



**GRUNDFOS
ECADEMY**

THE BOILER SYSTEMS COURSE

Learning outcome

**By the end of this course,
you will understand
and can identify:**

Understand the different types of boilers.

Explain the different requirements
of pumps in boilers.

Understand how to control the
water level in a boiler.

Be able to select the properly
sized pump for a specific application.

Understanding boiler types and boiler feed pump requirements



Boiler types/systems



Hot water boilers



Steam boilers



Thermal oil boilers

Hot water boiler



- Room-building and process heating applications
- Suitable for discharge temperatures of up to 280F
- Low energy losses



Hot water boiler - pumps



- Large range of pump models
- Not as many factors to consider
- Single-stage pumps – end-suction or split-case single suction
- Low liquid temperature
- Unpressurized system unlike a steam boiler



Steam boilers



- Ideal for industrial processes.
- High energy content making it perfect for cleaning applications and turbine operation
- Releases energy during condensation
- Suitable for small heat exchangers



Steam boilers - pumps



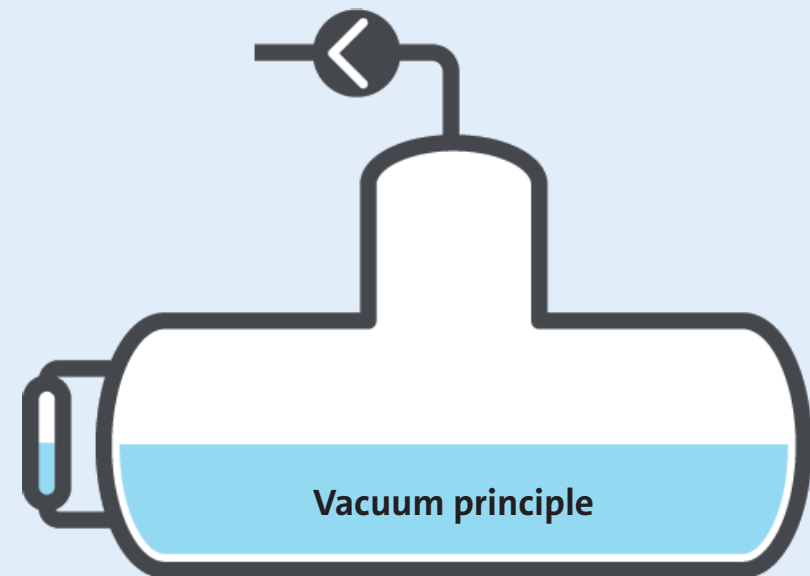
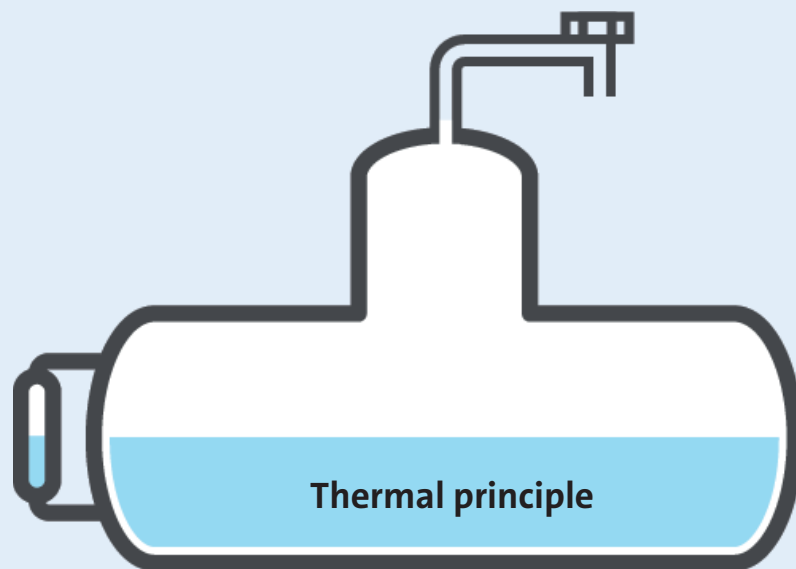
- Same pumps as in hot water boilers.
- Multi-stage pump needed to transfer water from deaerator to the boiler.
- Inline vertical multi-stage pump may be required as a feed water pump if you need to capture pre-heated water.
- Water heats and returns to the hot wells as condensate.



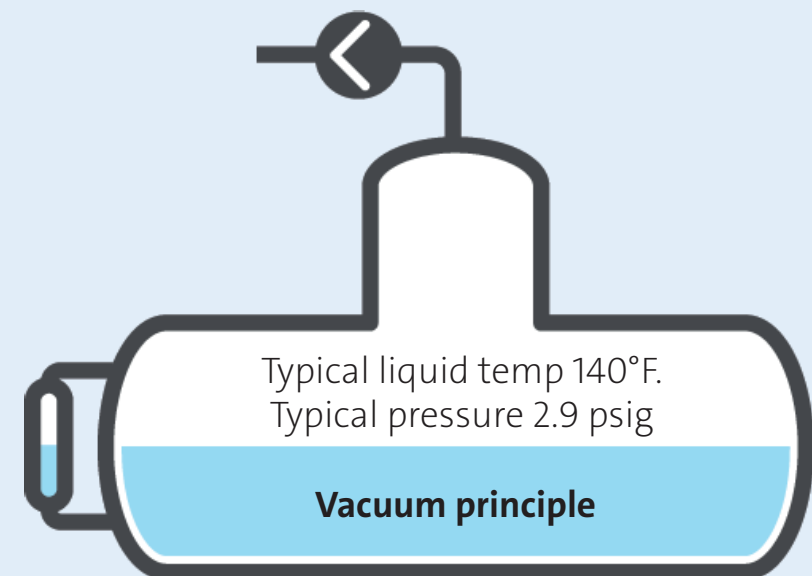
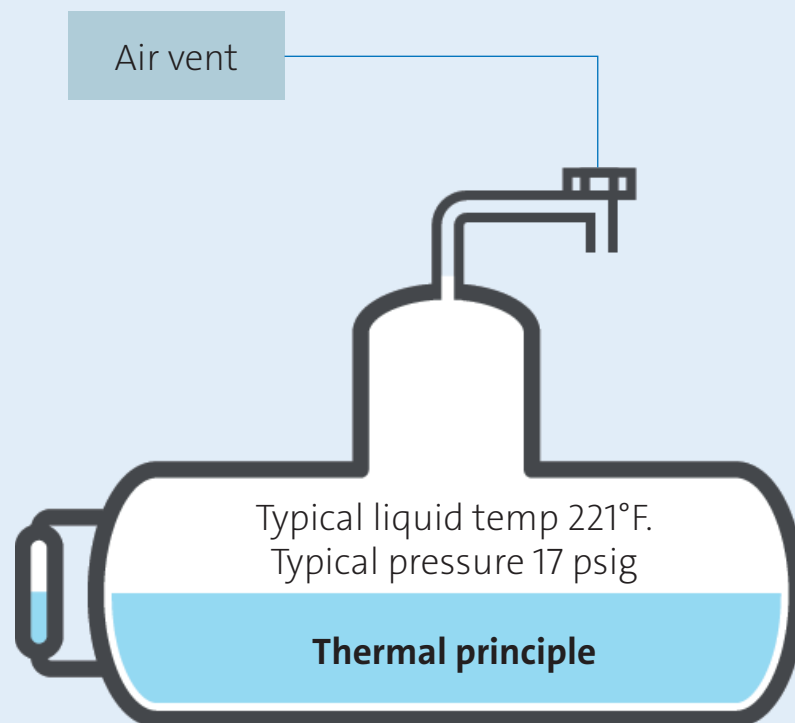
Deaerator/Condenser tank



- Only used in steam boiler systems.
- Identical construction.
- Two principles:
Thermal and vacuum.



