

Mechanical equipment and operation and maintenance

Session VI

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Mannvit

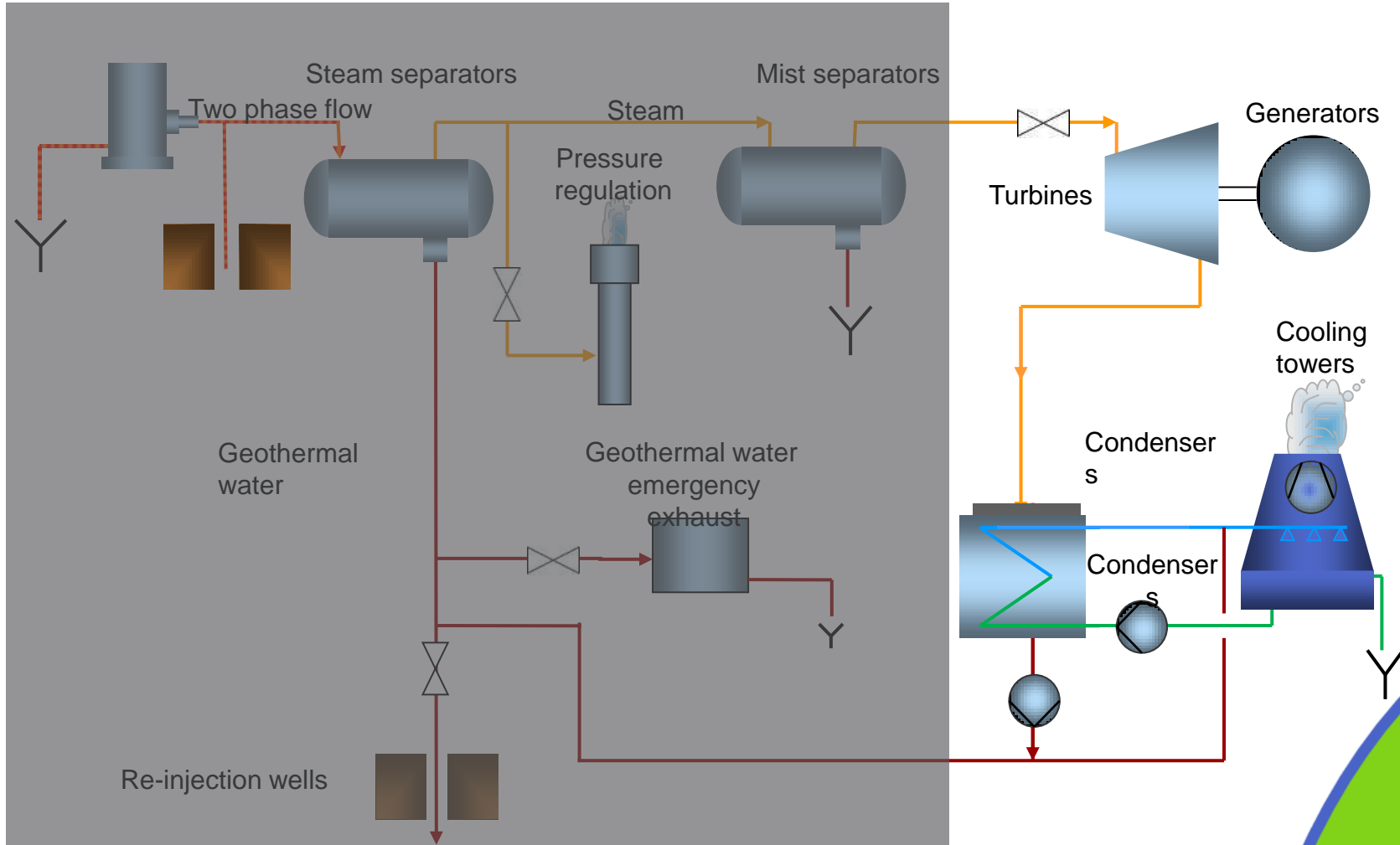
Strasbourg, Nov. 8th, 2012



Presentation overview

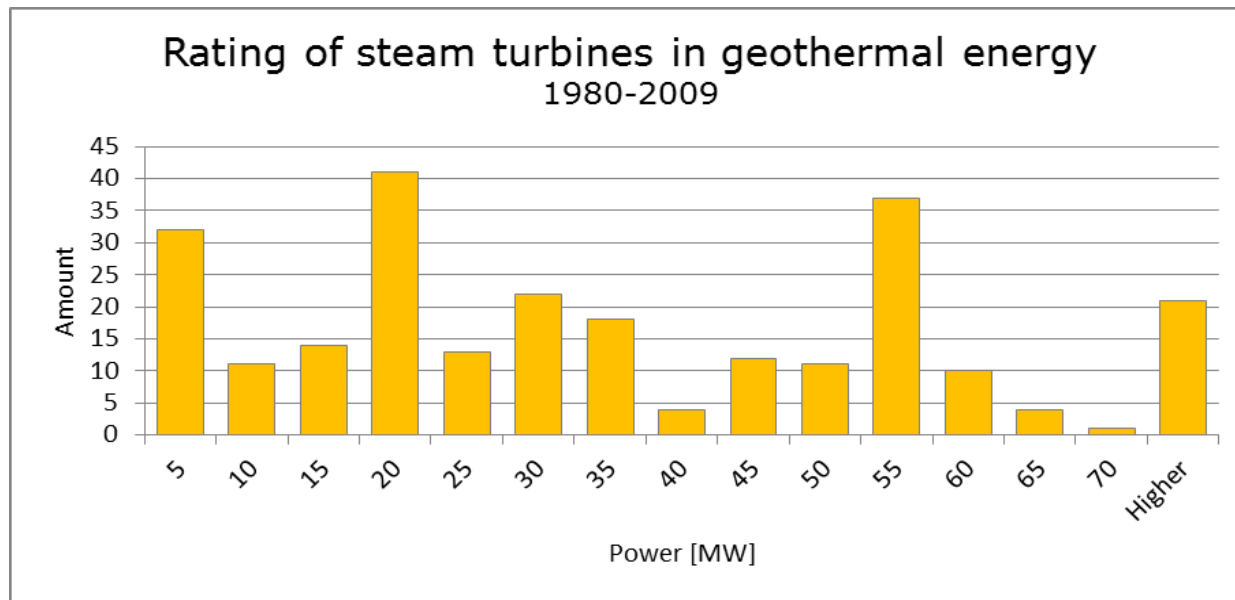
- Features of mechanical equipment used in geothermal power plants
