Technical Challenges of Goethermal Energy Utilisation

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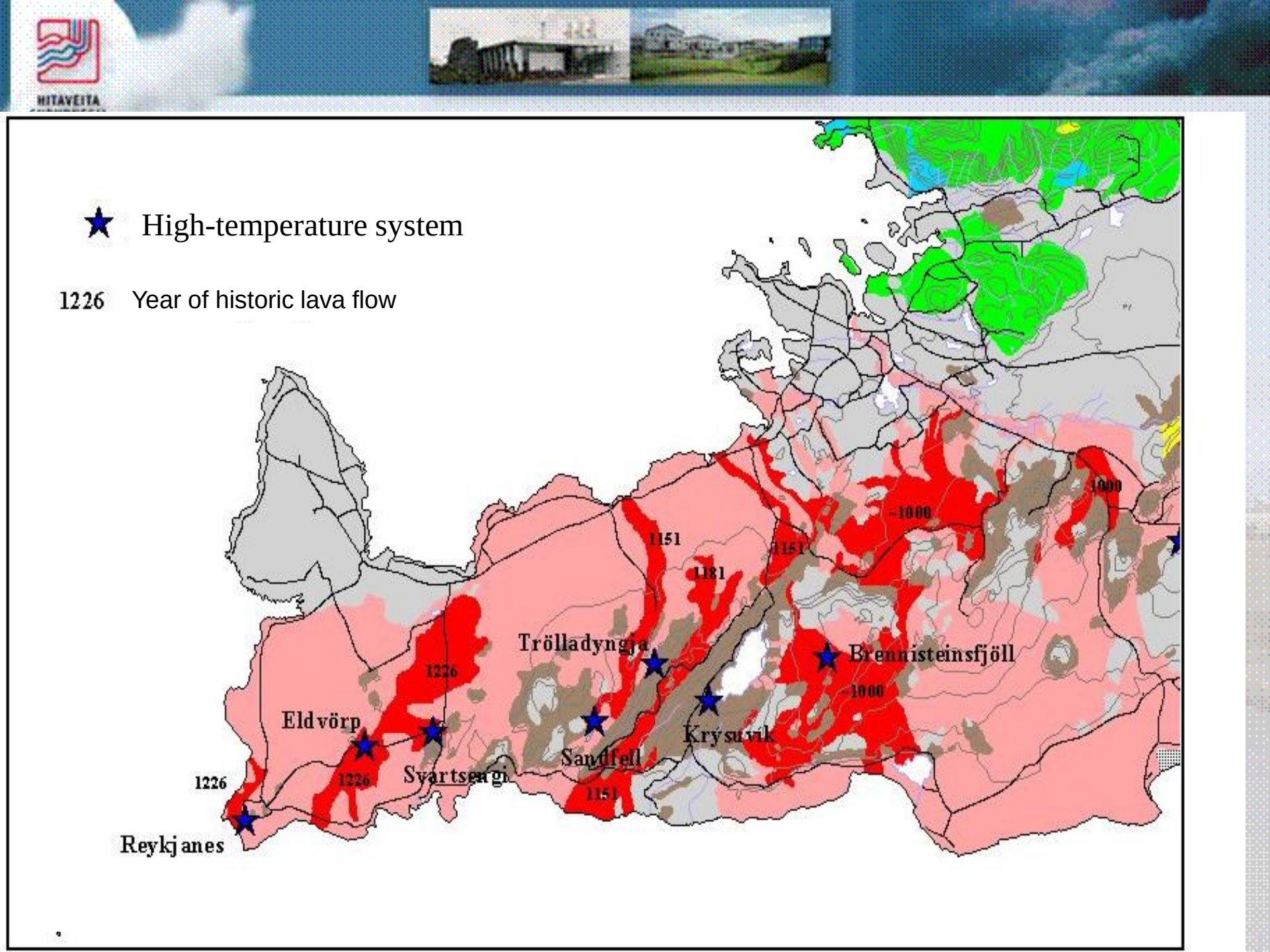
Verkís

Hitaveita Suðurnesja Geothermal Power Plants

- Svartsengi 1: 2 x 1 MWe og 50 MJ/s (decommissioned)
- Svartsengi 2: 75 MJ/s
- Svartsengi 3: 1 x 6 MWe
- Svartsengi 4 7 x 1,2 MWe
- Svartsengi 5: 1 x 30 MWe og 75 MJ/s
- Svartsengi 6: 1 x 30 MWe
- Reykjanes : 2 x 50 MWe

» Total: 324,4 MWe and MJ/s


High-temperature system
1226 Year of historic lava flow
Trölladyngja
Brennisteinsfjöll
Eldvörp
Svartsengi
Sandfell
Krýsuvík
Reykjanes
1226
1151
1181
~1000
1000

Geothermal Power Plant Main Parts

- Geothermal wells
- Well piping
- Separator station
- Steam piping
- Power station
- Steam turbine – Generator
- Cooling system
- Substation, switchyard
- High voltage line

Design tasks

- Mechanical (in approximate time sequence)
  - Preliminary Design: Concept design, dialogs between owner, designers and main machine producer
  - Process Flow diagram (PFD): Showing main equipment, connecting pipelines, valves, and flowrates
  - Process Instrument Diagram (PID): Similar to PID but with all instuments and their codes for function

Design tasks

- Mechanical, continued
  - Piping: Pipe dimensions, Pressure ratings, Design codes and standards, Safety , Pressure drop criteria and calculations
  - Power station Layout
  - Equipment submitted for tendering
  - Detail design

Design tasks

- Electical equipment
  - High Voltage
    - Single line diagram
    - Transformer specifications
    - Breakers specifications
    - Protection system specifications
  - Low voltage
    - Distribution cubicles
    - Cabling

Design tasks

- Control system
  - Control loops
  - Control equipment
    - Regulators
    - PLC computers
  - Remote monitoring
    - SCADA system
- Civil engineering
- Architectural drawings
- Landscape design