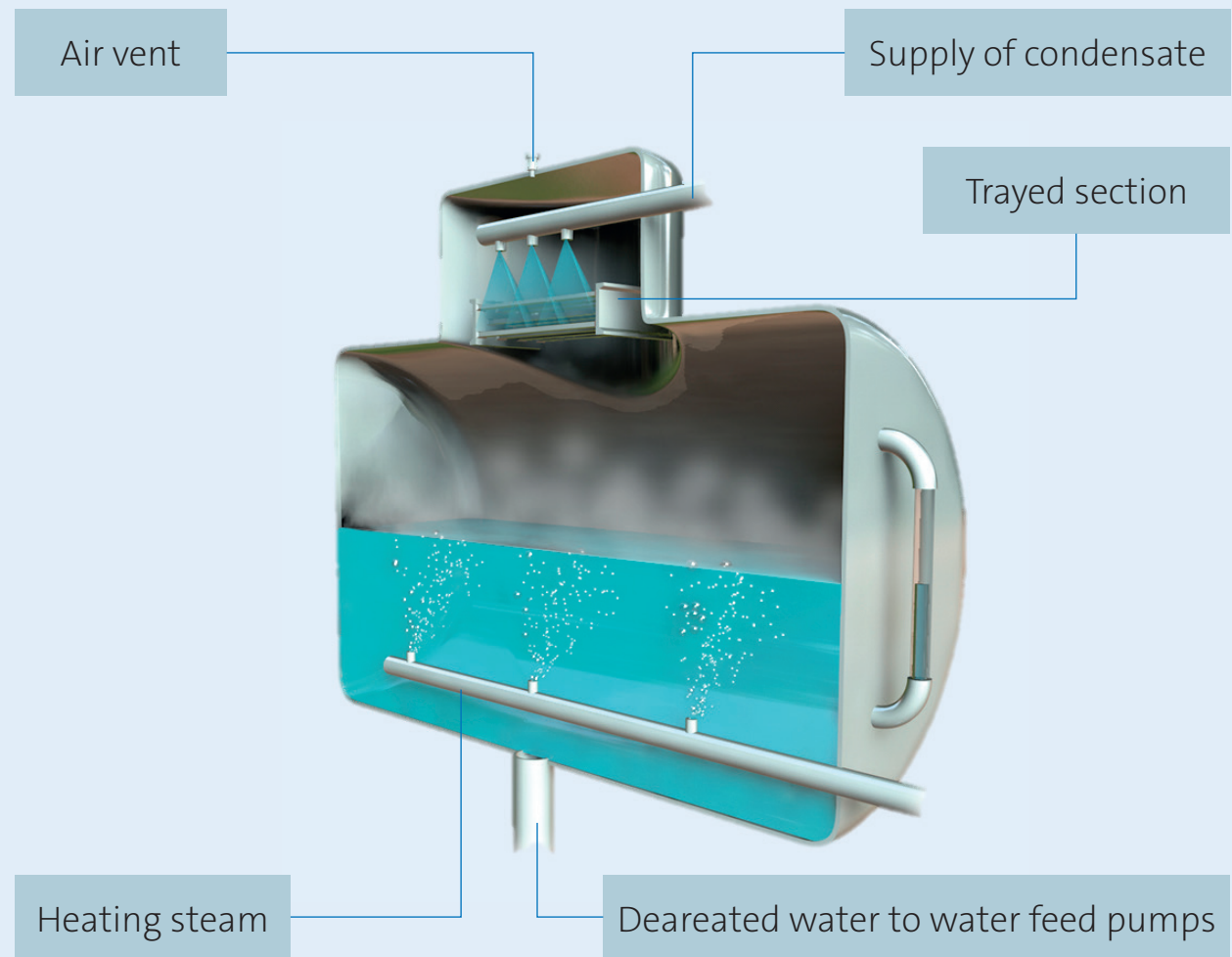
Deaerator/Condenser tank



Deaerator



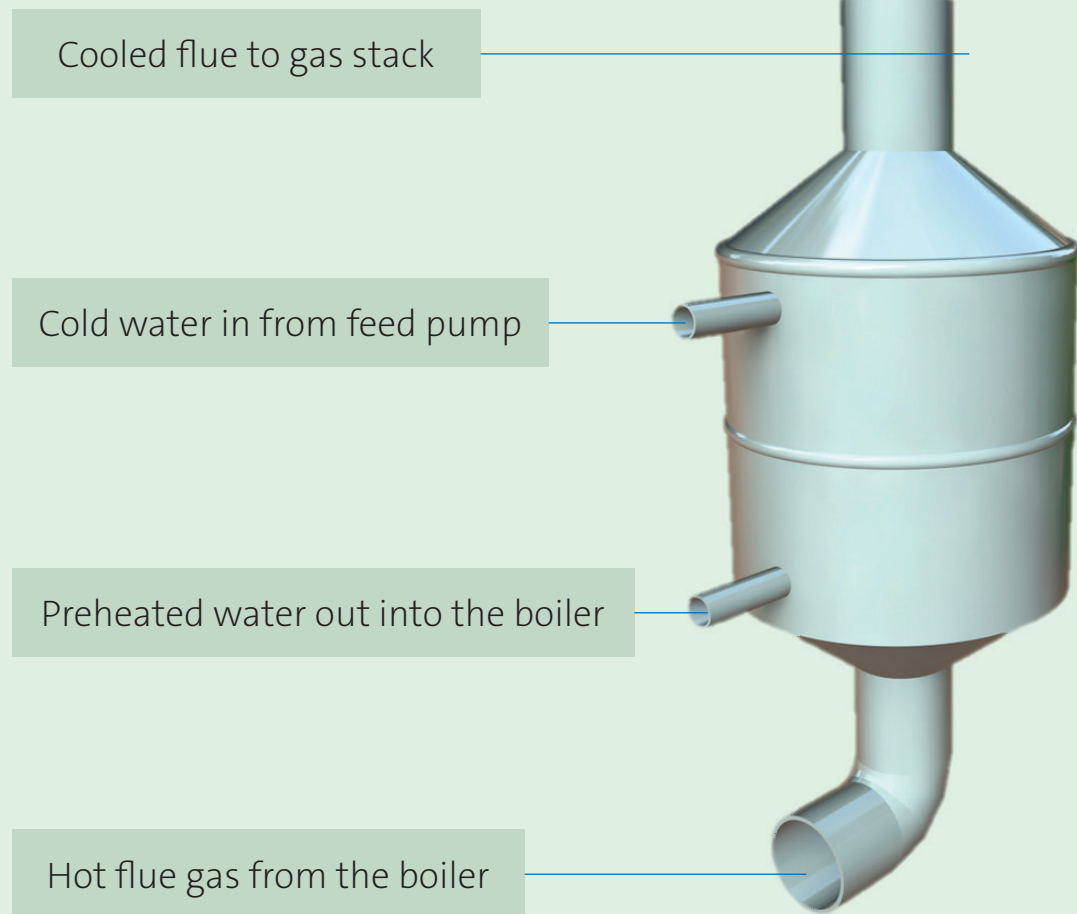
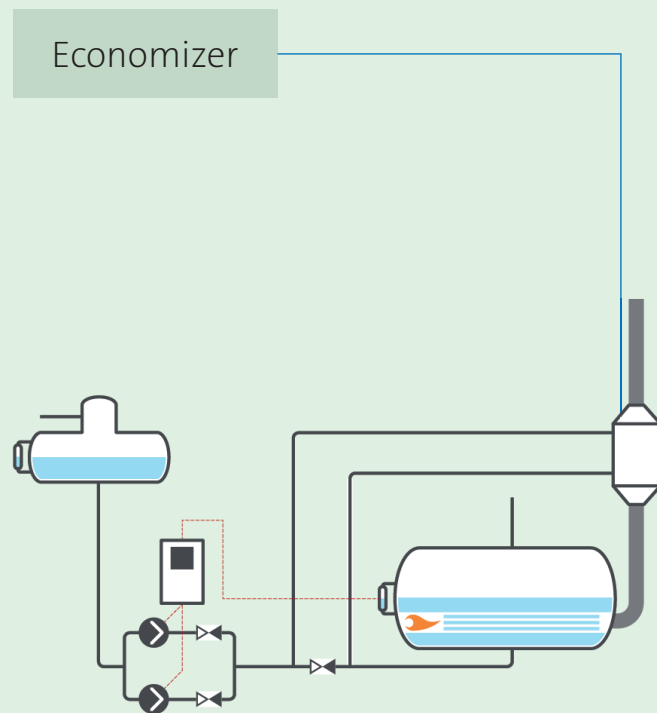
- Most important task is to reduce oxygen and carbonic acid levels to protect against corrosion.
- More and more normal to use hot wells or water tanks.
- You can dose chemicals to remove oxygen.



Economizer



The economizer is applied to utilize the residual heat in the flue gas.



Sizing the feed water pumps



Sizing of pumps can be difficult because of the following:

- Safety factors that require a slight oversizing of the pump.
- High-temperature boiler water.
- Treated water consisting of certain chemicals.



Boiler feed pump examples



CR



CRI



CRN



CRT

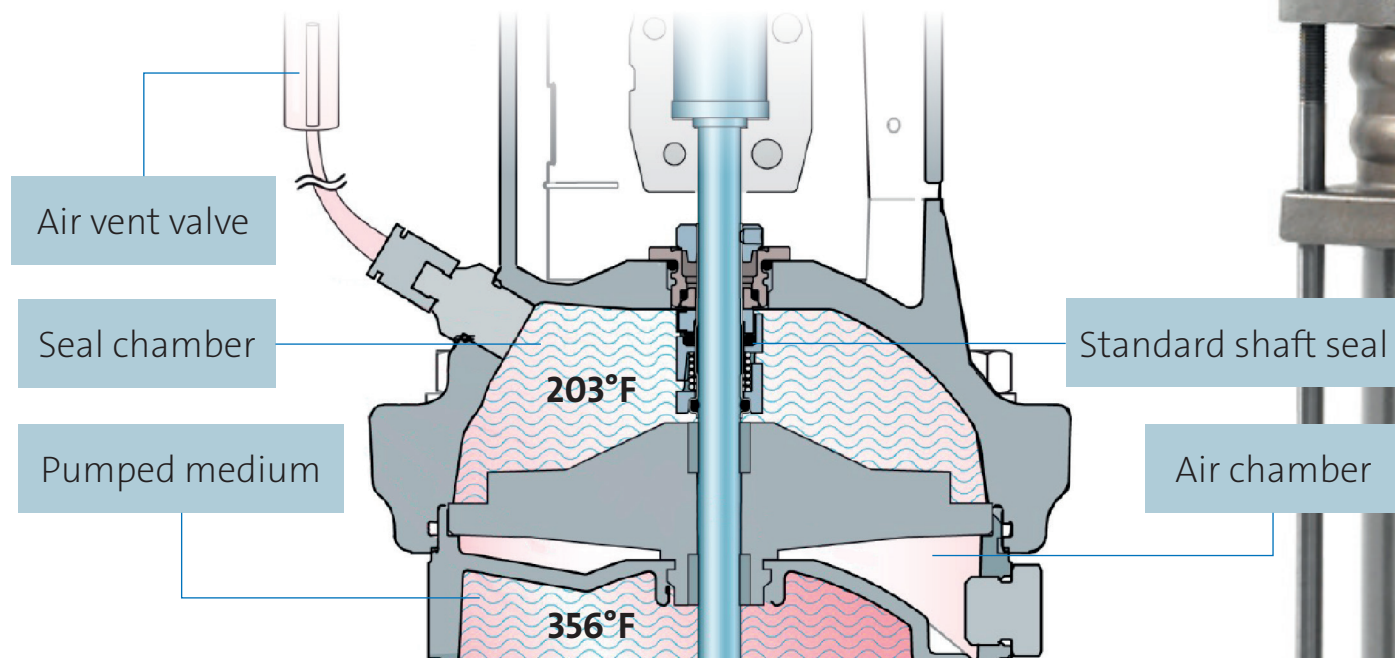


CRE

Air-cooled top

High temperatures are trouble

To deal with this pumps with air cooled top has a special air-cooled shaft seal chamber, ensuring that the liquid temperature around the shaft seal does not exceed the level it can withstand.

