Sample Conditioning for the water-steam cycle

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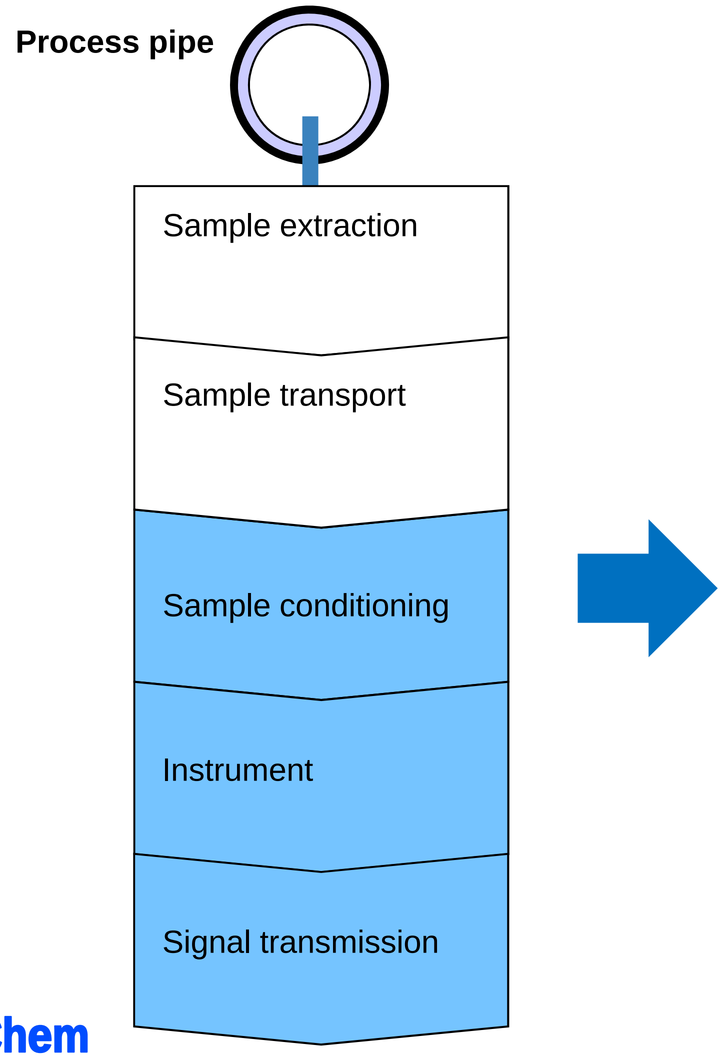
Sample conditioning for water-steam samples
One important step between process and online measurement



Process side conditions

- High temperatures /pressures
- Fluctuating plant load, Starts/stops

Sample conditioning

- Functional requirements
- Safety requirements
- Operation & maintenance requirements
- Cost of ownership

Downstream requirement

- Reliable sample flow for instruments & grab
- Pressure and temperature safety

Sample conditioning for water-steam samples (acc. VGB-S006 2012)

Sample line isolation

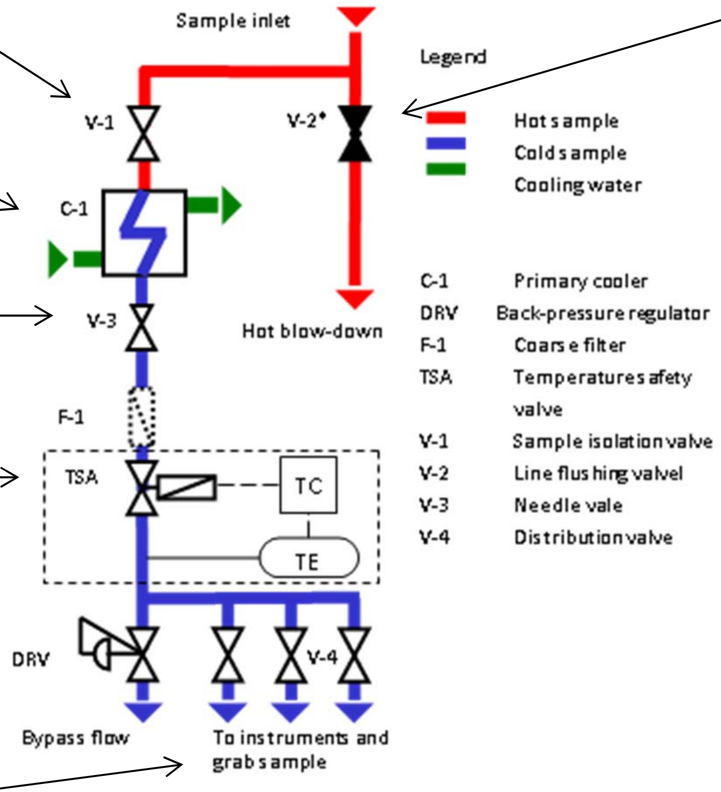
Sample cooling

Flow throttle
Pressure reduction

Temperature shut-off
(safety)