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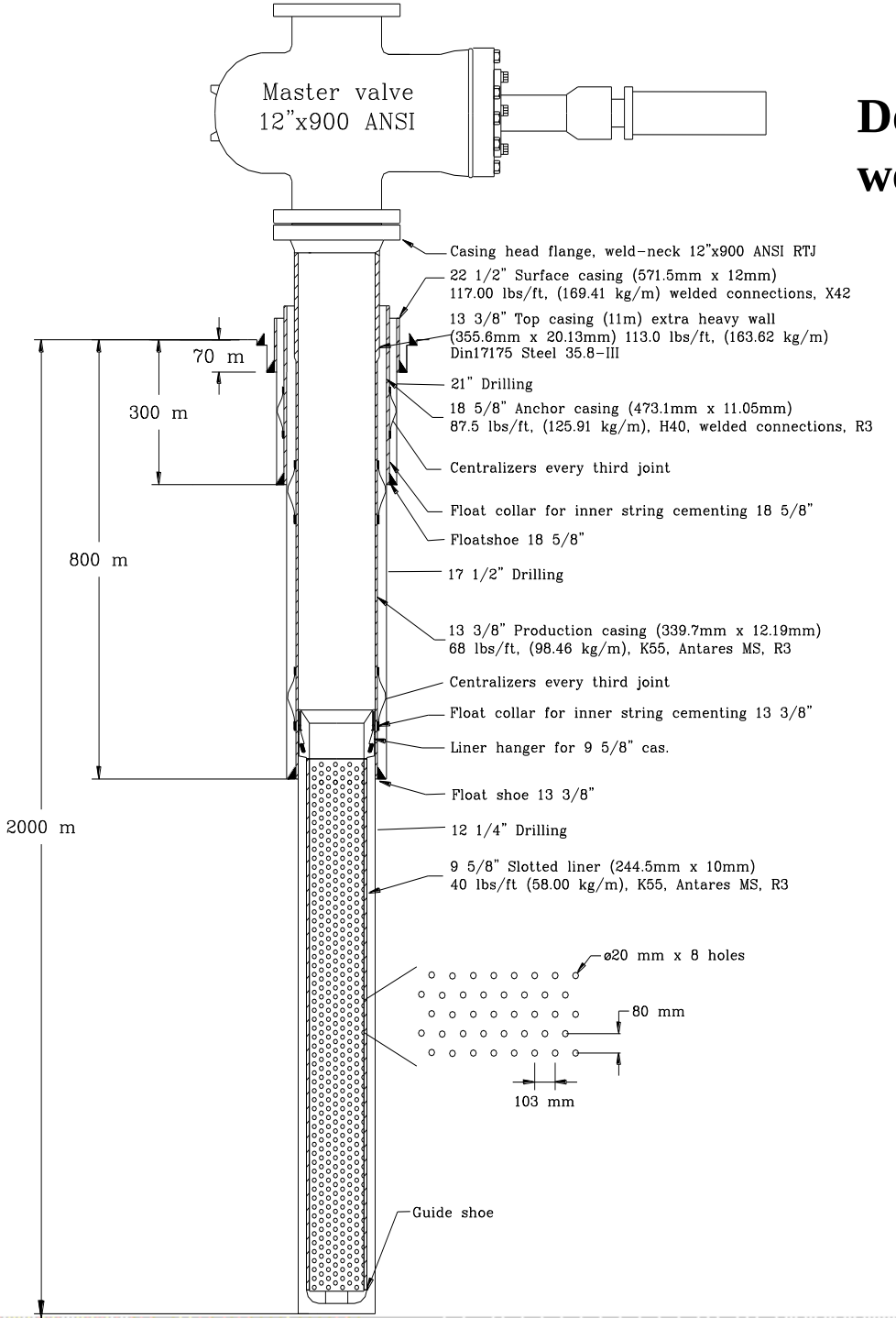
Design of a well



Geothermal wells

Problems in operation

- Scaling
- Corrosion
- Casing collapse
- Liner break
- Leaks
- Gas

Two Phase Pipelines

- Avoid slug flow
  - Incline two phase pipes down
  - Calculate the dimension of condensate pipe lines to ensure there is space for flash steam
- Keep them anchored

