Considerations for Selection of Energy Dissipation Valves

LANGFORD SUE

Outline

- Purpose
- Typical applications
- Fundamentals
- Valve types
- Considerations when selecting valves
- Case studies and lessons

Typical Applications

- In-line pressure reduction (PRV)
- End of a falling main (PSV)
- Atmospheric discharge from pressure main or dam
- Hydro-power plant bypass

Some Fundamentals

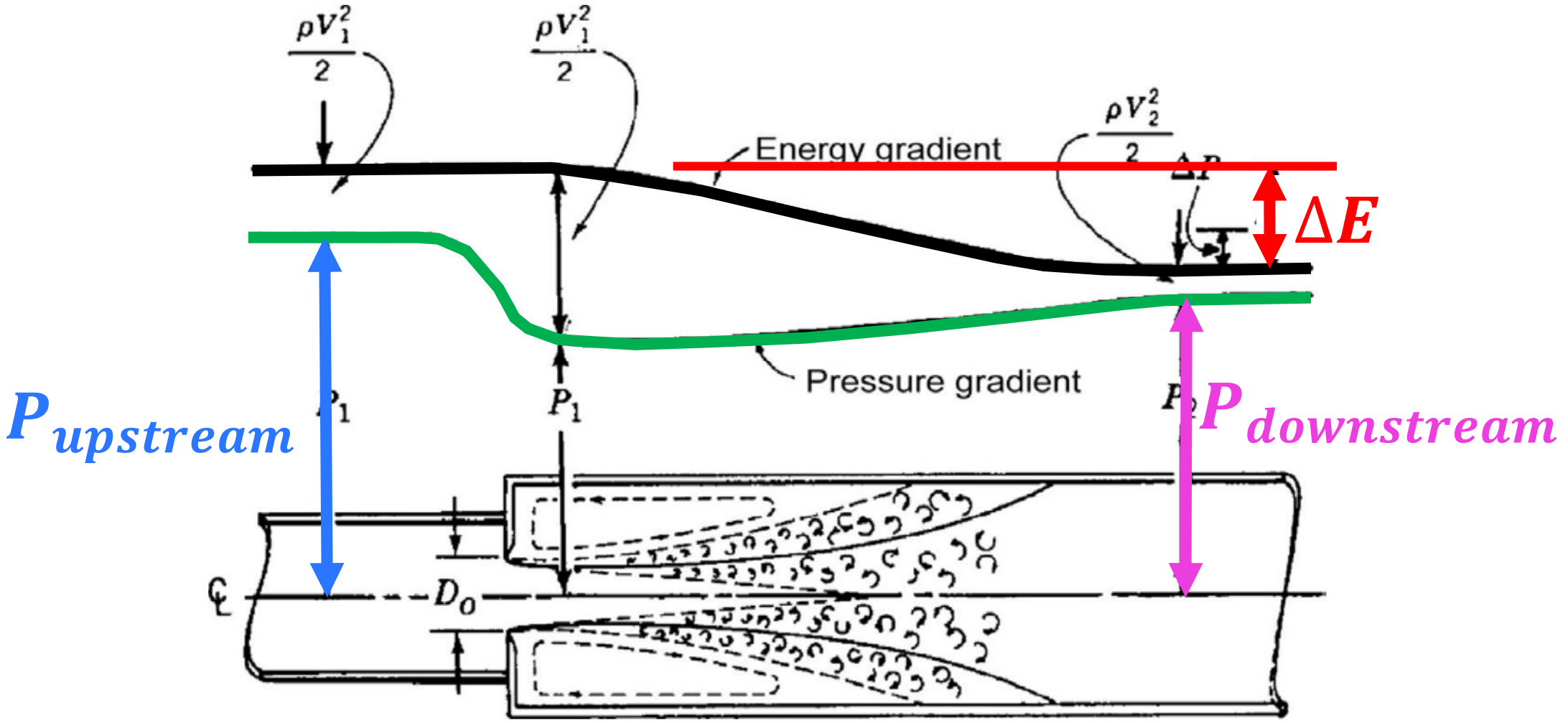
- Bernoulli equation

$$\frac{\rho V^2}{2} + \rho g h + P = constant$$

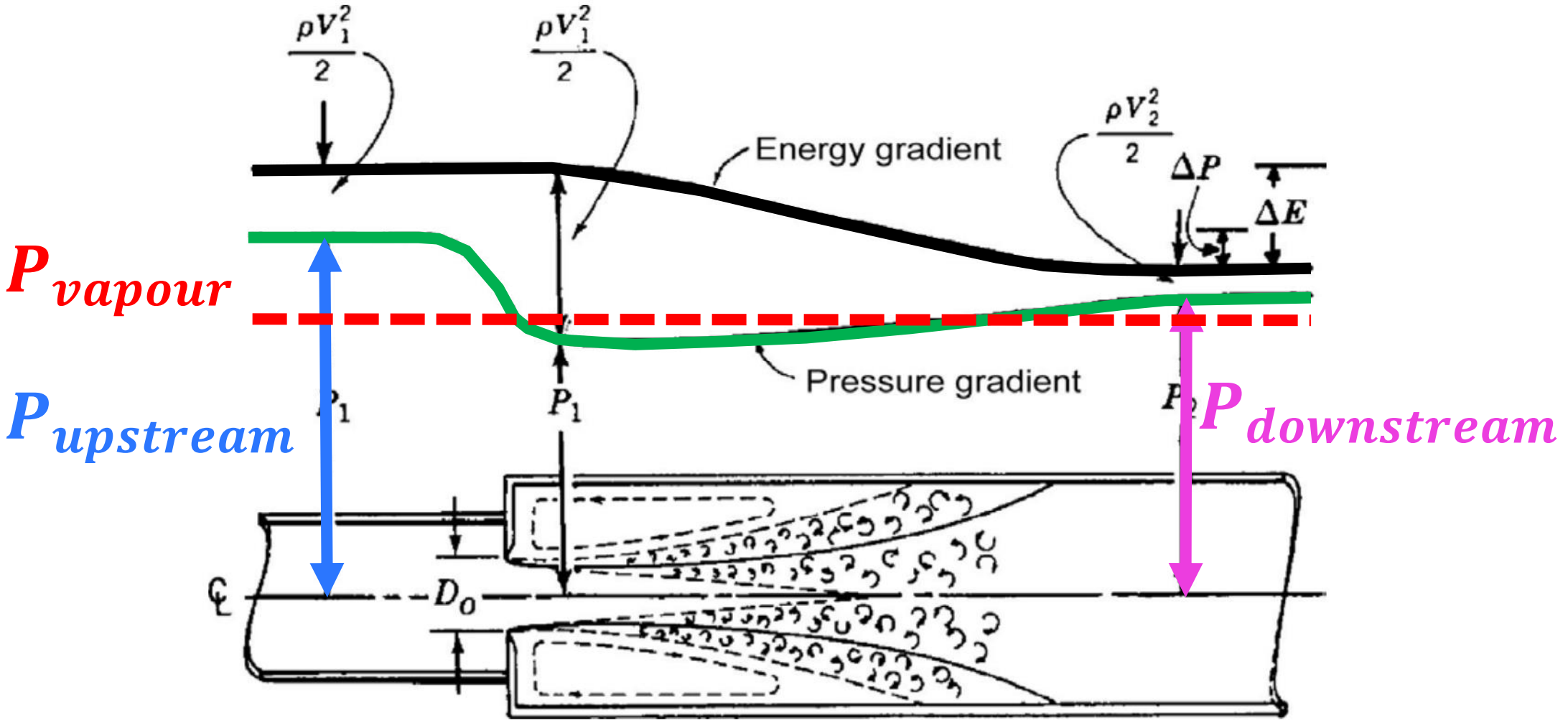
- Velocity => turbulence => energy dissipation