Sample pressure
regulation

Sample distributon to
instruments

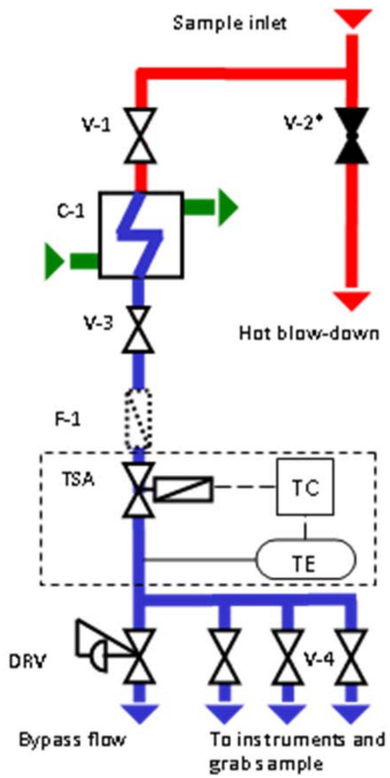


Sample line
flushing

Secondary
cooling

Filtration

Sample conditioning for water-steam samples
Temperature protection



Upstream conditions

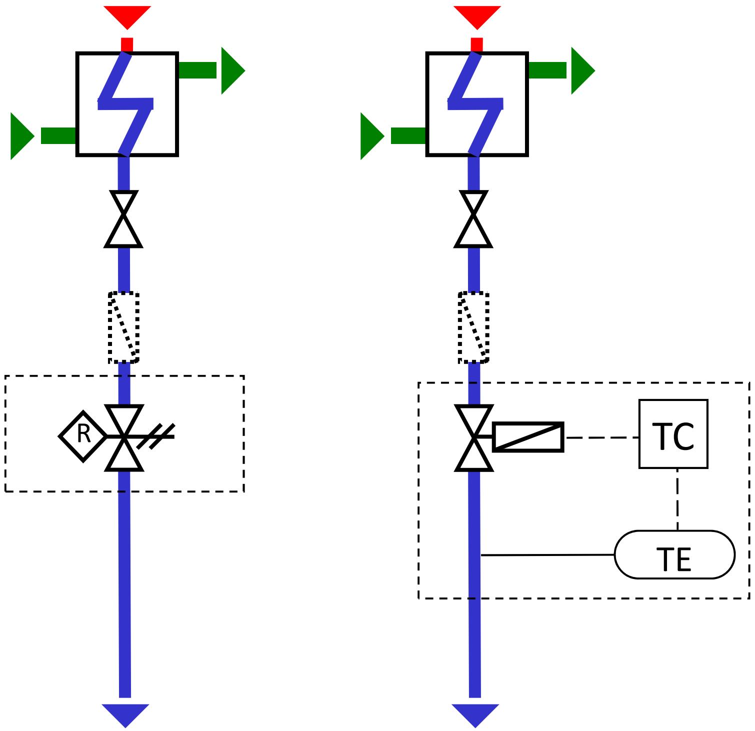
- Most samples have temperatures >50°C, up to 600°C
- Sample P 1-250 bar

Temperature shut-off is a mandatory safety function.
What are the design requirements?

Downstream

- SWAS instrumentation in shelter or room
- Instruments and other components not rated for high temperatures
- Operators taking grab smaples
- Open drains

Design requirements for temperature protection



Spring loaded mechanical T-protection valve

Solenoid valve with T-controller

- Stop sample flow completely
  - No bypass flow allowed: hot sample must be stopped
- Full line pressure rating for all components up to temperature shut-off valve
- Fast reaction (<3seconds)
  - Temperature sensor time lag?
  - Valve actuator switching time?
- Fail-safe in case of loss of power

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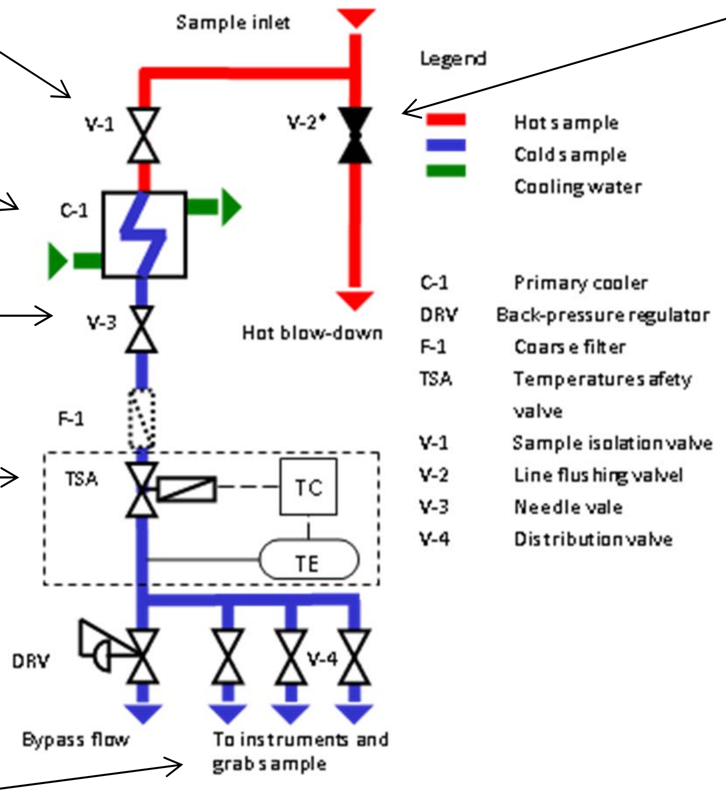