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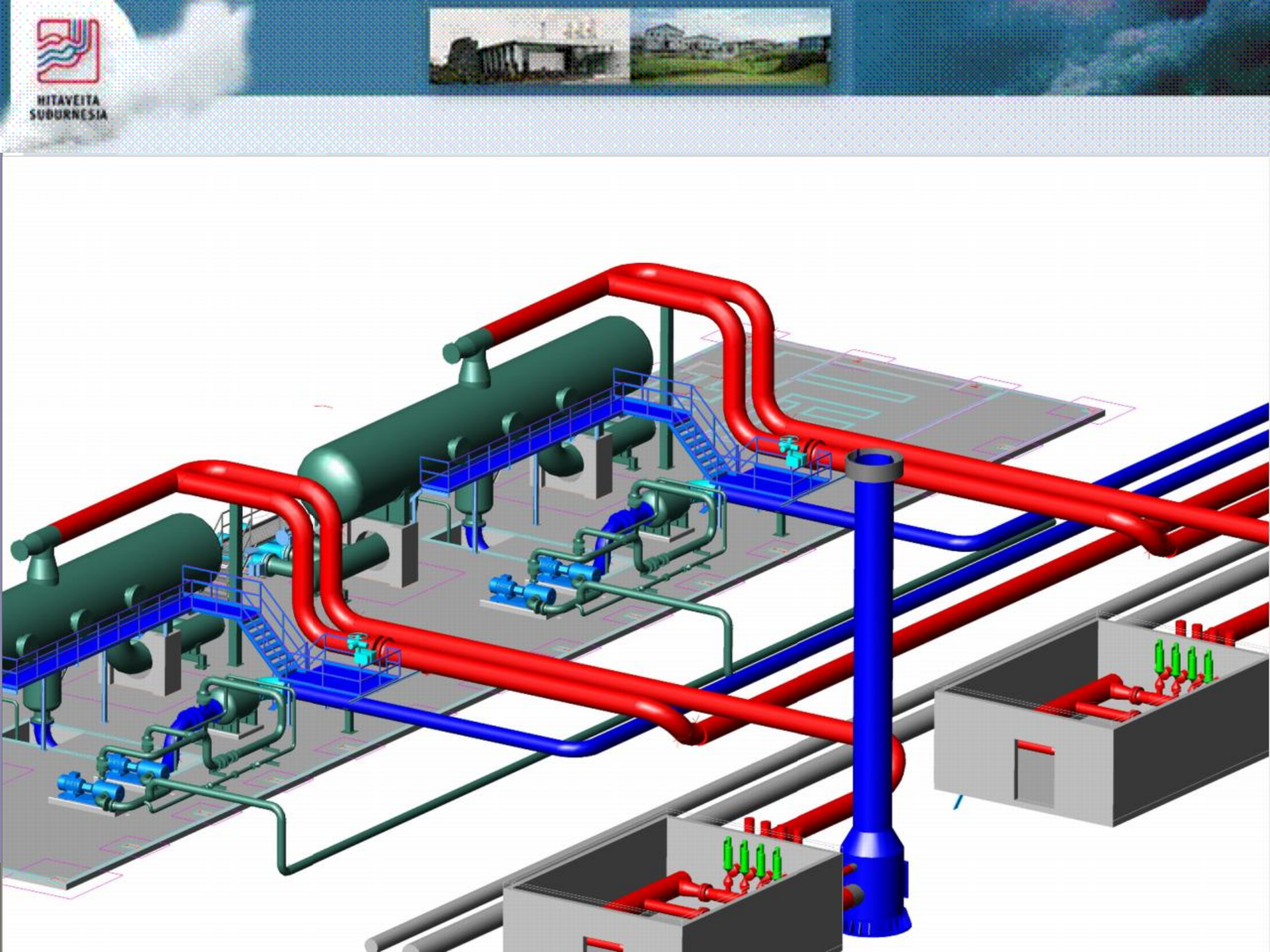
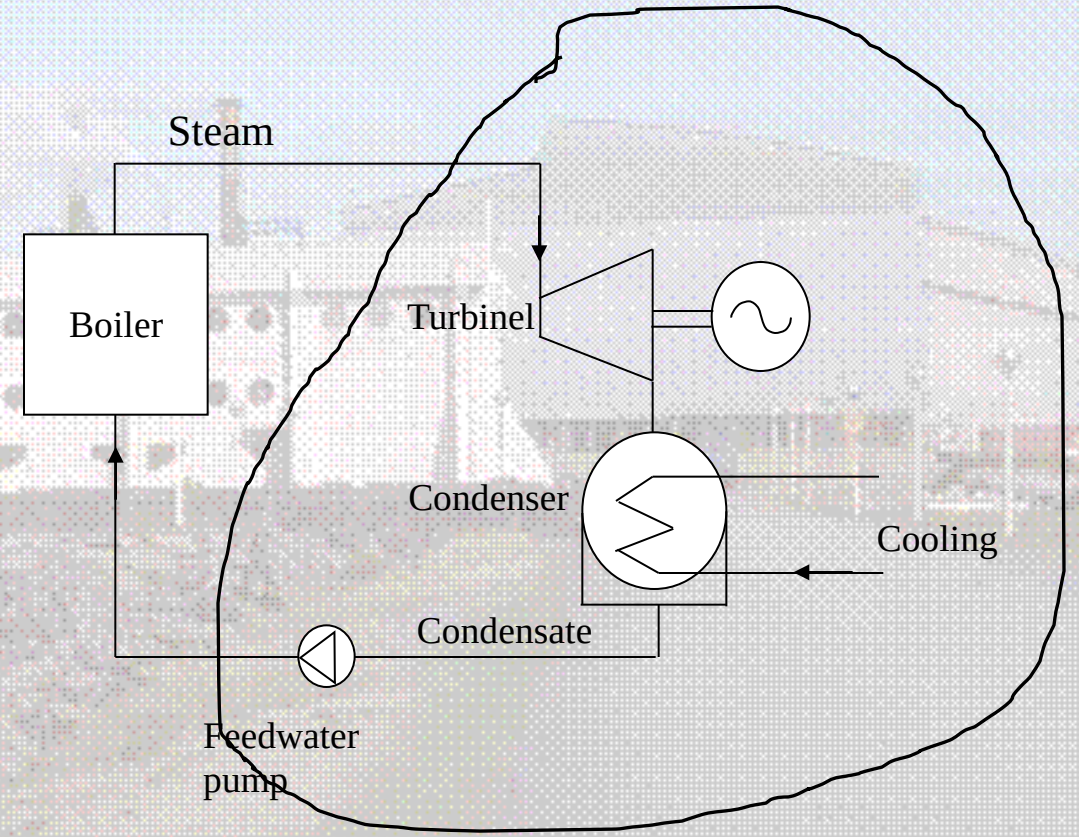
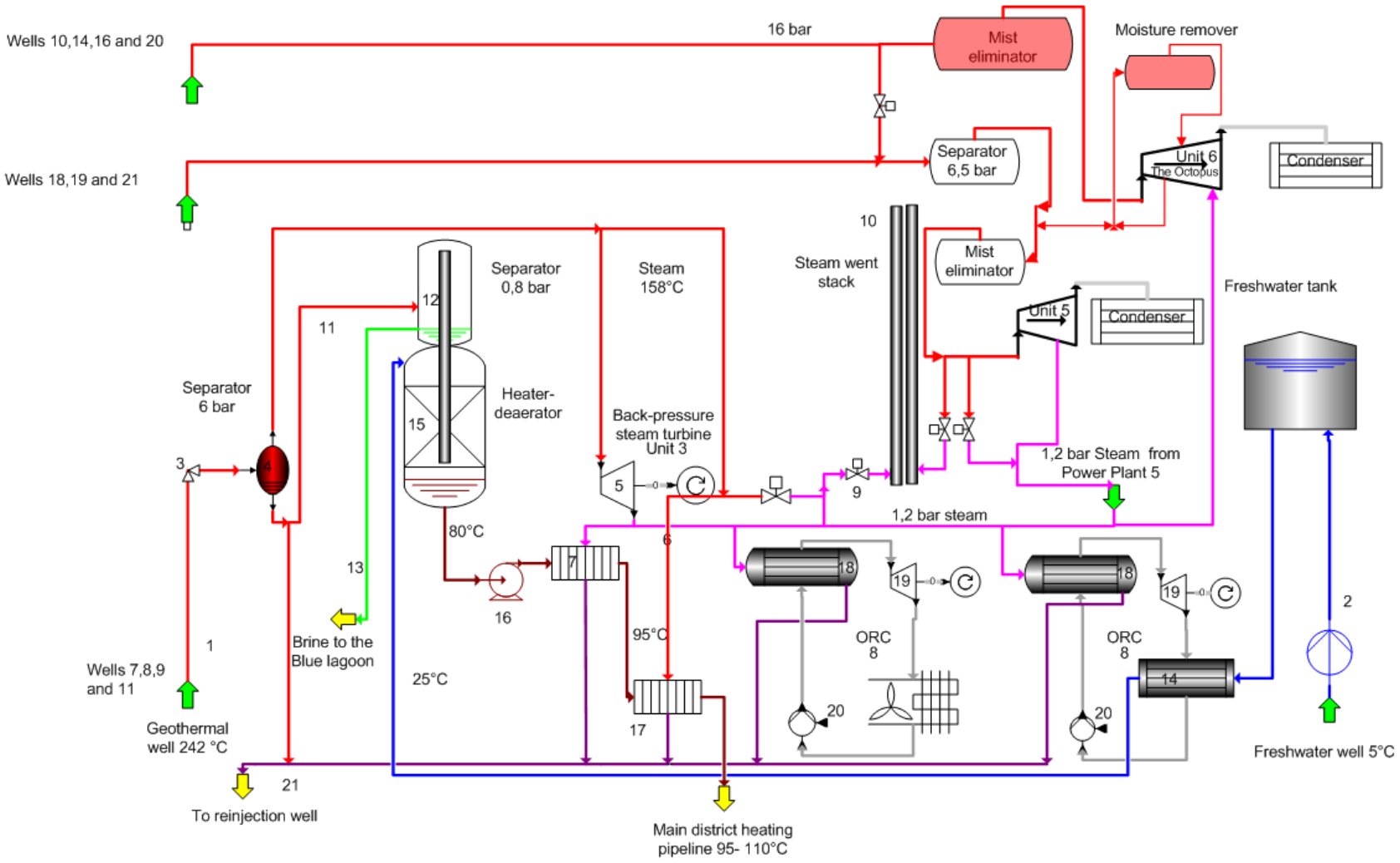


Rankine Cycle



Svartsengi – Single Line Diagram



Equipment design choices

- Separators: Vertical Cyclone or horizontal gravity?
- Separators on each wellpad or two phase flow pipeline to a central separator station?
- Length of main steam pipe?
- Impulse or reaction steam turbine?
- Cooling tower or natural cooling-water?
- Vacuum pumps: Steam ejectors, water ring pumps, or hybrid?