$$\Delta P = K \frac{\rho V^2}{2} \qquad \Delta H = K \frac{V^2}{2g}$$

Energy Dissipation

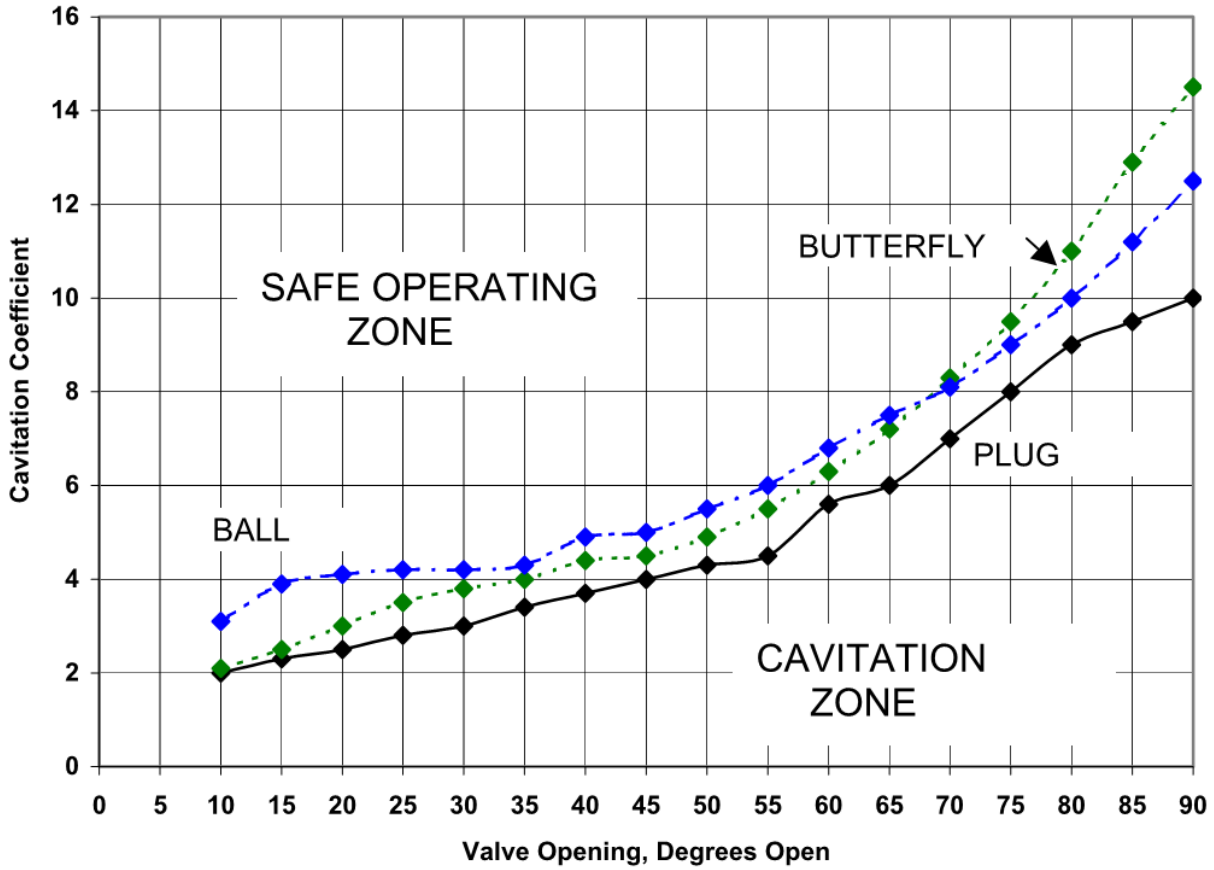


Cavitation


$\frac{\rho V_1^2}{2}$
$\frac{\rho V_1^2}{2}$
$\frac{\rho V_2^2}{2}$
Energy gradient
ΔP
ΔE
P_{vapour}
$P_{upstream}$
Pressure gradient
P_1
P_1
P_2
$P_{downstream}$
D_o