Sample line
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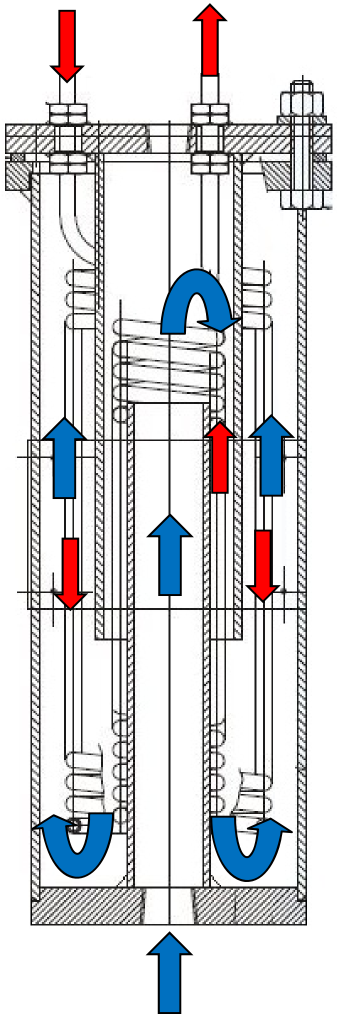
Base function

Optional

Primary cooling - helical tube sample cooler design basics



Characteristics

- Sample flows in cooler coil /double coil (typically 40 – 60l/h). Coil sized for high pressure and high temperature
- Cooling water flows on shell side (counterflow guided by baffles). Shell sized for lower pressure, highly turbulent cooling water flow

Key thermodynamic and hydraulic data

- Typical heat exchange area 0.2 - 0.35 m2
- Cooling power 20 – 40kW
- CW mass flow required: ~20x sample flow for water, ~40x sample flow for steam
- Pressure drop accross cooler on CW side 0.4 – 0.7bar
- Sample outlet T 2-3°C above CW inlet T

Features for maintainability

- Flanged shell to allow coil inspection / cleaning
- Port at lower end for purging and/or CW supply

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Sample conditioning for water-steam samples: When is secondary sample cooling required?

Primary sample cooling

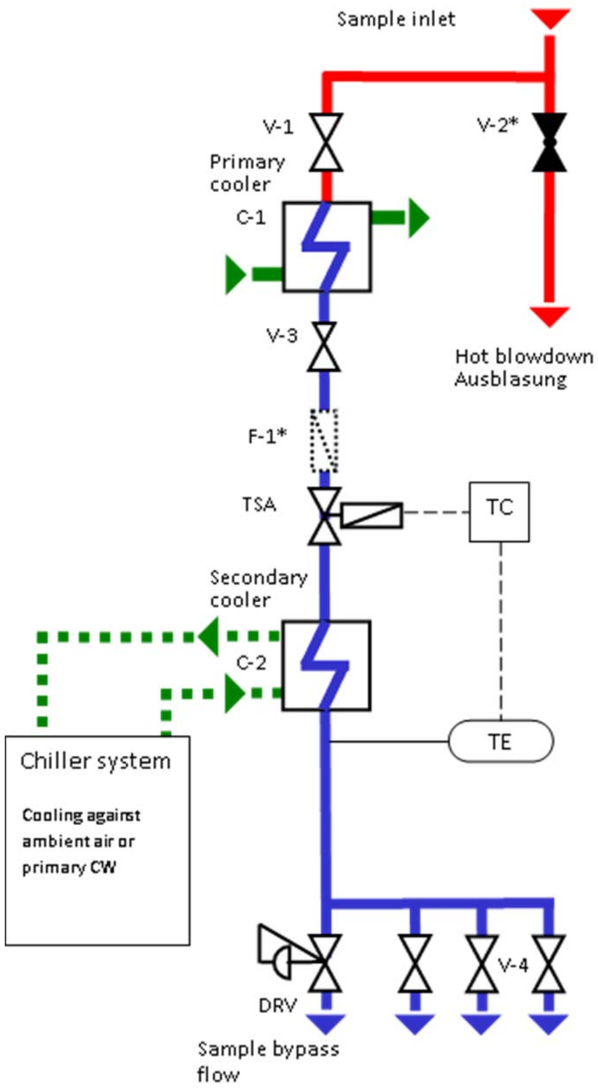
- Reduces sample temperature to primary cooling water inlet T plus 2-3°C
- Sample temperature changes with primary CW temperature

Secondary sample cooling (acc. VGB S006 2012)

- Should be used **ONLY if primary cooling water is too warm** to reduce sample temperatures below 45°C
- Should **simply reduce sample temperature below 45°**, where online instruments can handle the sample and compensate measurements to ISO conditions.

- Secondary cooling **SHOULD NOT BE USED FOR THERMOSTATIC CONTROL OF SAMPLE T AT 25°C!**
  - It does not work reliably in all load conditions
  - T-changes downstream of the chiller occur
  - It is expensive (invest and maintenance)

WHY NOT?