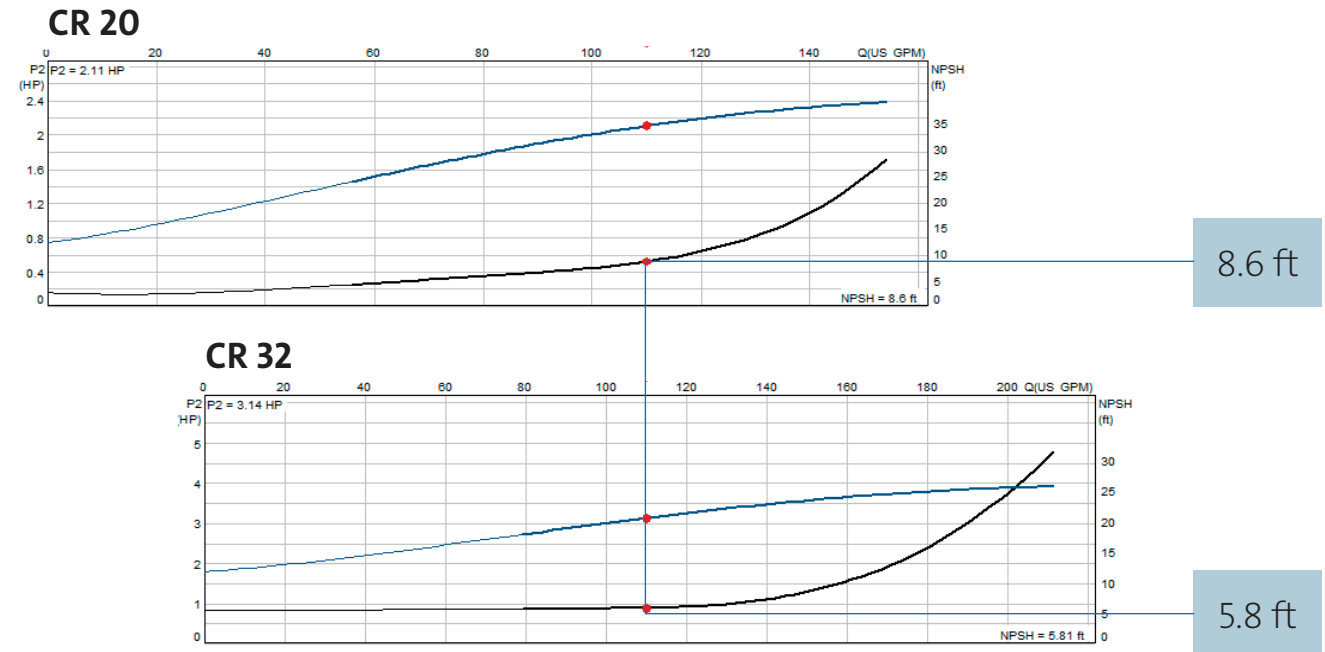




Poor inlet conditions can cause low NPSH

Poor inlet conditions can cause low NPSH

- Standard pump provided with an oversized first impeller.
- Specially suited for handling poor inlet pressure and hot water.
- Max. pressure; operating pressure of the pump.
- Max. liquid temp; up to 356°F (180°C) combined with air-cooled top.



Ensure constant water level with variable speed



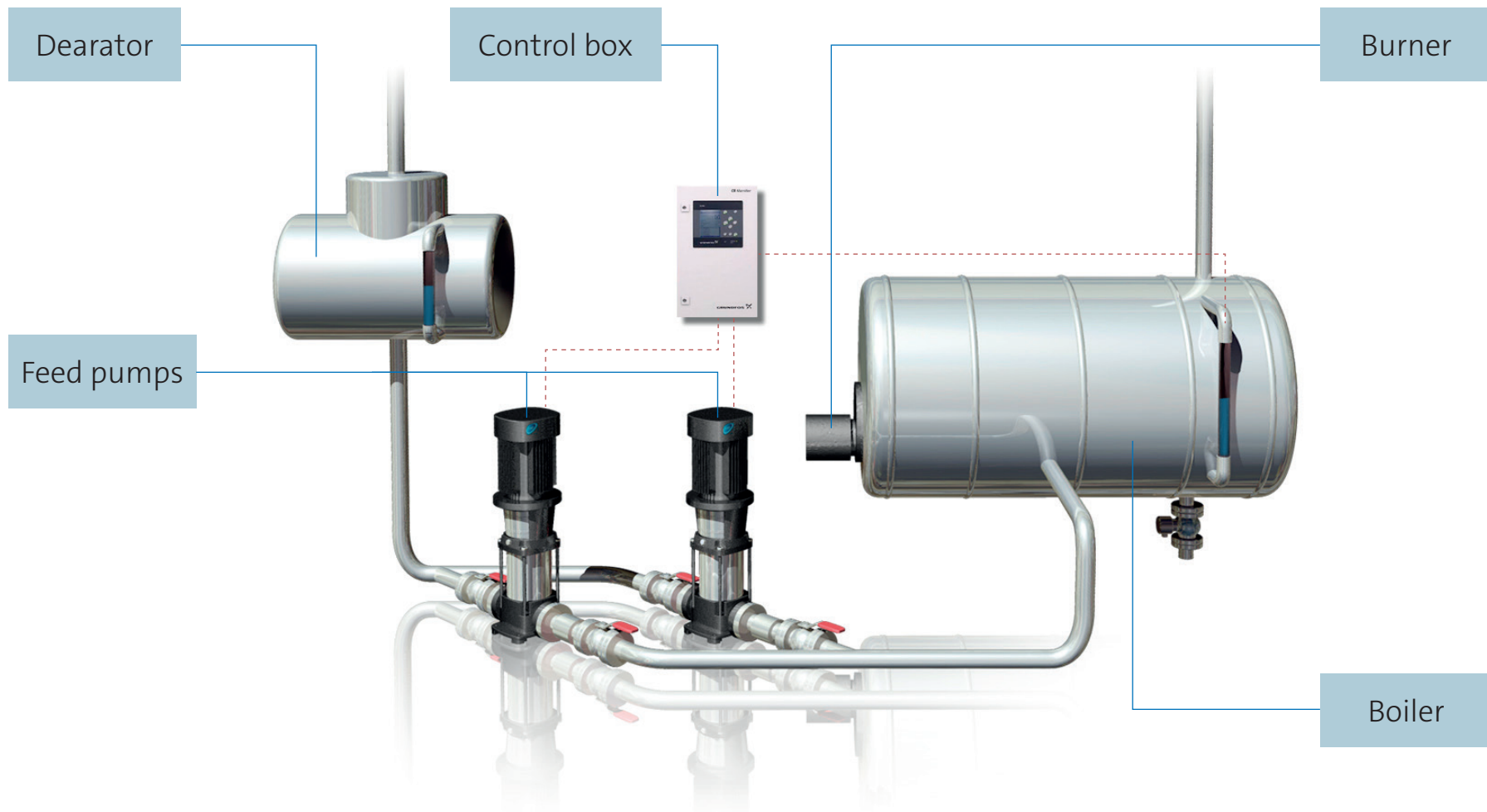
Ensure constant water level with variable speed

- No need for an expensive motorised feed valve.
- Smaller pump compared with regulation valve-controlled water level.
- Reduction in needed head and flow from pump.
- No pressure loss from feed valve.
- Steady steam quality.