Reykjanes Plant separator

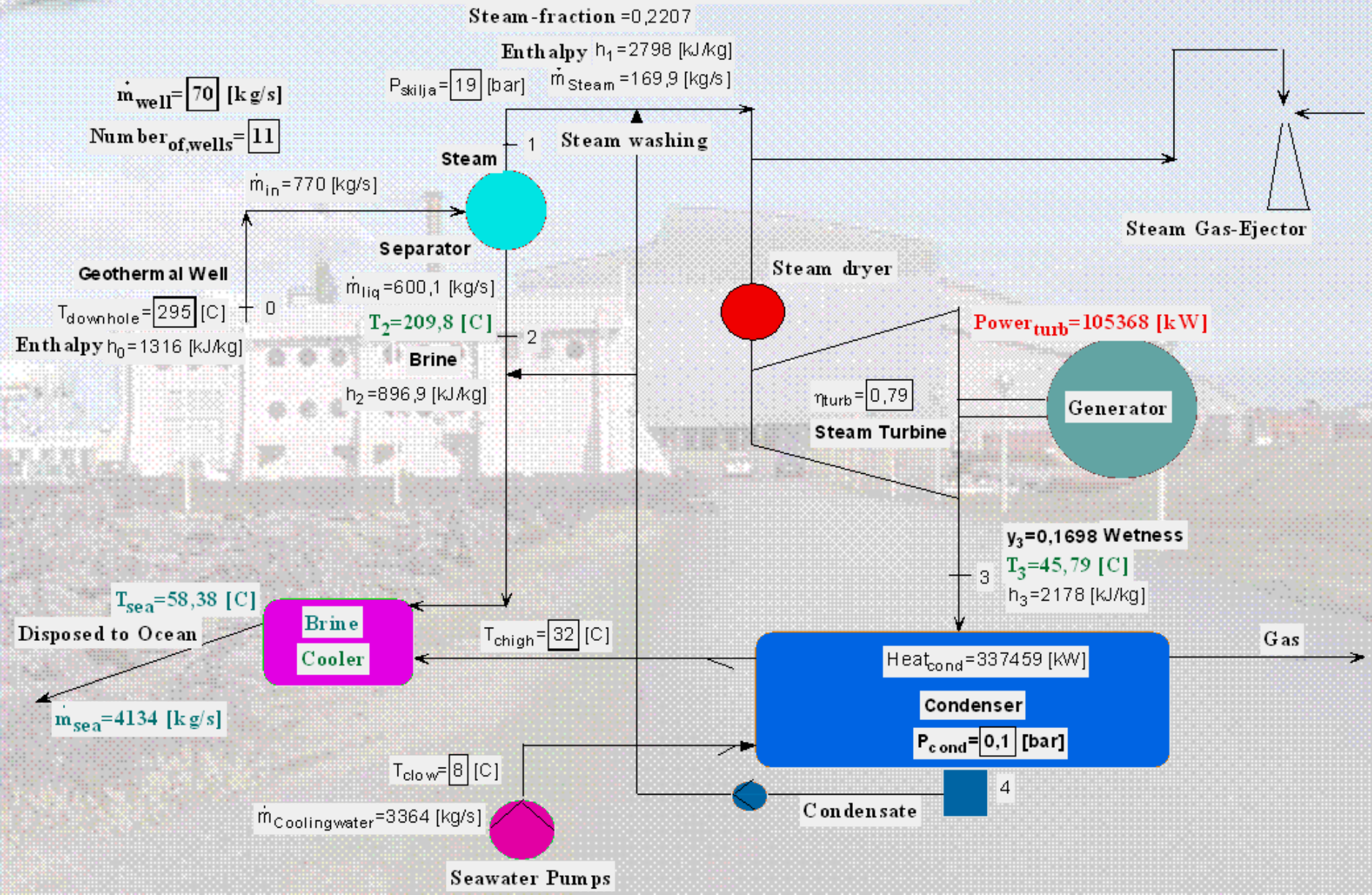
Reykjanes Principles

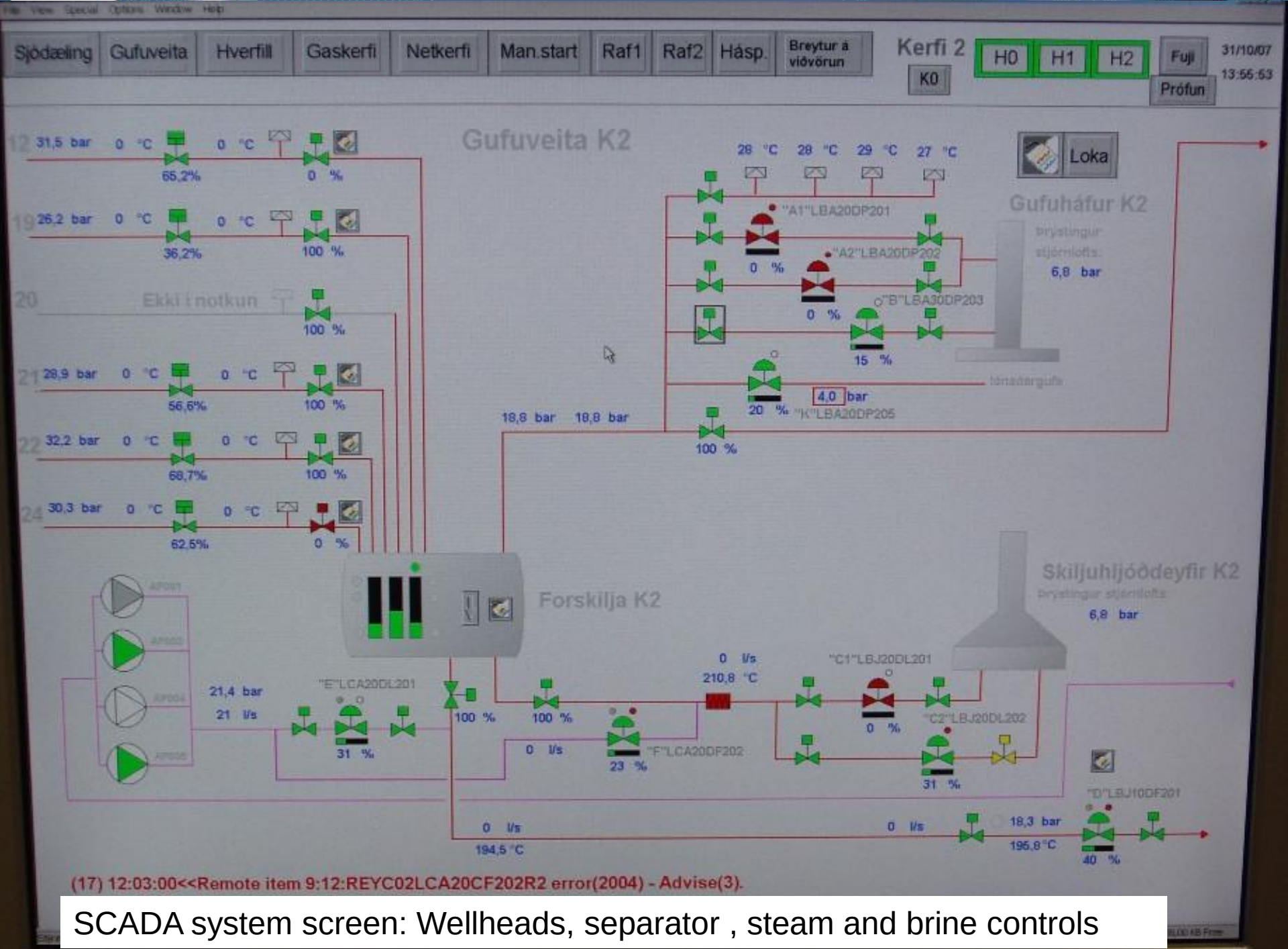
- High separator and inlet pressure to reduce scaling in separators
  - Steam wetness in low pressure stages is high, danger of erosion
- Double flow reaction turbines
  - Lower steam velocity reduces danger of erosion
- Seawater cooled condenser
  - Minumum steam and vapour plumes
- Remote monitoring and control
  - Lowers operation cost
- **Environmentally benign power plant**