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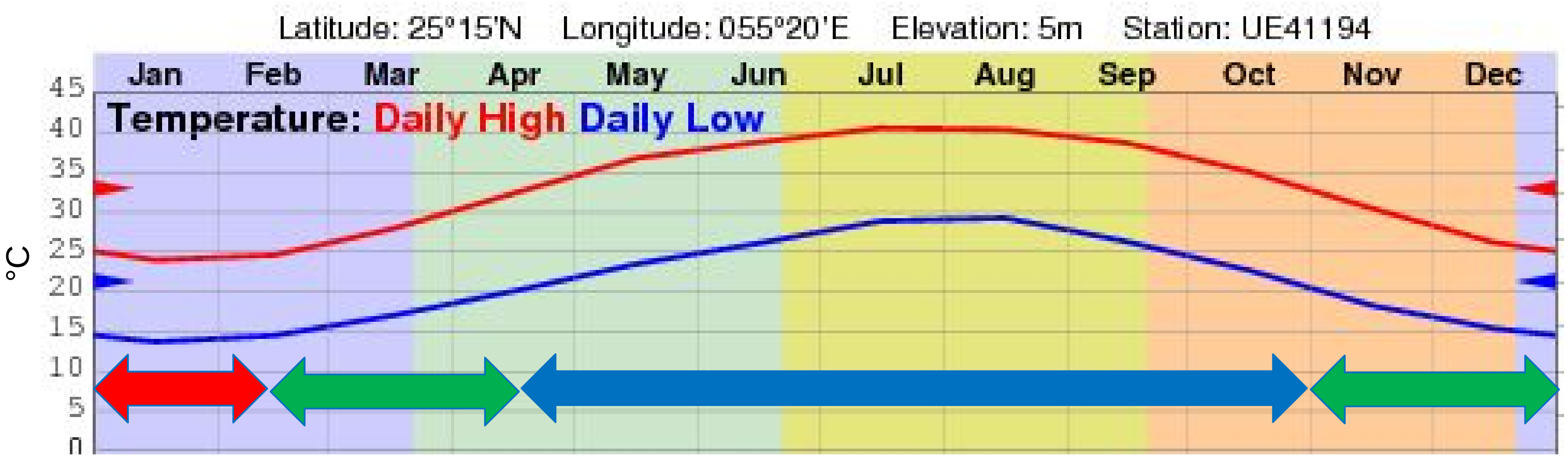
Example of chiller requirements – bad practice
Chiller attempting precise sample T control at 25°C

Daily high / low T-chart for Dubai, UAE



Chiller must operate all year round with changing load cases:

- in cooling duty during extended hot period, when PGB-cooling water is >25°C (typically ambient >20°C)
- in mixed duty (part load cooling daytime, heating nighttime, 2 no-load-transitions every day) during intermediate periods
- mainly in heating duty during cold period where PGB-coling water is below 23°C

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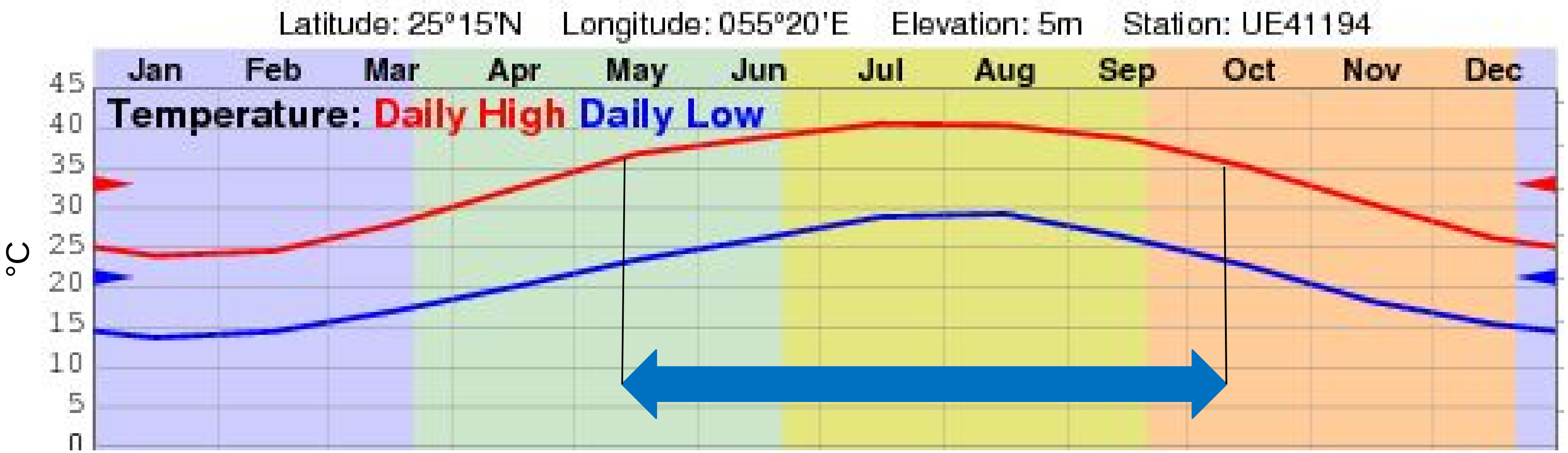
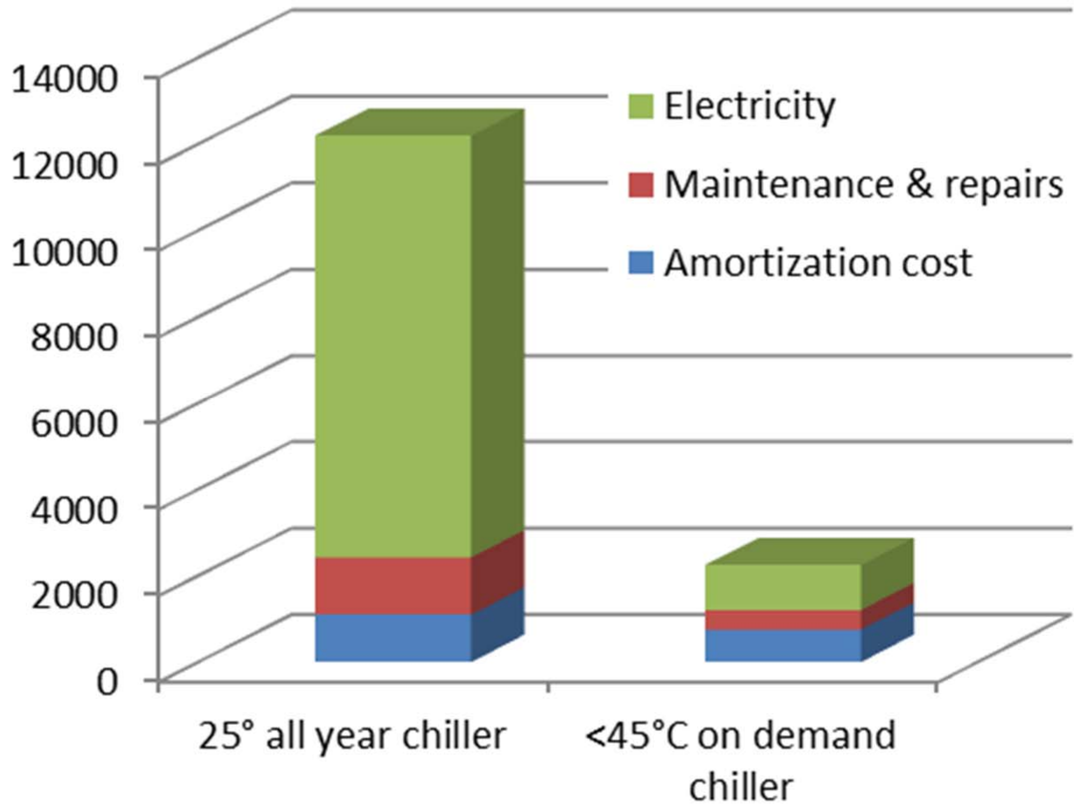
Daily high / low T-chart for Dubai, UAE