**How to control the water
level in the boiler?**

Boiler feed – On/Off control



Boiler feed – On/Off control

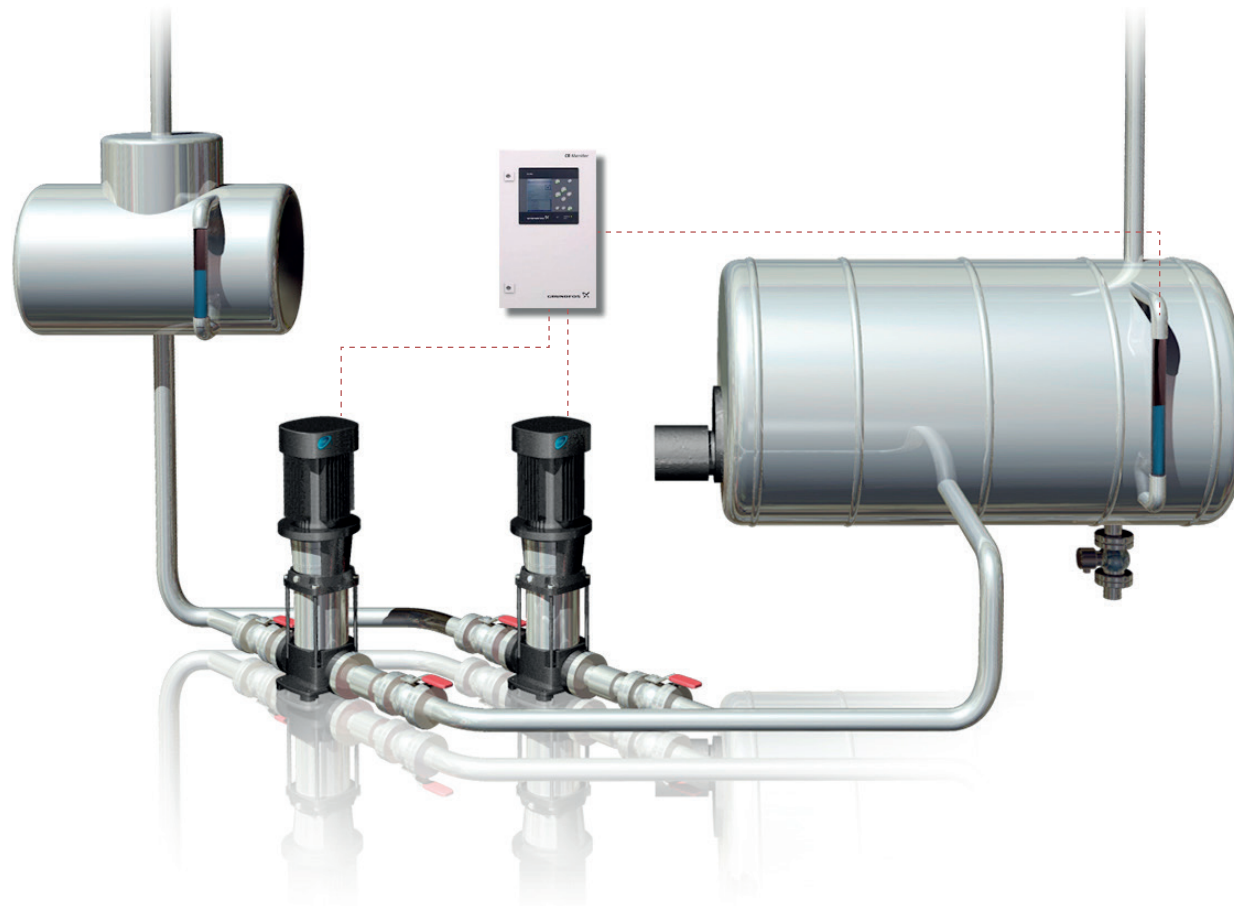


Benefits

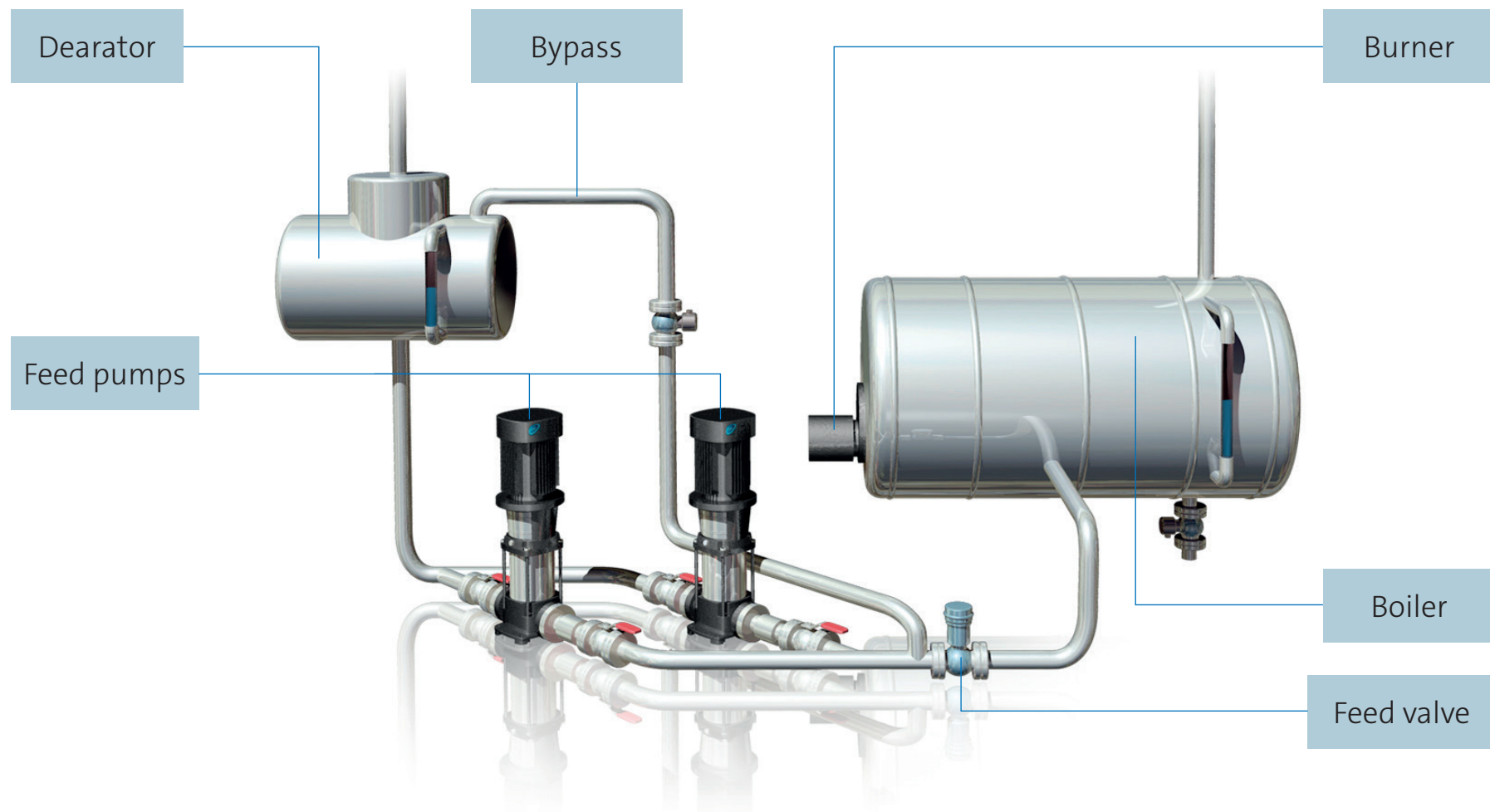
- Inexpensive.
- Easy to install.
- No bypass piping.

Drawbacks

- Poor steam quality
- Large amount of stress on the boiler construction.