Design Principles for Reykjanes

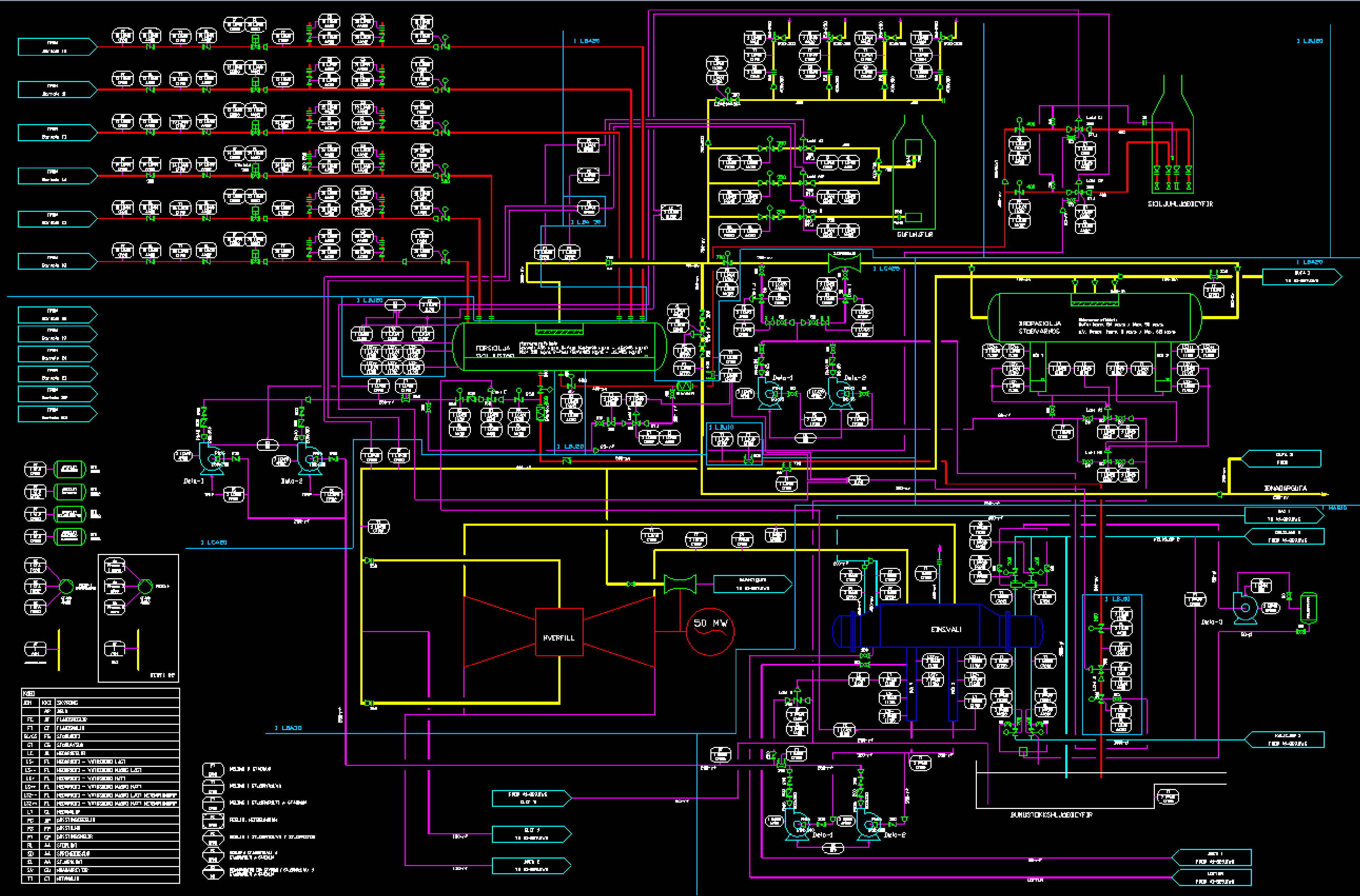
- Independent system for each unit, one separator, one moisture separator, one cooling system.
- Easy maintenance
- Ample maintenance space in power station
- Remote operation
- Quality steam