- Chiller operatoes in cooling duty, only during hot period, when PGB-cooling water is >40°C (typically ambient >35°C)
- Even in during hot period, the chiller is not required during night time
- Chiller is sized only to bring down sample temperature in a range of 35 - 45°C (reduces chiller size, facilitates T-control in all load conditions)
- **REQUIRES ONLINE INSTRUMENTATION WITH CORRECT TEMPERATURE COMPENSATION**

Unnecessary secondary cooling is expensive…
…too expensive to do it just to be on the safe side!

Chiller operating cost (US$/year)



Sampling system with 15 sample lines, electricity cost 20ct/kWh, amortization over 20 years,
25°C all year chiller: invest 22k, 7000 h/y, 20kW cooling power, average η0.4
-45°C chiller: invest 15k, 2000 h/y, 10kW cooling power, average η0.3

Further arguments against all year chiller to 25°C:

- Chiller failure more likely in all year duty
- Sample temperature may still change downstream of chiller (e.g.room temperature influence**)**

Sample conditioning for water-steam samples (acc. VGB-S006 2012)
Sample pressure and flow regulation

Sample line isolation

Sample cooling

Flow throttle
Pressure reduction

Temperature shut-off
(safety)

Sample pressure
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Sample distributon to
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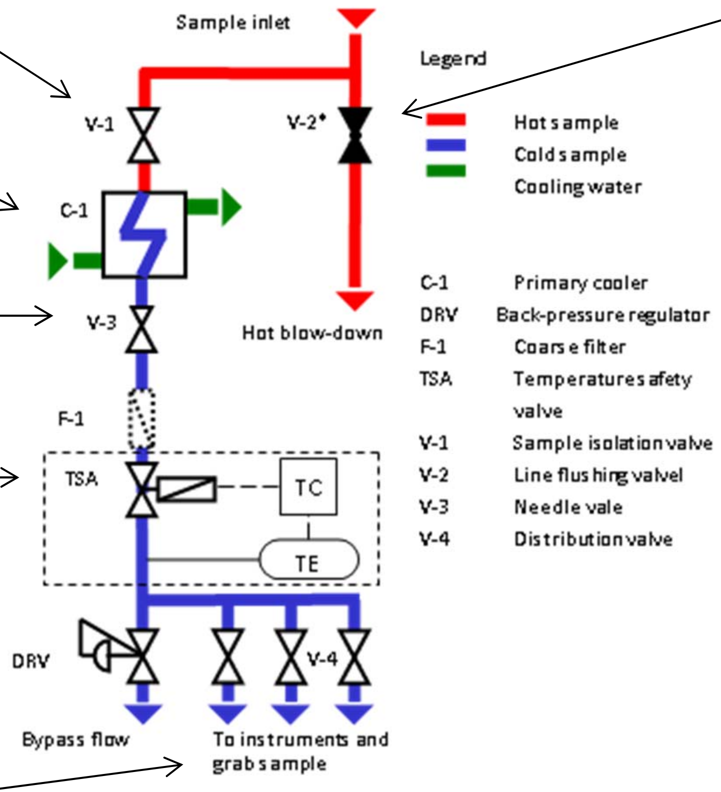