Boiler feed – Feed valve



Boiler feed – Feed valve

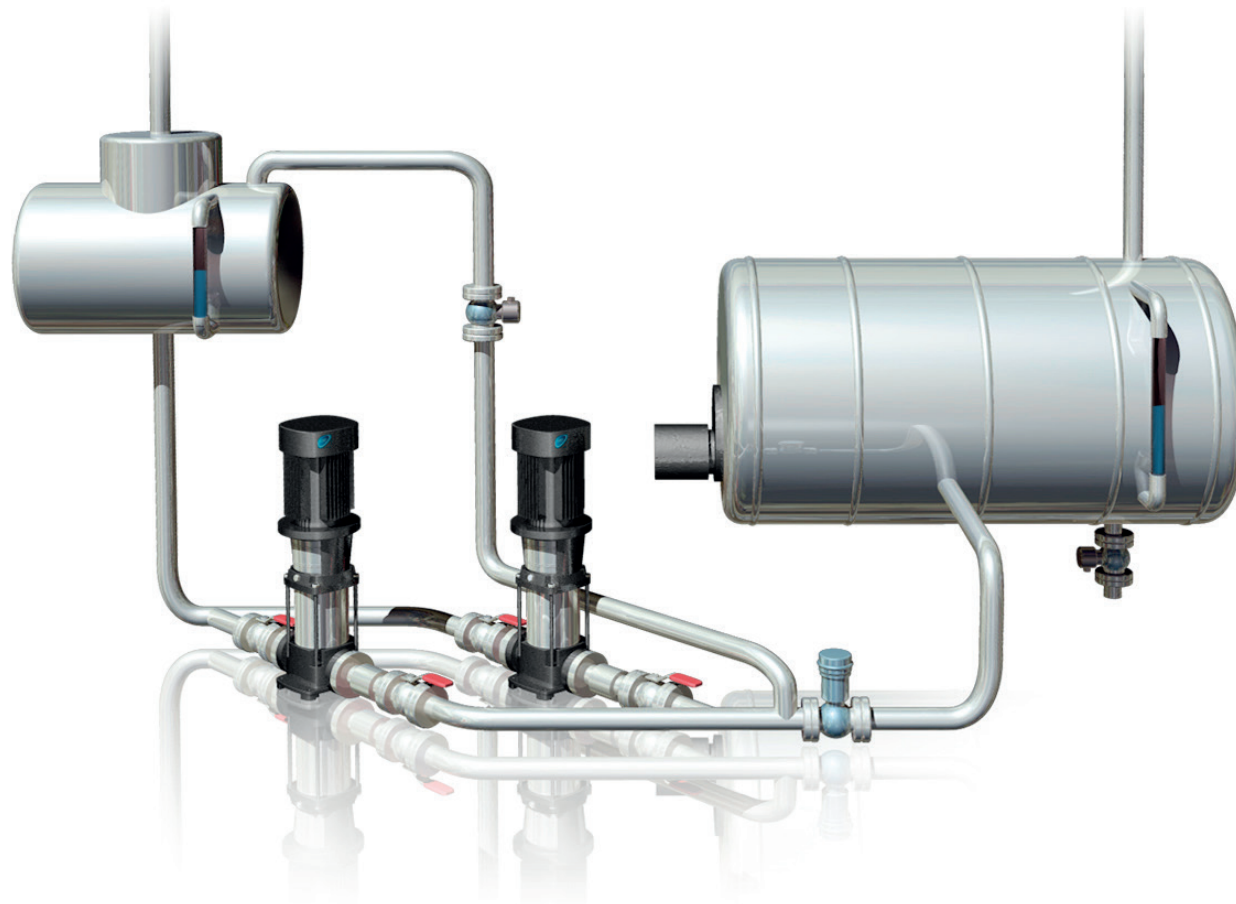


Benefits

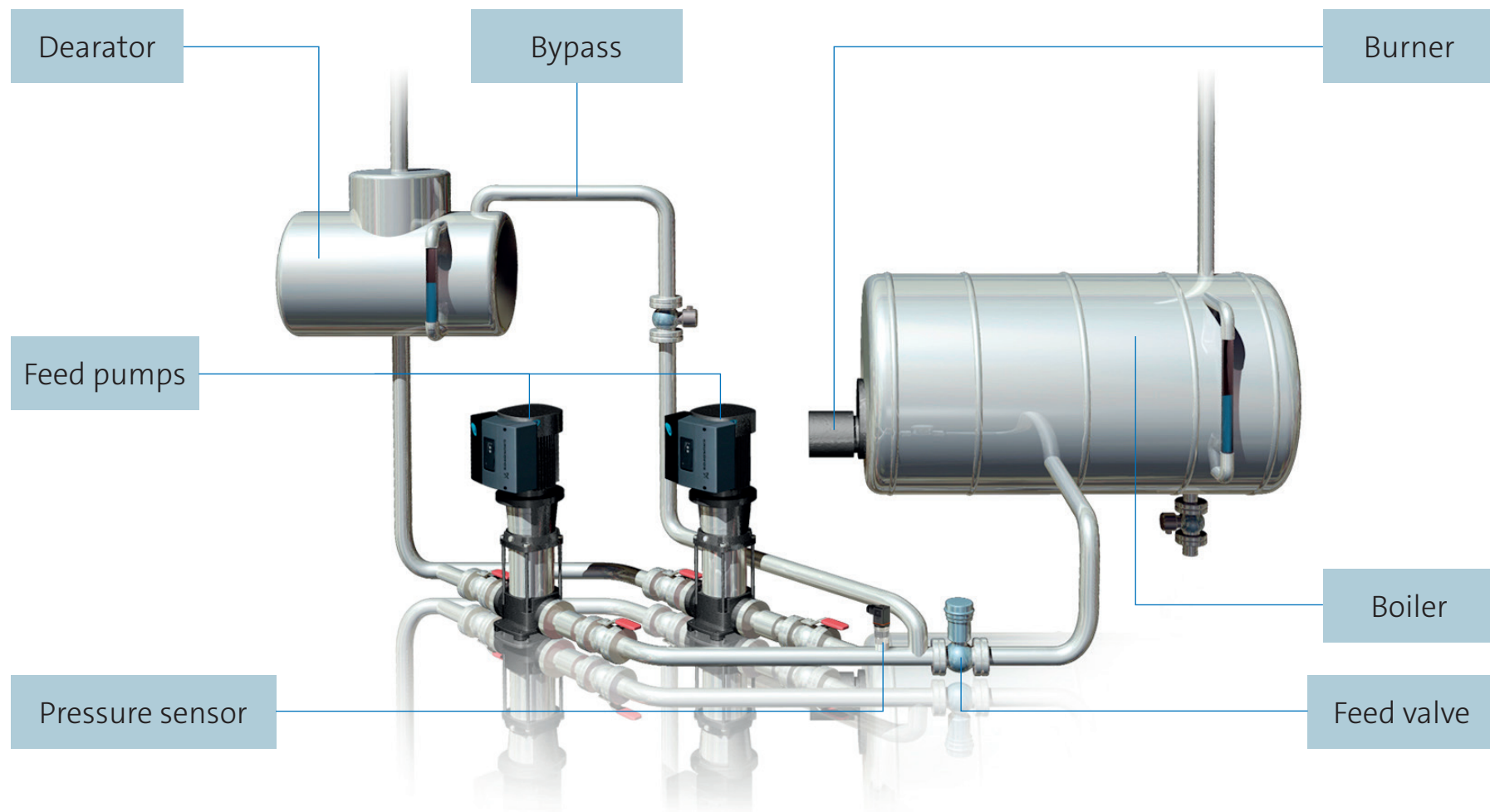
- Adjusts the boiler feed water to steam consumption.

Drawbacks

- High energy consumption.
- Expensive feed valve.
- Significant pressure loss across the feed valve.



Boiler feed – Feed valve with variable speed pumps





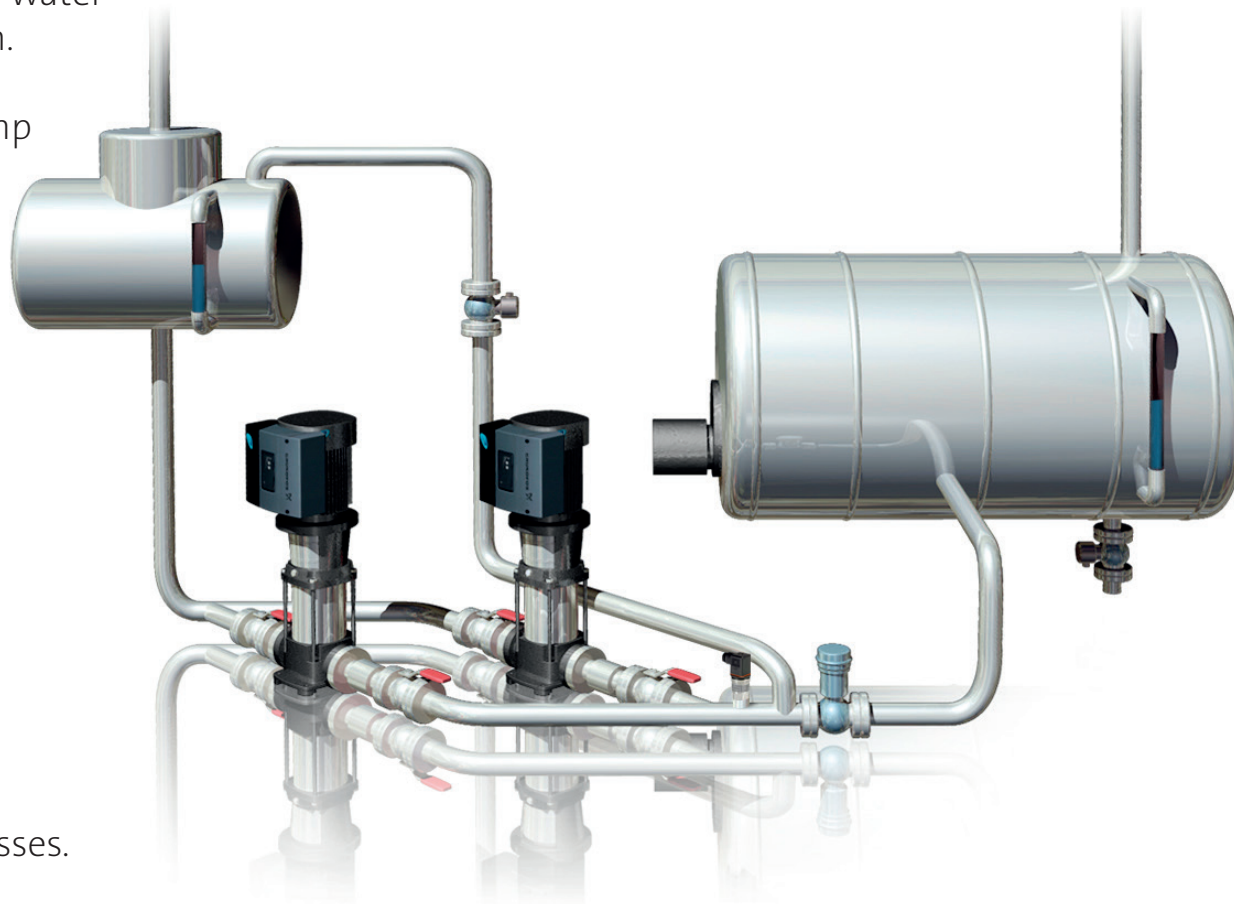
Boiler feed – Feed valve with variable speed pumps