Cavitation Index

$$\sigma = \frac{(P_{upstream} - P_{vapour})}{(P_{upstream} - P_{downstream})}$$



Courtesy of Valmatic

Beca

Valve Types

Low-Moderate Pressure Dissipation

- Orifice plate
- Butterfly
- Pinch
- Ball
- Plug
- Globe (PSV/PRV)

Moderate–High Pressure Dissipation

- Segmented ball
- Multi-orifice
- Multi-port sleeve
- Needle/plunger
- Fixed cone/hollow jet

Courtesy of Ramén Valves AB

Moderate–High Pressure

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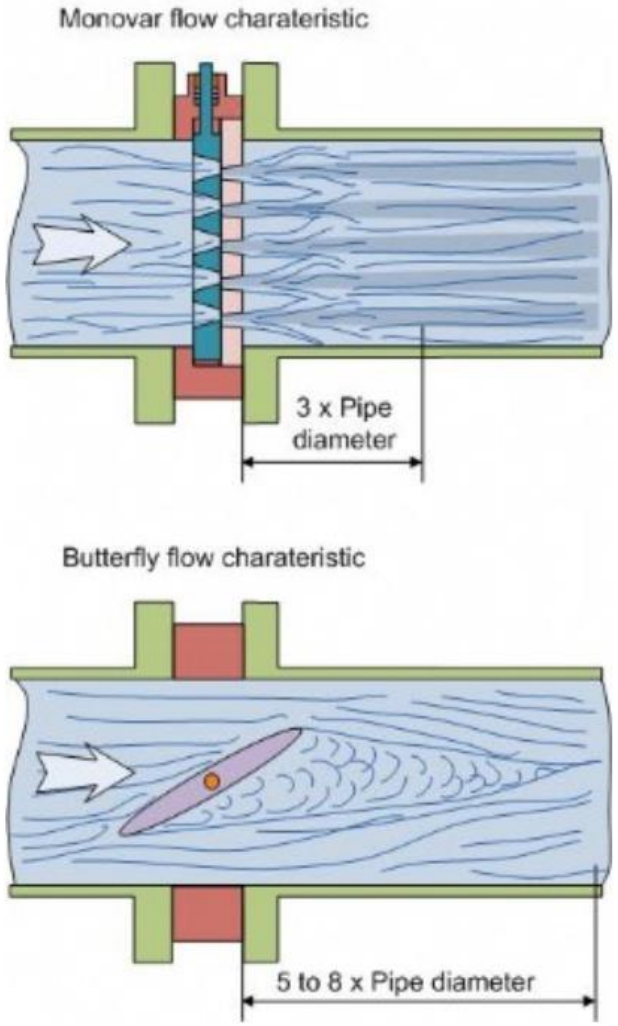

Courtesy of Monovar

Moderate–High Pressure

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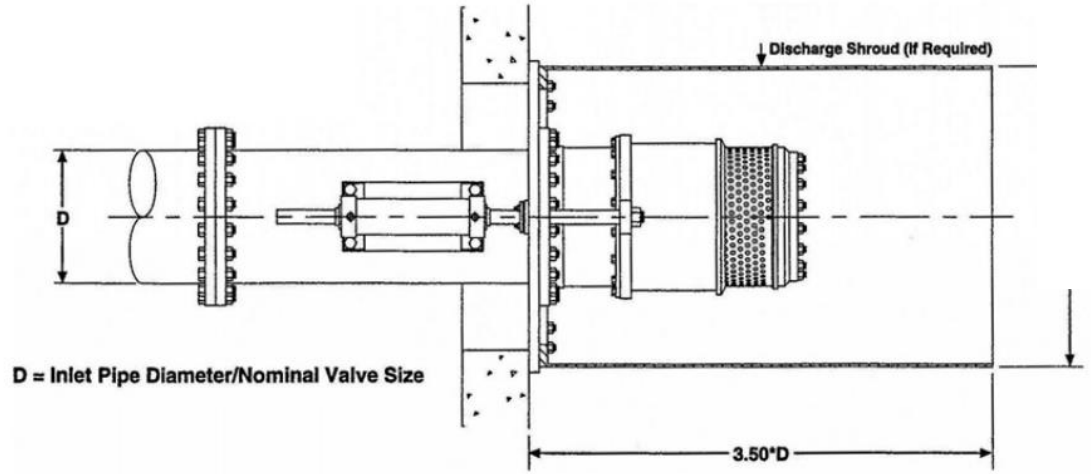

