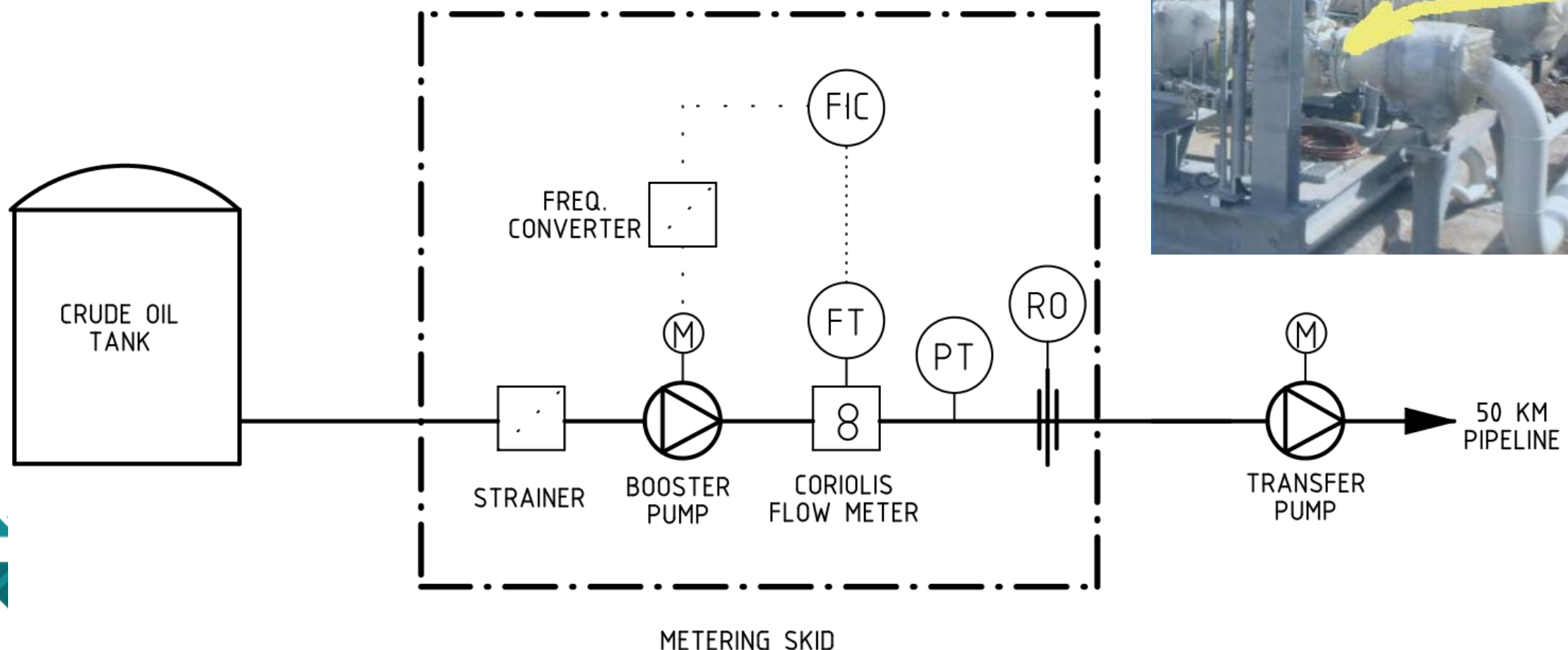
Startup of the transfer pump resulted in:

- **Instability of the booster pump**
- **Back Pressure of the Coriolis meter dropped below vapor pressure**
- **Coriolis meter stopped functioning, and could only be activated by restarting by switching off/on the power supply**

Back Pressure on Liquid Flow Measurement

Project (Engineering)

Restriction orifice on the outlet flange of the metering skid solved the issue



Conclusion

- “Everybody” is aware of the Back Pressure requirements, but are we actually applying them?
- Hydraulic calculation for each system is essential
- Proper control valve selection, and not just ‘Line size’
- Back Pressure Control is essential in Metering Systems, and needs to be tuned for fast control
- Think sometimes out of the box for simple solutions like restriction orifices

Back Pressure on Liquid Flow Measurement

Questions?

THANK YOU