Benefits

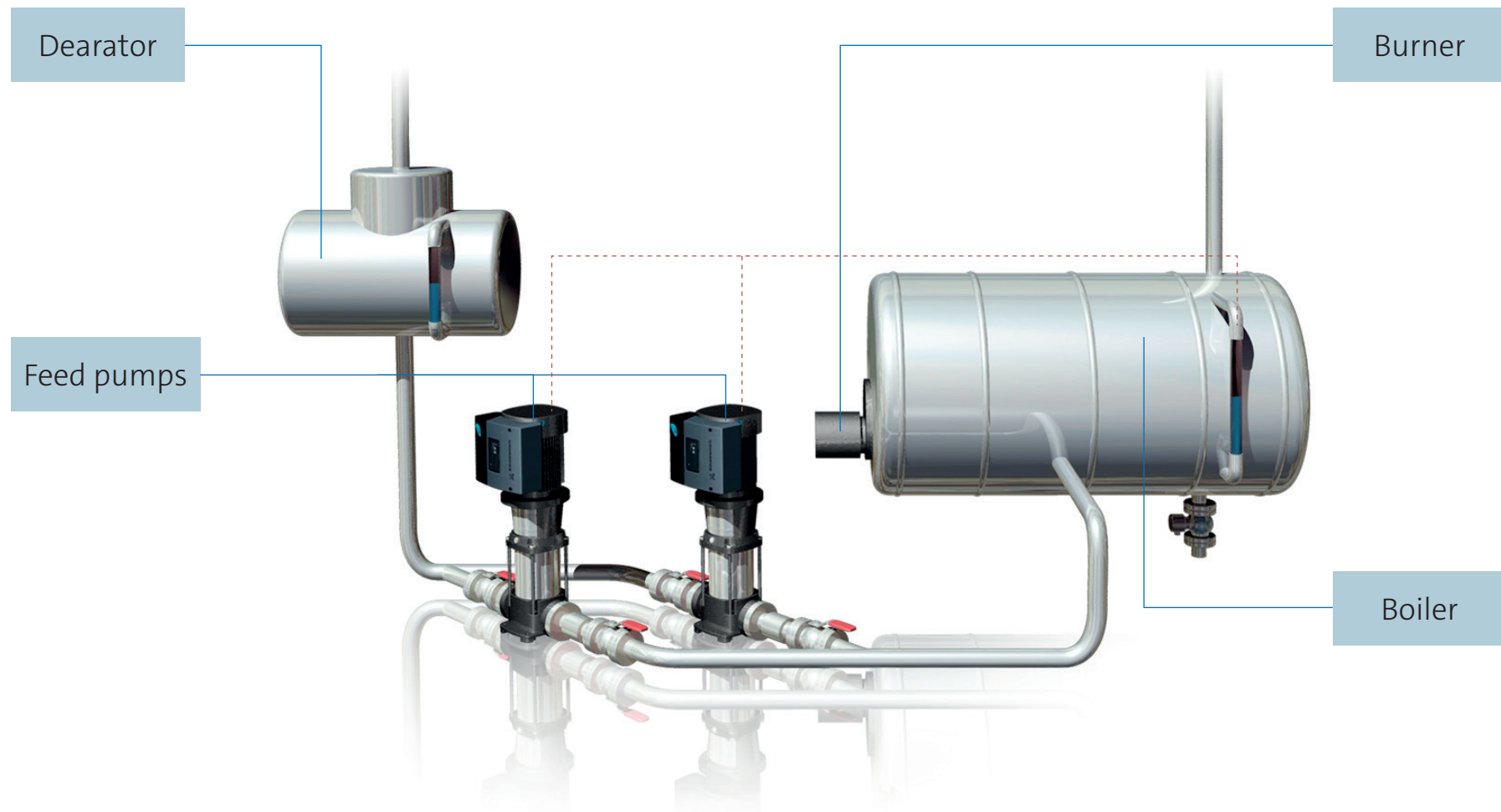
- Adjusts the boiler feed water to steam consumption.
- Energy savings on pump operation.
- Constant differential pressure across the feed valve.

Drawbacks

- Bypass contributes to energy losses.
- Expensive to purchase and install.
- Significant pressure losses.



Boiler feed – Variable speed pumps without a feed valve

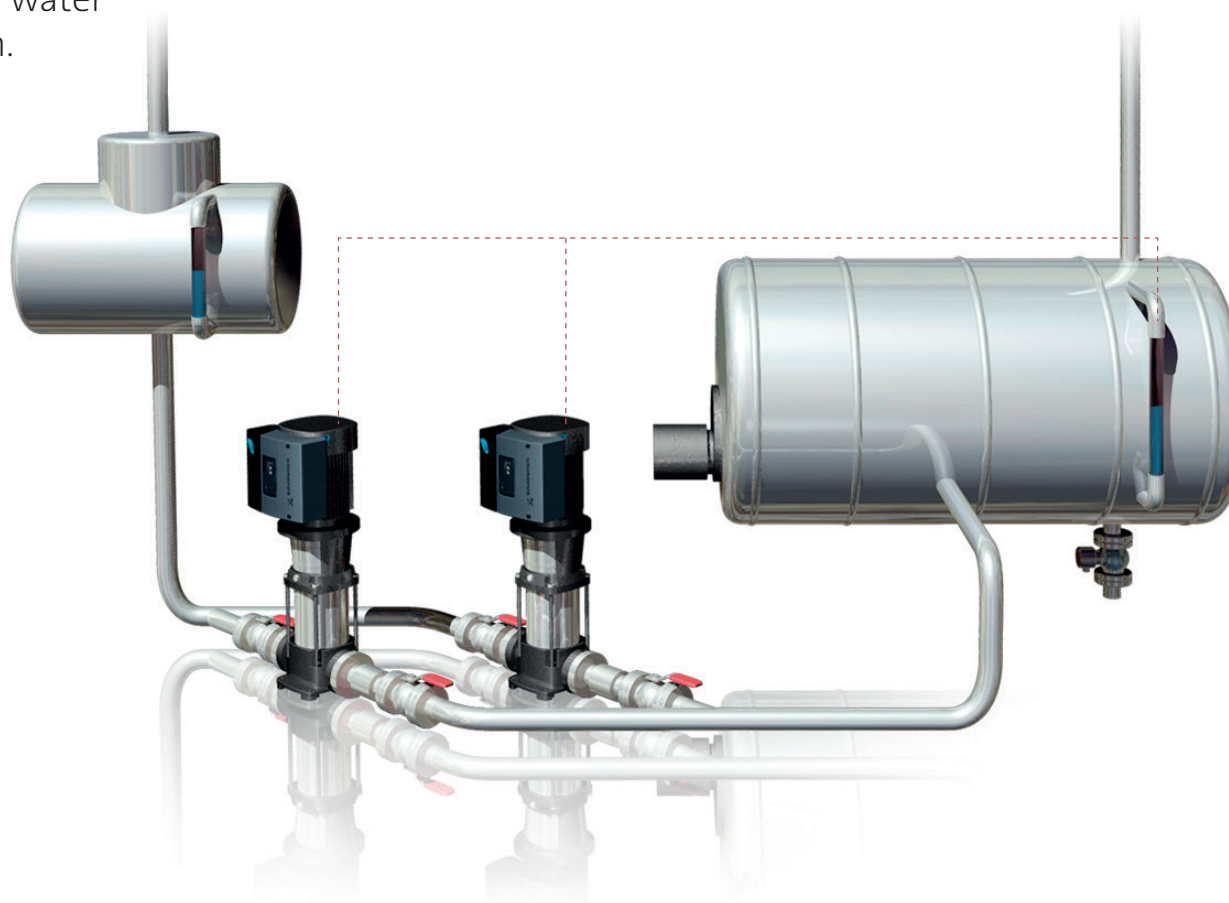


Boiler feed – Variable speed pumps without a feed valve



Benefits

- Adjusts the boiler feed water to steam consumption.
- Energy savings on pump operation.
- No pressure losses.
- Easy savings with a variable frequency drive.



3 crucial operational aspects



**Set the
regulation loop
precisely**

**Define a
minimum
frequency**

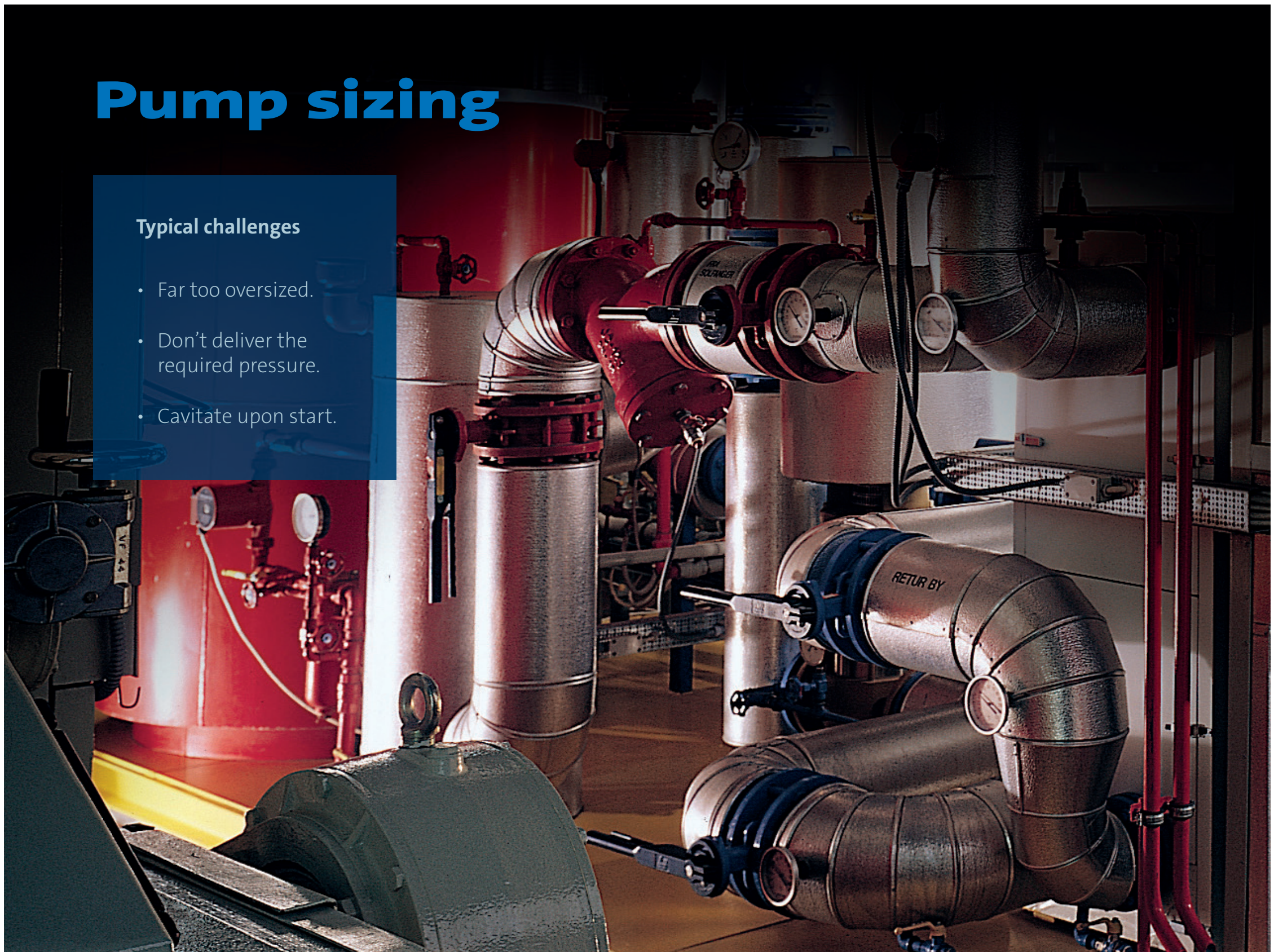
**Stop the pump
when the steam
consumption
is zero**