Sample line
flushing

Secondary
cooling

Filtration

Base function

Optional

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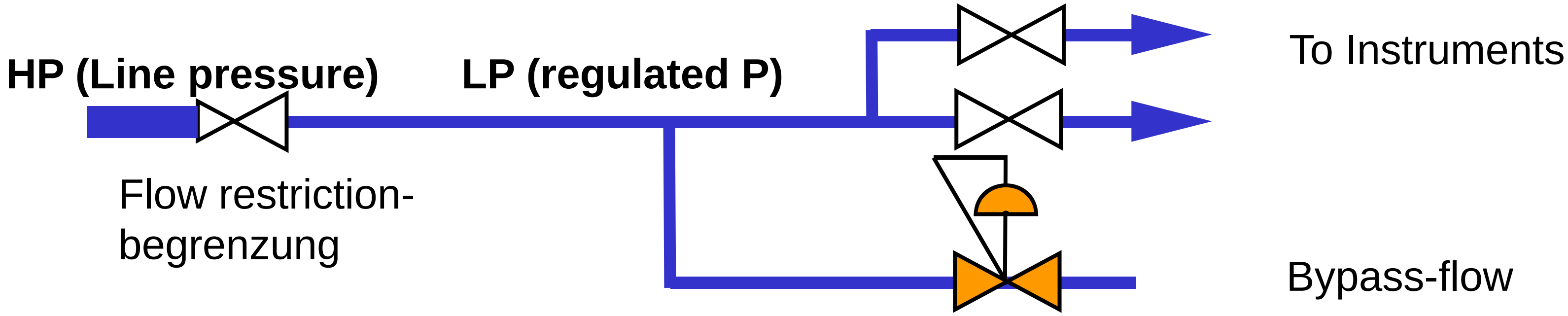
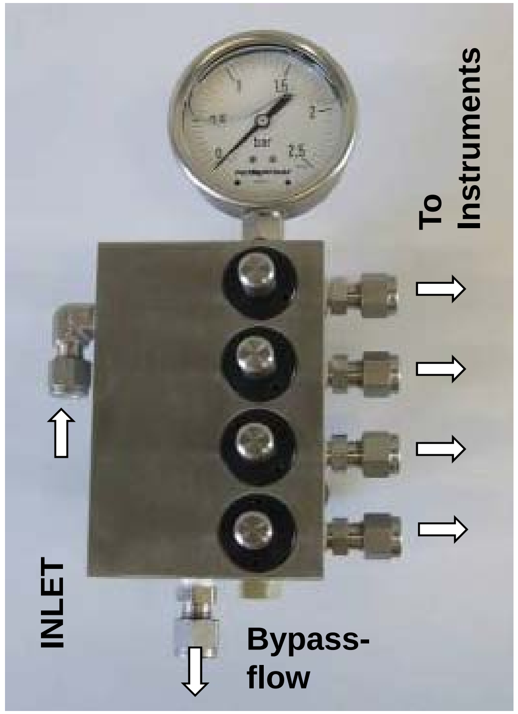
Sample pressure regulation using back-pressure regulator