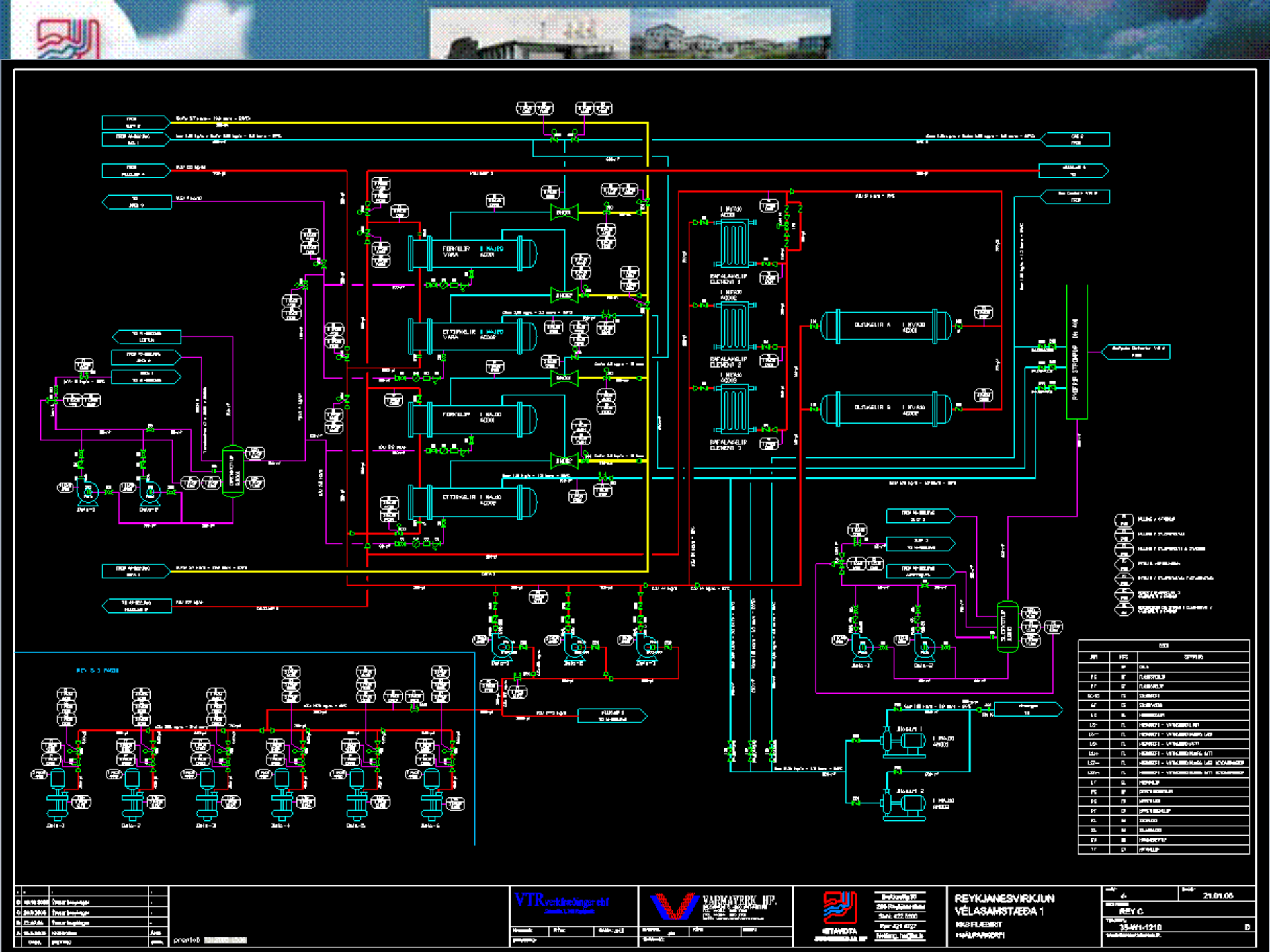
Reykjanes 2 x 50 MW Geothermal Flash Steam Power Plant