Sizing pumps for boiler feed operation

Pump sizing

Typical challenges

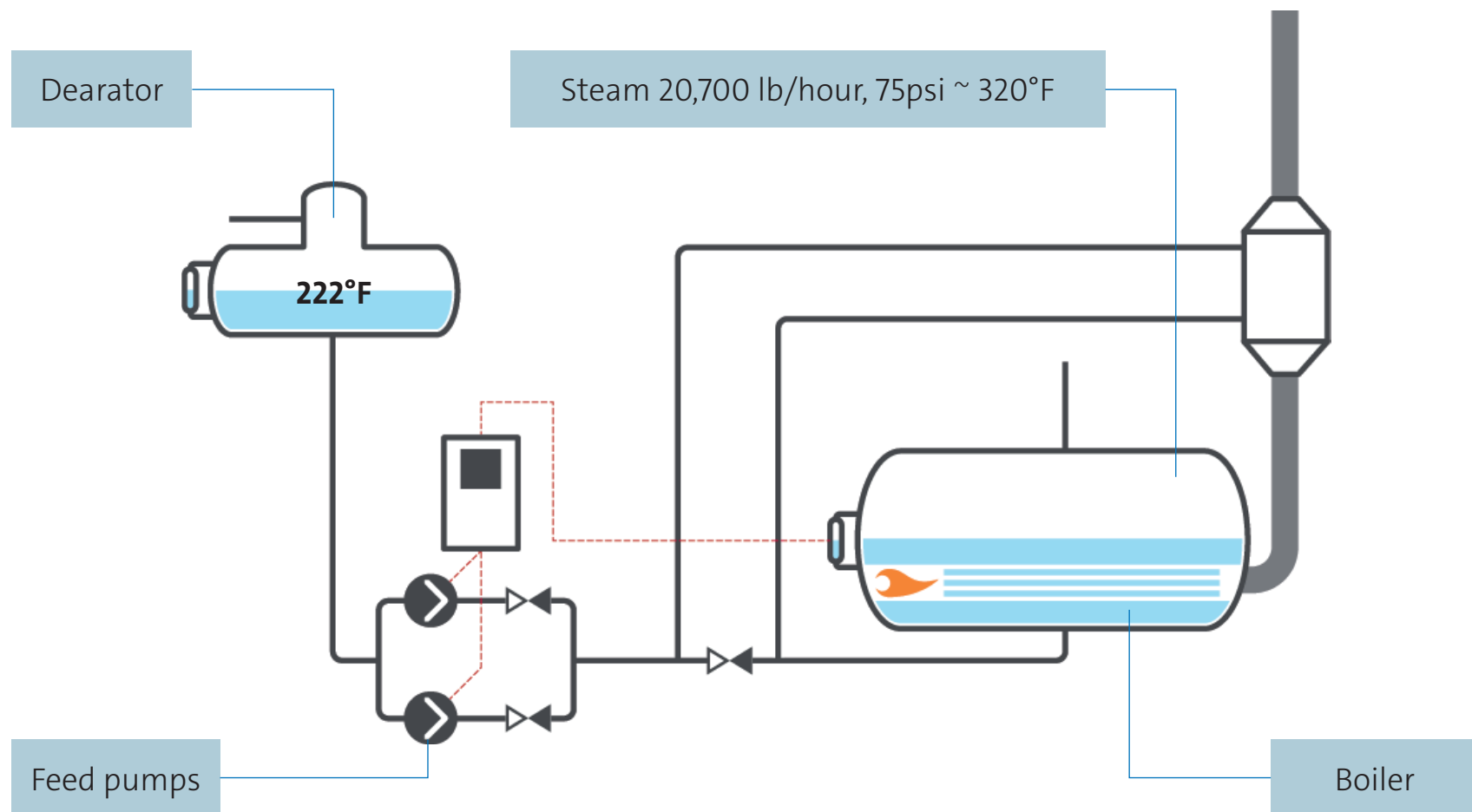
- Far too oversized.
- Don't deliver the required pressure.
- Cavitate upon start.



Pump sizing



Never use the steam temperature – the pump will always meet the temperature from the deaerator.



Pump sizing



The rules:

$$Q_{\text{Pump max}} = 1.25 \times Q_{\text{Boiler}} = 1.25 \times 41.4 = 54 \text{ gpm}$$

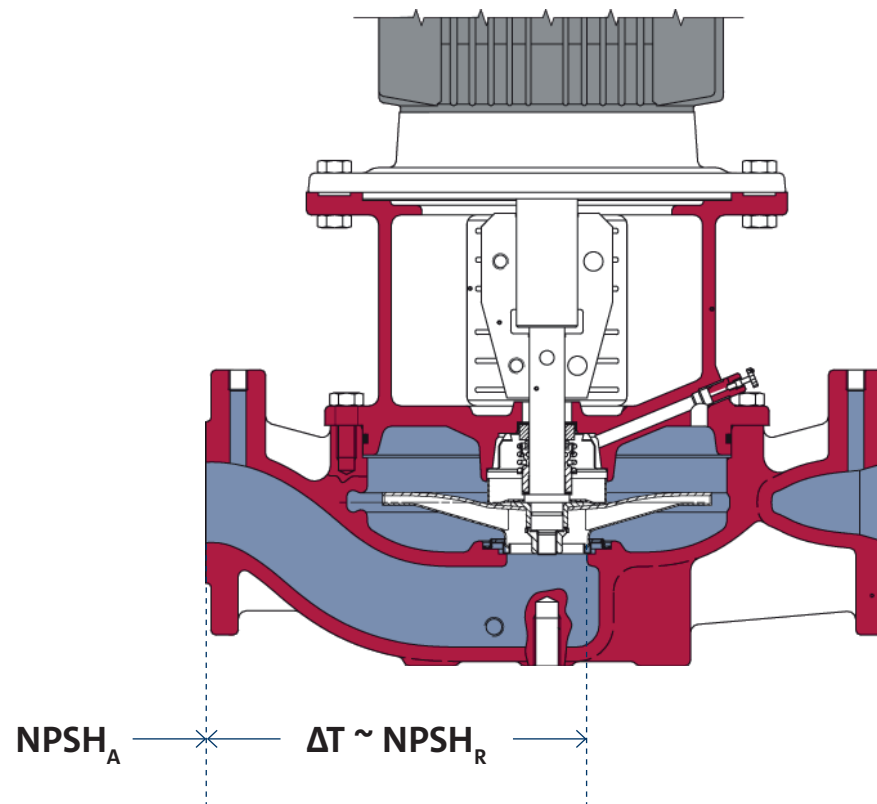
ASME Code

- Requires the boiler feed pump be able to put water in the boiler at the evaporation rate at a pressure which is 3% greater than the highest setting of the safety valves.
- Normally 25 % is added to flow as "catch-up"

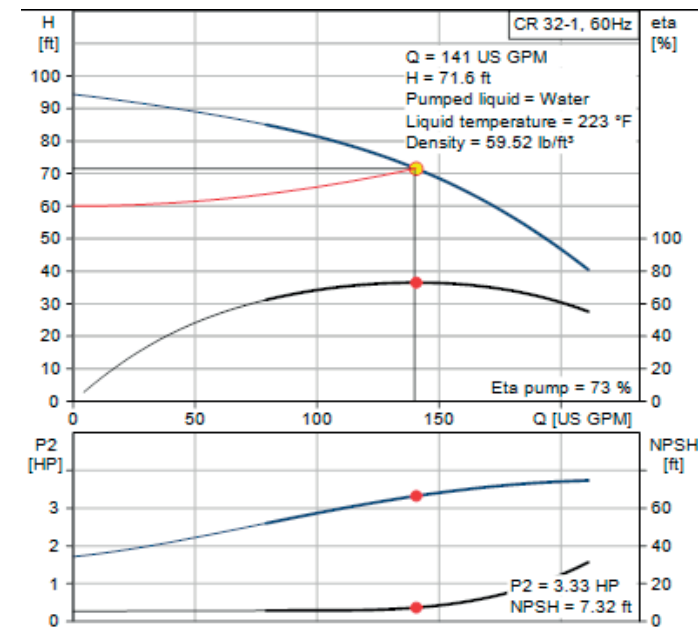
European rules according to EN 12952-7

- Flow: The pump has to be able to do a flow 1.25 times the max. flow on the boiler nameplate. And continuous 1.15 times the max. flow on the nameplate.
- Pressure: The pump has to be able to do a pressure 1.10 times the max. pressure on the nameplate on the boiler.