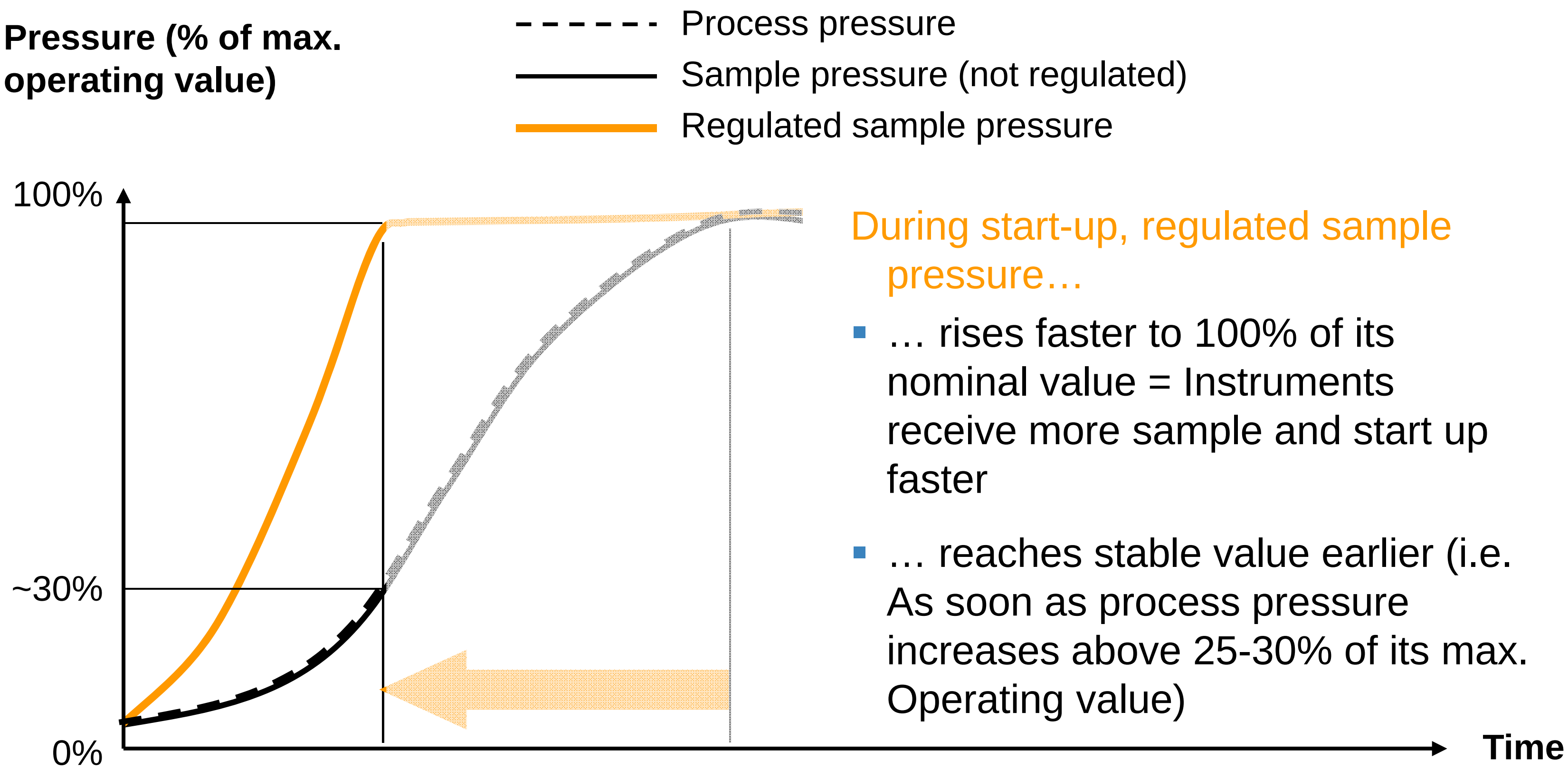
Example

Back-pressure regulator

- Integrated manometer and distribution channels to instruments
- Fixed regulating pressure of 0.5bar
- 5-150 l/h normal operating range



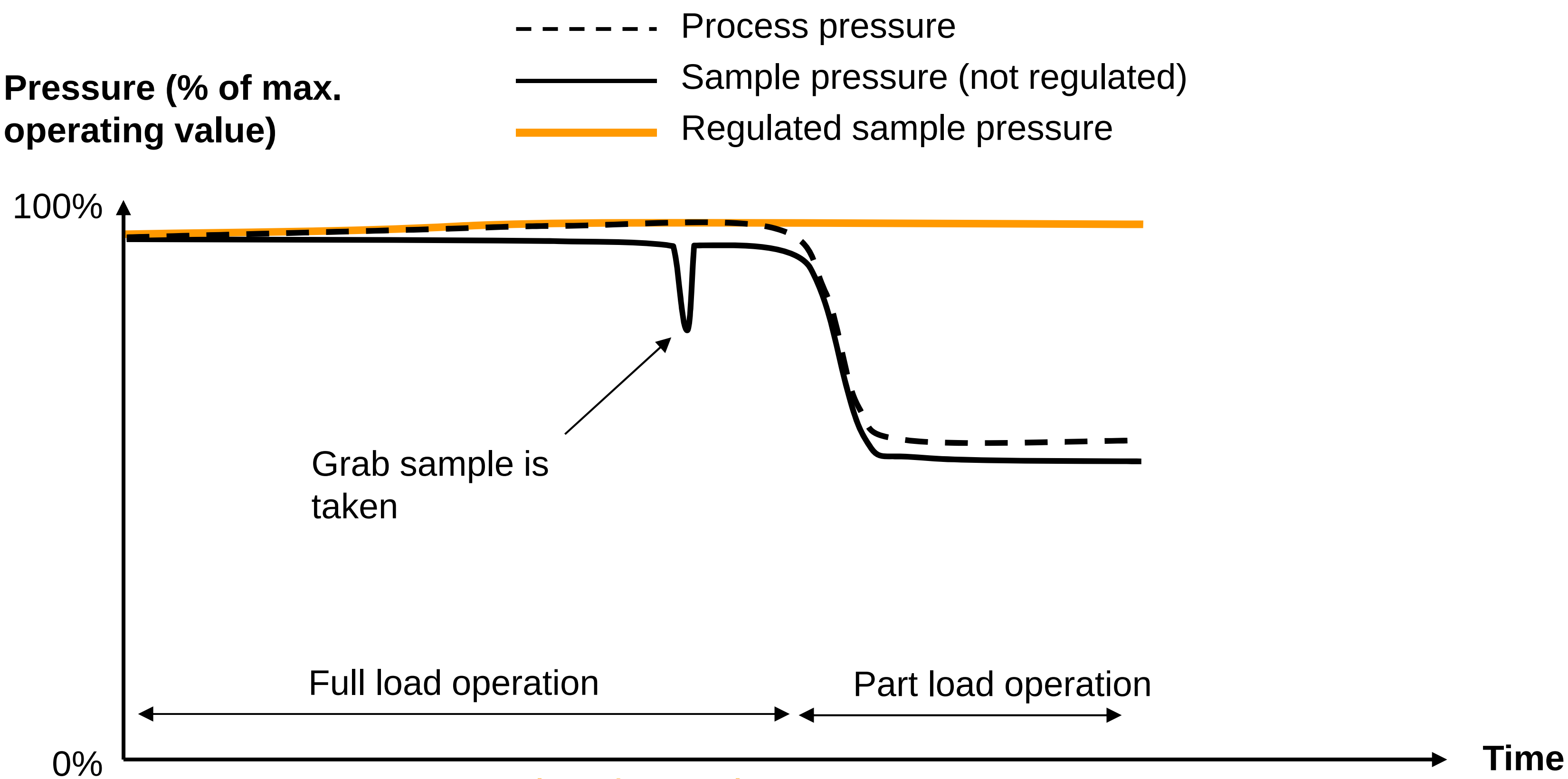
Sample pressure regulation – SAVING TIME AT START-UP



During start-up, regulated sample pressure…

- … rises faster to 100% of its nominal value = Instruments receive more sample and start up faster
- … reaches stable value earlier (i.e. As soon as process pressure increases above 25-30% of its max. Operating value)

Sample pressure regulation – GUARANTEES STABLE BOUNDARY CONDITIONS



Regulated sample pressure stays constant, compensating for the following distrubances:

- Load changes on process side
- Punctual change in sample flow requirement (grab sample)
- Changes in hydraulic resistance upstream