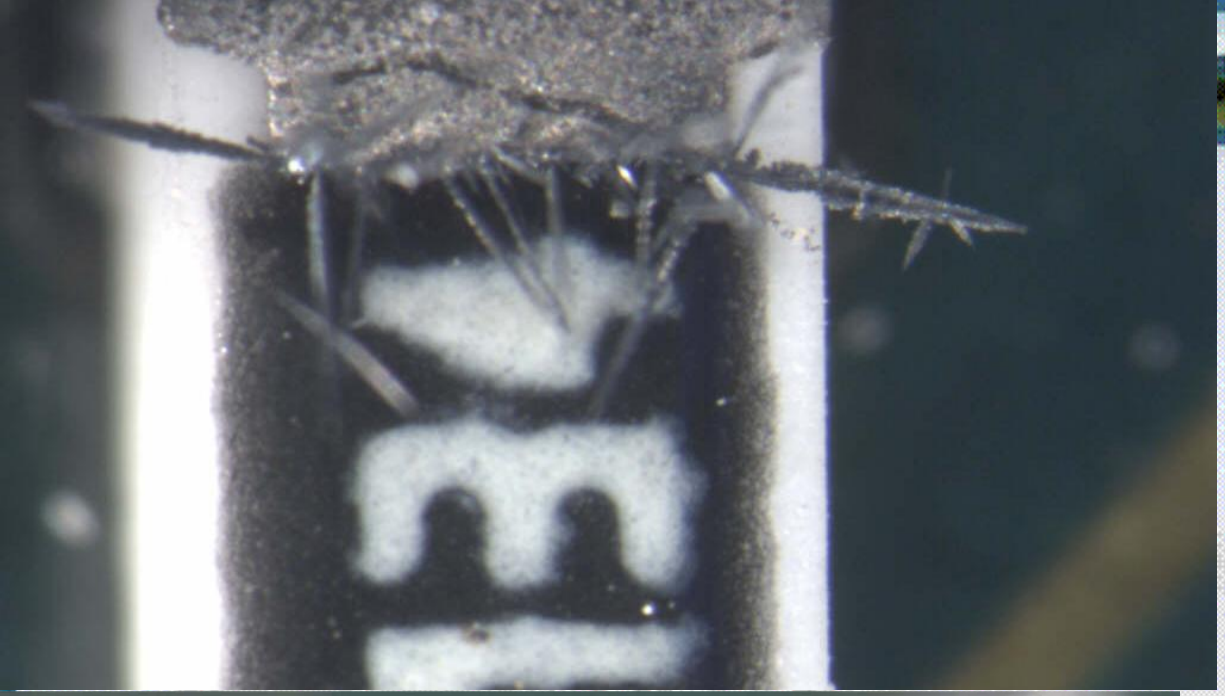


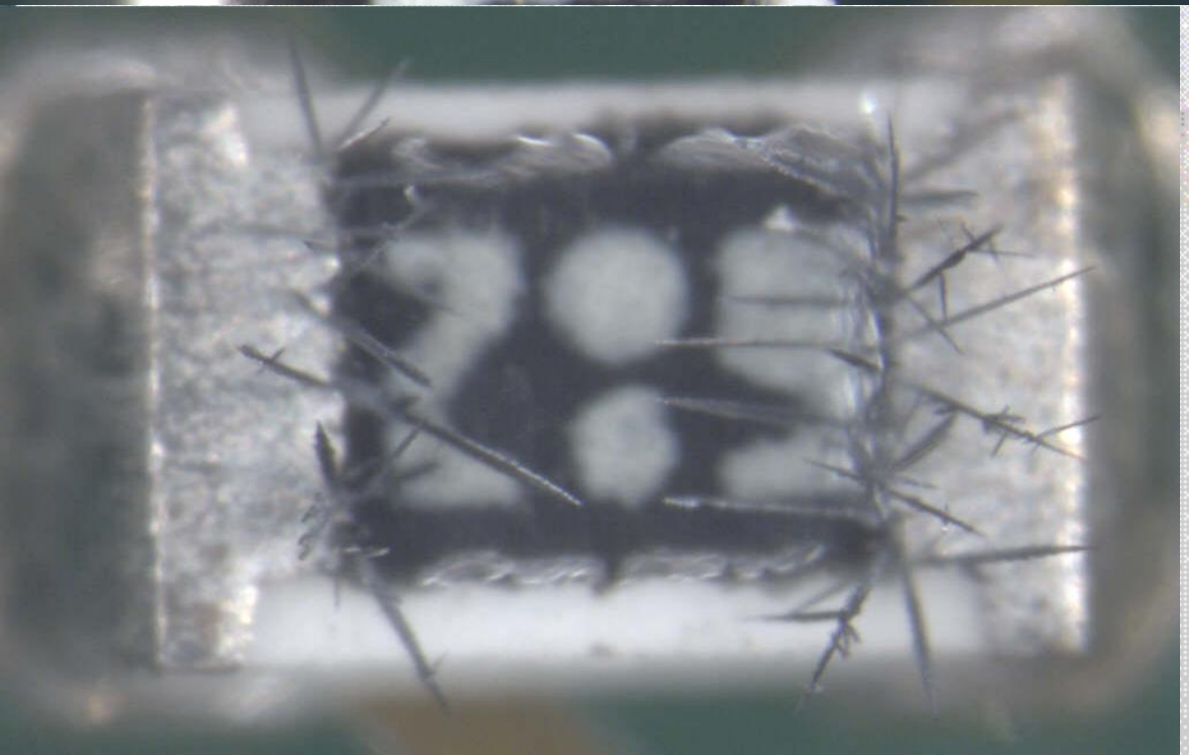


SCADA system screen: Wellheads, separator , steam and brine controls


HVERFILL
50 MW
EIMSVALI


REYKJANESVIRKJUN
VÉLASAMSTÆÐA 1
VTR verkfræðingar ehf
VARMAVERK HF.
21.01.05
REY C
33-441-1210
D





Silbersulfid-Kristalle auf Chip-Widerstand

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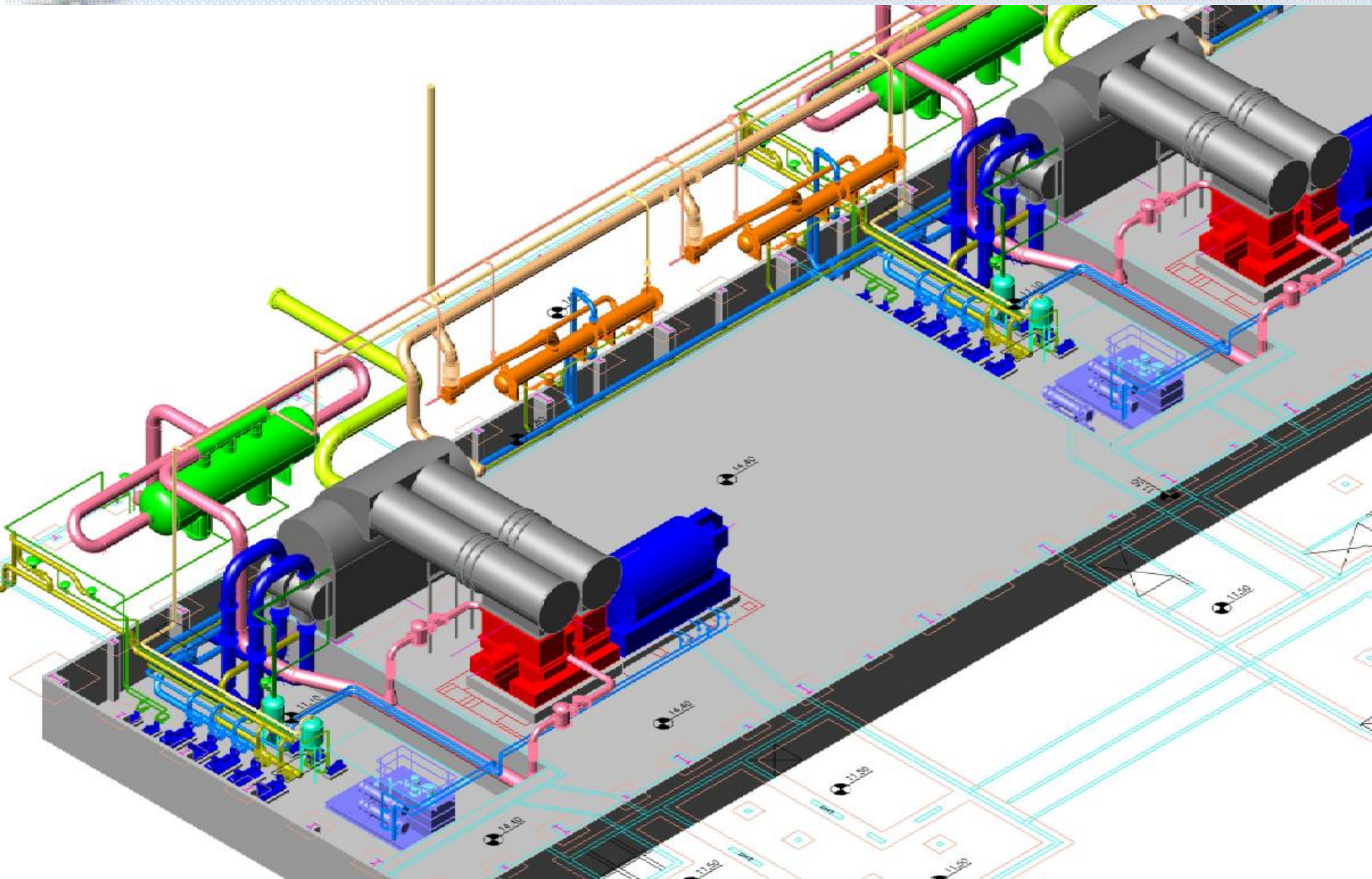
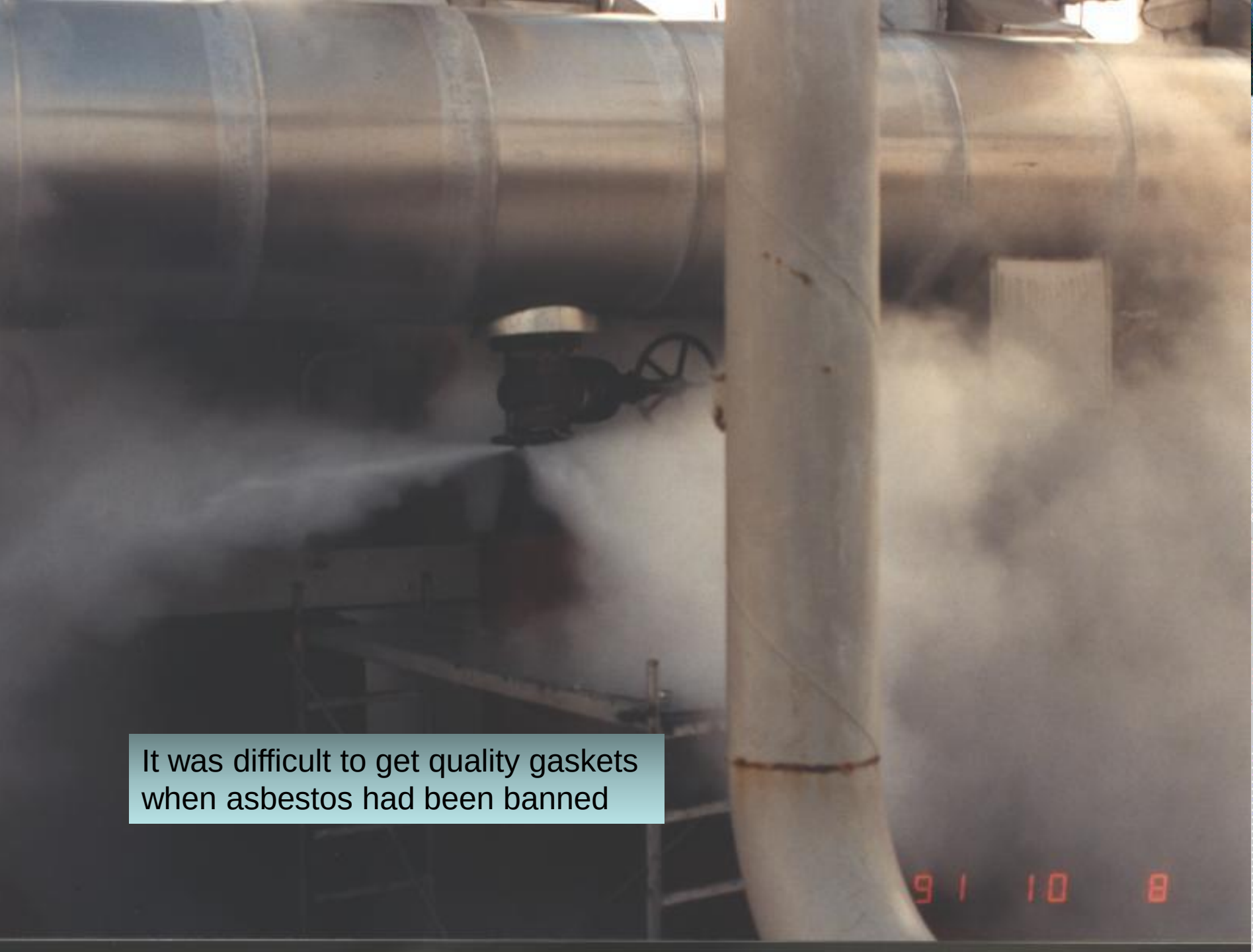
Reykjanes Power Station