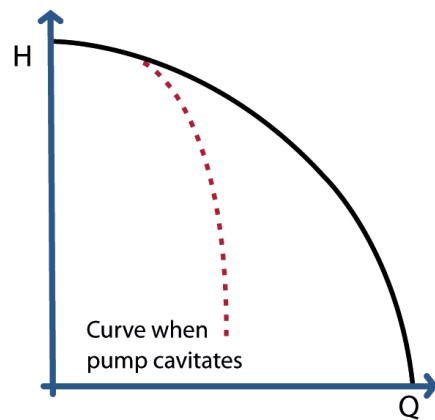
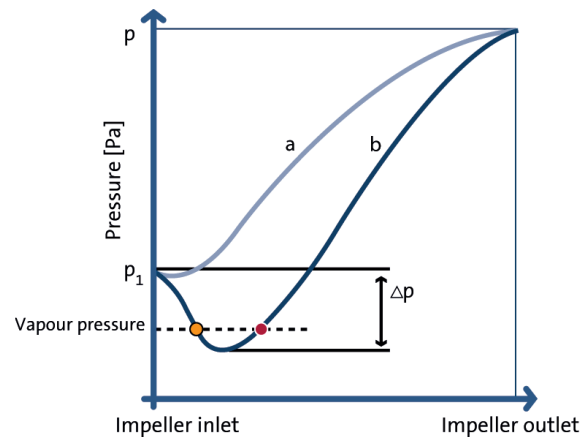
Pump sizing / NPSH



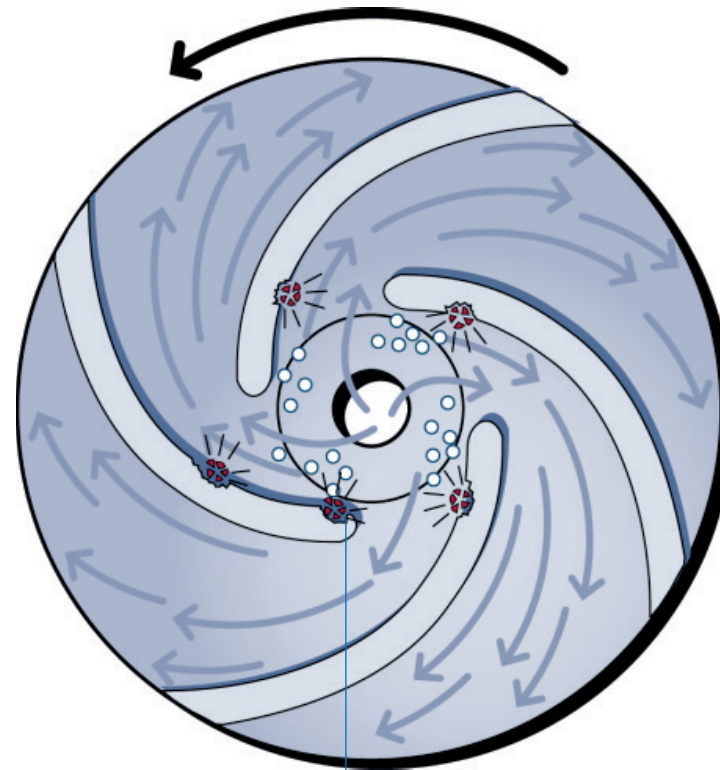
$$NPSH_A > NPSH_R$$



Cavitation



a = front of impeller vanes, b = back of impeller vanes



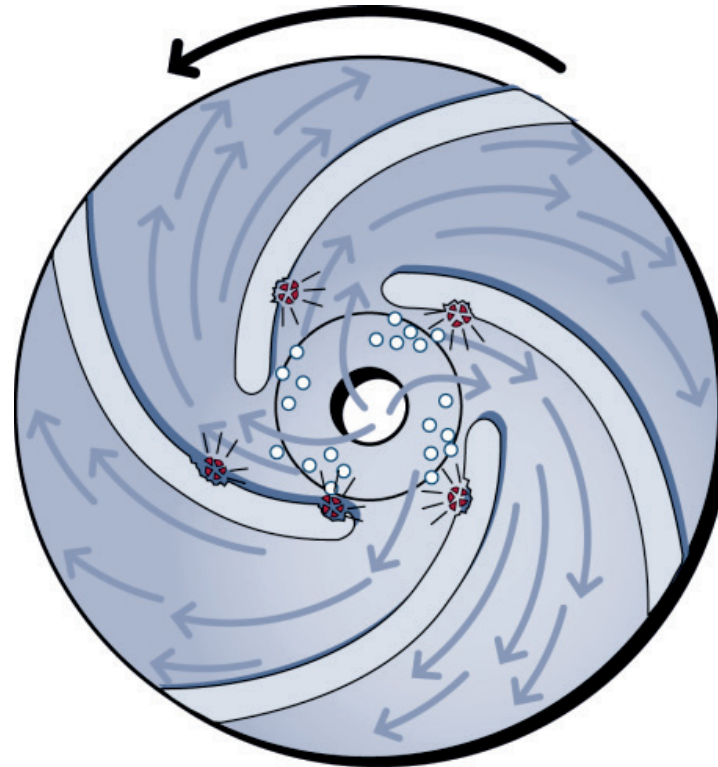
Imploding water bubbles

Cavitation



How to avoid cavitation

- Lower the pump – typically in an open system.
- Increase system pressure – typically in a closed system.
- Shorten the suction line to reduce friction losses.
- Increase the suction line's cross-section area to reduce fluid velocity.
- Avoid pressure drops from bends and obstacles in the suction line.
- Lower the fluid temperature.



Cavitation



How to avoid cavitation:
 $NPSH_{system} > NPSH_{Pump}$

$$NPSH_{system} = h_b - h_f - h_v \pm h_{geo} - h_s$$

$NPSH_{system}$ The pressure available on the inlet of the pump.

h_b Pressure inside the deaerator.

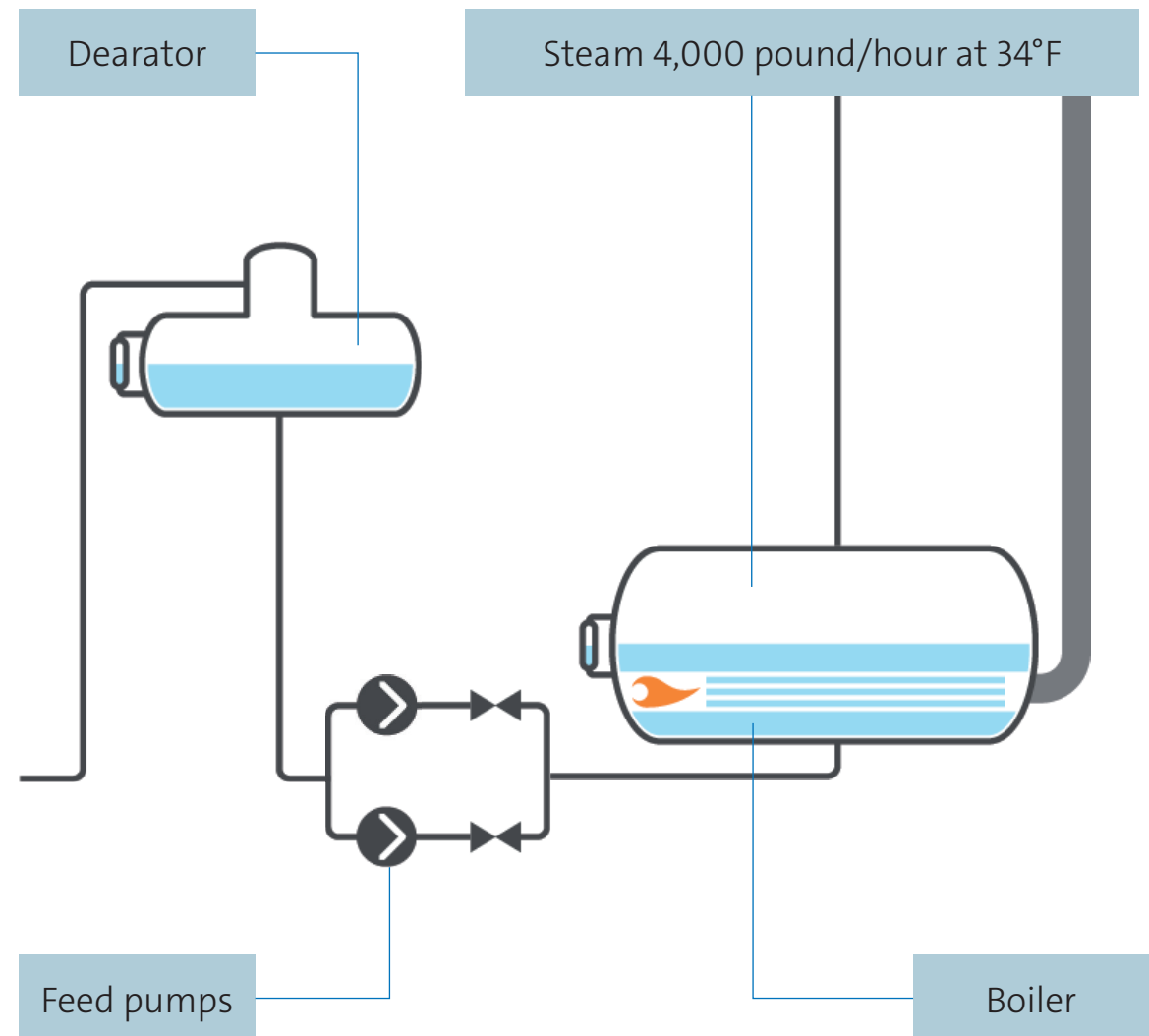
h_f Friction loss in the suction pipe.

h_v Vapor pressure of the liquid.

h_{geo} The water level above or under the pump inlet.

h_s Safety factor. Normally varies between 2-4 feet.

In boiler systems with an atmospheric deaerator, the atmospheric pressure and the vapor pressure always equalize each other due to the boiling in the deaerator.





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