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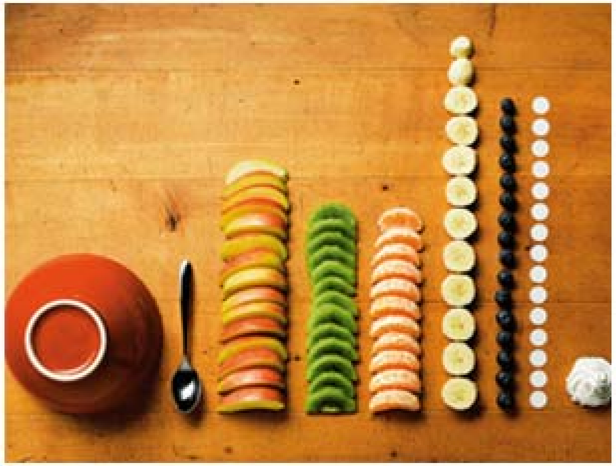
Instrument arrangements in traditional manner: defined by technical limitations that no longer apply

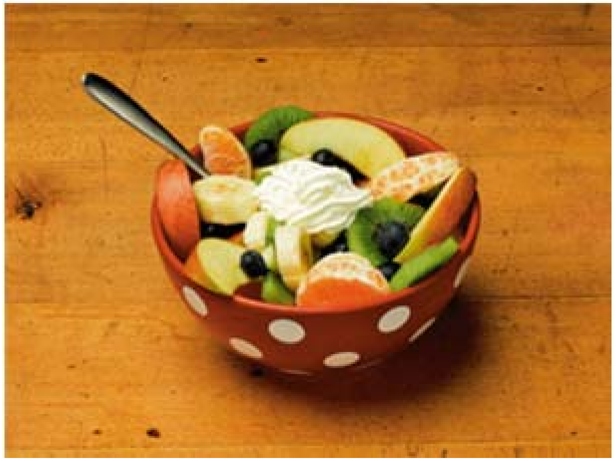


Typical instrument arrangement in traditional dry&wet rack systems

- Flow cells grouped by measurement type
- Separate grab sampling section
- Dry section (originally for panel mounted transmitters)
- Space optimized arrangement

- Difficult operation and maintenance
- Upgrades / modifications impossible
- Process perspective is missing

Instrument arrangement today – defined by function

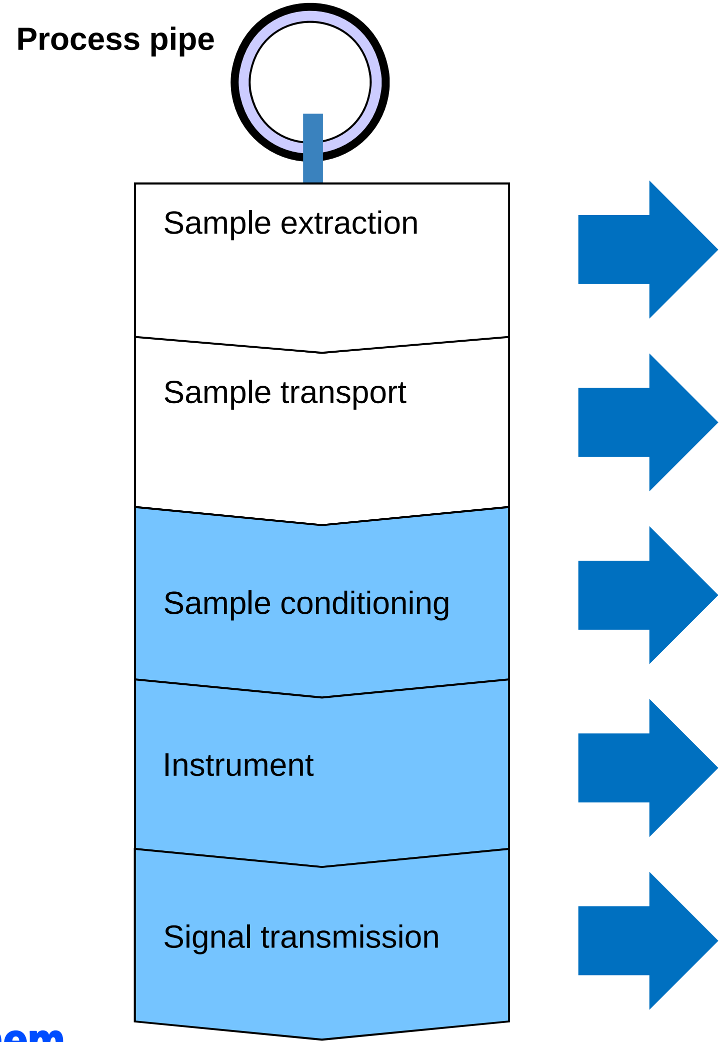


Recommended instrument arrangement acc. to VGB S006

- Group functional elements by measurement chain (flowcell, sensor, transitter, flow regulation)
- Group measurements by sample line, with grab sample
- Modular arrangement per measurement chain

- Easier operation and maintenance
- Upgrades / modifications possible
- Instrumentation provides process perspective

Conclusions – from process to online measurement value



Elements requiring special attention

- Correct extraction point
- Adequate extraction probe

- Sample pipe size / material
- Sample pipe length – subsystem arrangement
- Pipe routing

- Key functions (temperature protection, cooling & pressure regulation)
- Functional arrangement by sample line

- Temperature compensation
- Self-diagnosis capability
- Functional instrument arrangement

- Digital bus vs. analog signal exchange
- Remote diagnostic information to DCS

Thank you for your attention!