Reykjanes condenser

Inside a condenser

Gas exhaust system: Steam ejectors and intercondensers



It was difficult to get quality gaskets when asbestos had been banned

Hydrogen sulphide can cause cracks in high manganese steel

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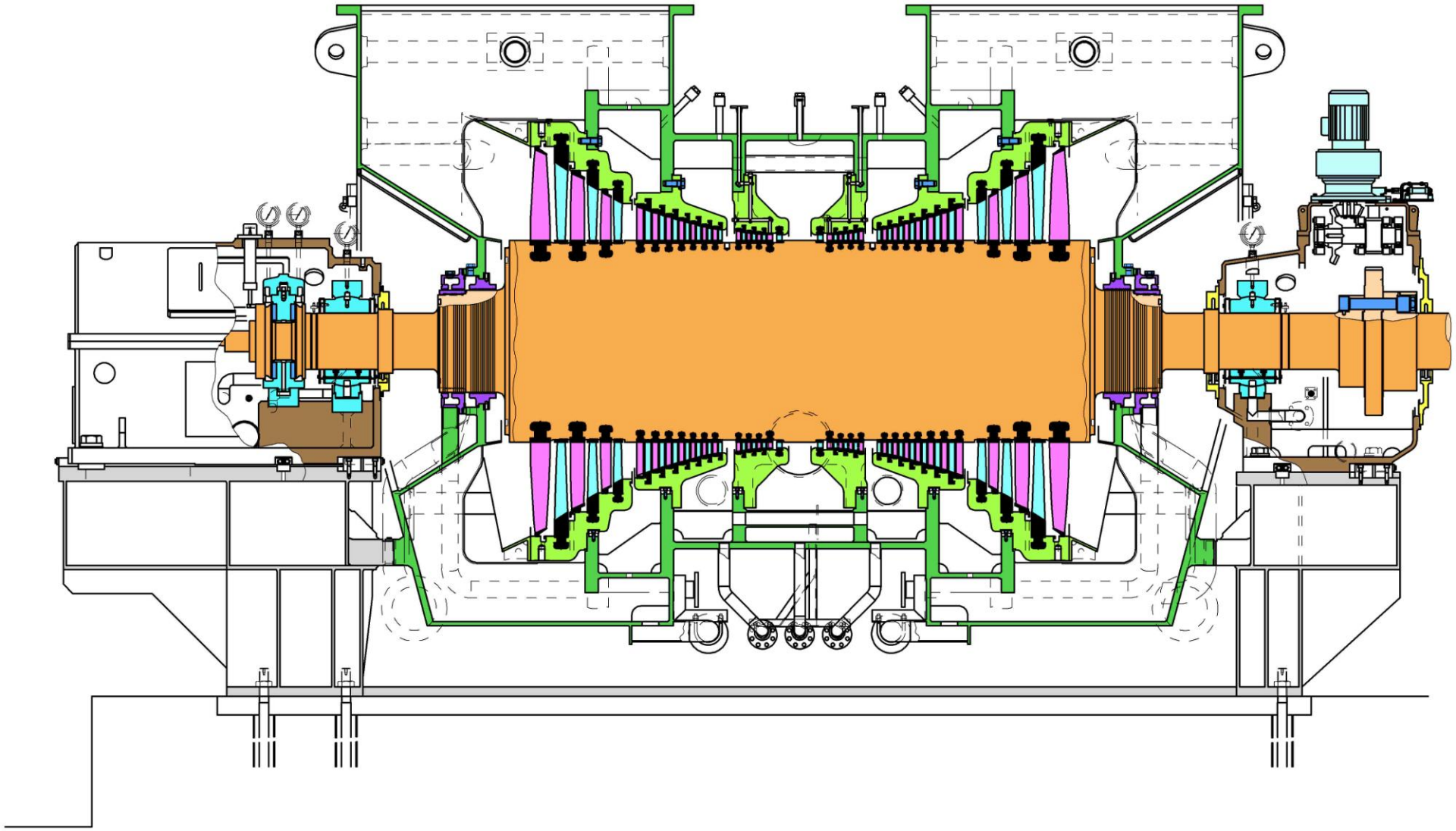
50 MW turbine, 80 kg/s, 18,0/0,1 bar




Snorkel


Drops from silencers are bad for
glass and glossy car surfaces


GRP (Glass Reinforced Plastic) piping must
be handled with care

Svartsengi 6 cooling tower. Ice may be a problem.

Remember

- Preserve exergy
- Avoid scaling
- Silica scaling starts at $T_{resevoir}$ – 100°C
- Vertical separators can be over-/underloaded
- Direct contact condenser can cause sulfur scaling in cooling tower and condensers
- Consult operating and maintenance staff


Everything clear?