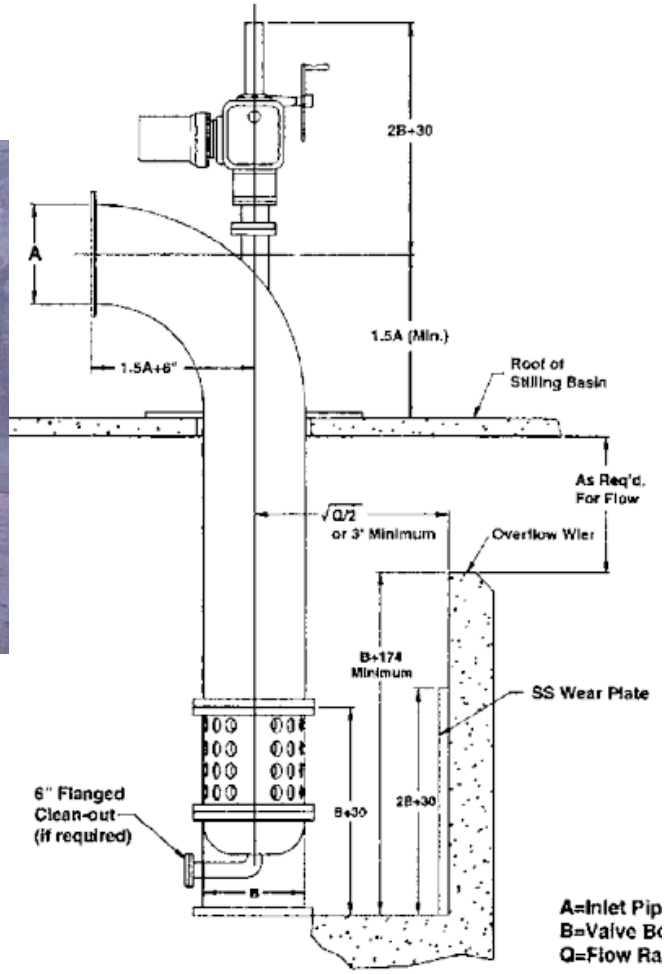

Courtesy of Bailey Valves

Beca

Moderate–High Pressure

- Segmented ball
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Courtesy of Ozkan Valves

Moderate–High Pressure

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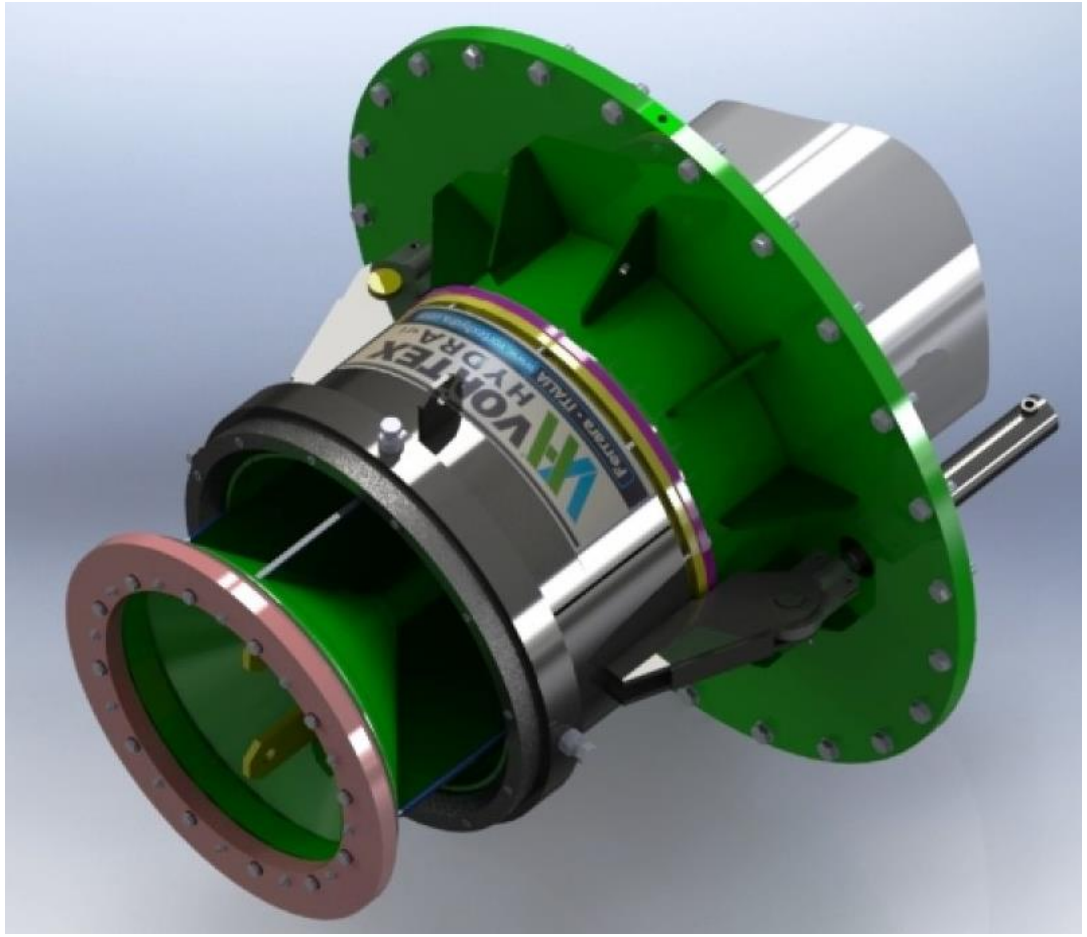
- Multi-orifice
- Multi-port sleeve
- Needle/plunger
- Fixed cone/hollow jet



Courtesy of Vortex Hydra Valves

Considerations when Selecting Valves

System and Fluid Properties

- Range of flows and pressures
  - Multiple valves in parallel or series
- Frequency and duration of flow
- Criticality (duty/standby)
- Solids and grit
  - Free passage size
  - Wear on valve seats and bearings
- Controllability (v-ports)
- Seating/unseating – actuation/torque
- Transient pressures

Cavitation

- Cavitation = noise and vibration
- Avoid cavitation
- Provide sufficient backpressure/submergence
- Multi-stage pressure drop (valves in series)
- Control unavoidable cavitation
- Valve selection and sizing – base on actual test data at the required valve size (not extrapolated)

Suppliers

- Off-the-shelf vs bespoke valve
- Supplier’s reputation and support during design and operation
- Testing (physical testing, CFD)
- Previous installations and performance
- Lead time
- Spares

Construction

- Cost – size, pressure class, material
- Supporting structures
  - Size and depth
  - Foundations - valve mass, geotechnical conditions
  - Noise attenuation
- Actuators
- Power supply, instrumentation, comms/telemetry

Operations and Maintenance

- Position indication or mechanical limiters
- Maintainable components
- Frequency of inspection and maintenance
- Access
  - Hatches and ladders
  - Ventilation
  - Lighting
  - Restricted/confined space access
  - Crane access, removable covers
  - Drainage
- Erosion control of any free discharge
- Public access

Case Studies and Lessons

Raw Water River Discharge

- Enlarge two existing raw water DN225 scours to DN1000 outlet to a river
- Supplement environmental flows (2 weeks - twice per year)
- 1.2m^3/s discharge at each site
- 135m pressure
- Key issues – high pressure, noise, ecology, indigenous heritage, value-for-money (constructability and risk)

Option	Benefits	Risks
Submerged multi-port sleeve valve in a discharge chamber	▪ Proven for high dP ▪ Valve type was known to authority ▪ Low risk of cavitation and vibration	▪ Large and heavy ▪ Valves and installation are expensive ▪ Risk of noise ▪ Large buried structure required (safety) in difficult ground next to river ▪ Limited suppliers, long lead times for spares or replacements
Inline needle valve or end-of-line fixed cone or hollow jet valve	▪ Proven for high dP ▪ Valve type used by authority (dams) ▪ Low risk of cavitation and vibration	▪ Large and heavy ▪ Valves and installation are expensive ▪ Required large supporting structures (pit or headwall) in difficult ground next to river ▪ Manage ‘rooster tail’ free discharge and noise ▪ Limited suppliers, long lead times for spares or replacements
Anti-cavitation ball valve/s with flow restrictor valve in series	▪ Proven for high dP ▪ Direct-buried ▪ Low risk of cavitation and vibration ▪ Lower cost	▪ Valve type not known to water authority ▪ Limited use in local municipal water systems ▪ Limited suppliers, long lead times for spares or replacements ▪ Risk of damage from solids

Raw Water River Discharge – Key Lessons

- Energy dissipation can be very noisy
- Valve selection needs to be fit for purpose
- Supplier engineering reps are your friend
- Need to know valve position, particularly with valves in series
- Client needs to be comfortable with the valve type

Falling Sewer Main

- Urgent replacement of failing gravity sewer
- SPS and 6.5km of DN650 GRP
- Raw wastewater
- 80mm free passage size
- Variable flows up to 650L/s
- End control to prevent drain down
- Manage cavitation of dissipating 50m head

Option	Benefits	Risks
Orifice plates	▪ Cheap and simple ▪ Readily available	▪ Low pressure loss capability (multi-stage) ▪ No controllability - range of orifices sizes required with associated diversion valves and controls ▪ Pressure drop required orifice < 80mm ▪ Susceptible to cavitation
Throttled isolation valves (ball, globe, or plug)	▪ Reasonably cheap and simple ▪ Some controllability ▪ Can be opened fully to clear blockages ▪ Parts and replacements readily available	▪ Low pressure loss capability (multi-stage) ▪ Limited controllability – requires multiple trains with associated diversion valves and controls ▪ Risk of blockage due to snagging of fibrous and fatty material when valve is throttled ▪ Susceptible to cavitation
Throttled pinch valves	▪ Can be opened fully to clear blockages ▪ No sharp edges in the flow and so not likely to snag fibrous material ▪ Some controllability ▪ Moving valve parts isolated from wastewater	▪ Low pressure loss capability (multi-stage) ▪ Limited controllability – requires multiple trains with associated diversion valves and controls ▪ Susceptible to cavitation ▪ Internal sleeve is a maintainable item

Falling Sewer Main - Residual Risks

- Limited controllability and need for regular maintenance
  - Three parallel trains to cater to the range in flow
  - DN200 pinch valve (open/close) at the head of each train
  - Provides system redundancy during maintenance and sleeve replacement
- Low pressure loss capability and risk of cavitation
  - 1No. DN200 PN16 pinch valve (open/close)
  - 3No. DN450 pinch valves (control and progressive energy dissipation
  - 3No. DN150 local contractions (>80mm)
  - 10m residual head to inlet works providing back-pressure to control cavitation

Falling Sewer Main – Key Lessons

- Confirm the selected valves have been used before in the same application
- If not, seek test/verified data at the size and pressure required
- Work with and gain the interest of the manufacturer (don’t underestimate the value they add)
- Do not be afraid to ask the “stupid” questions
- Be prepared to challenge the project fundamentals (e.g gravity sewer)

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