- Example showing methods used for choosing a gas extraction system
- O&M with photographs of extreme conditions shown

Power Plant Preliminary P&ID



Power Plant - Turbine

- Axial turbines
 - Single flow
 - Double flow
- Turbo expander



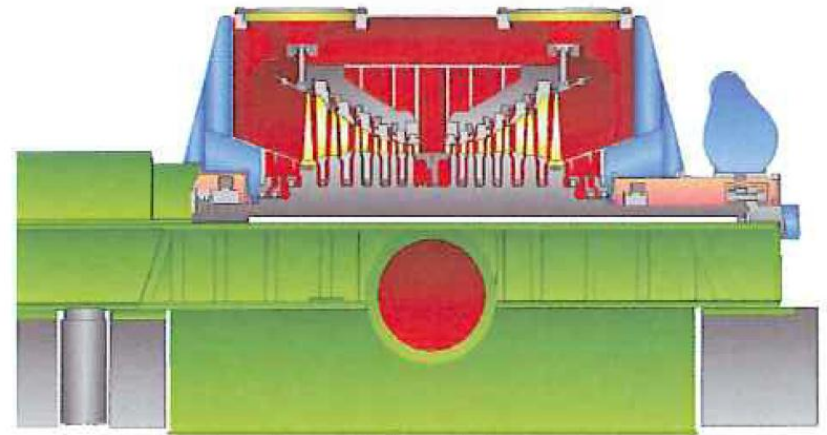
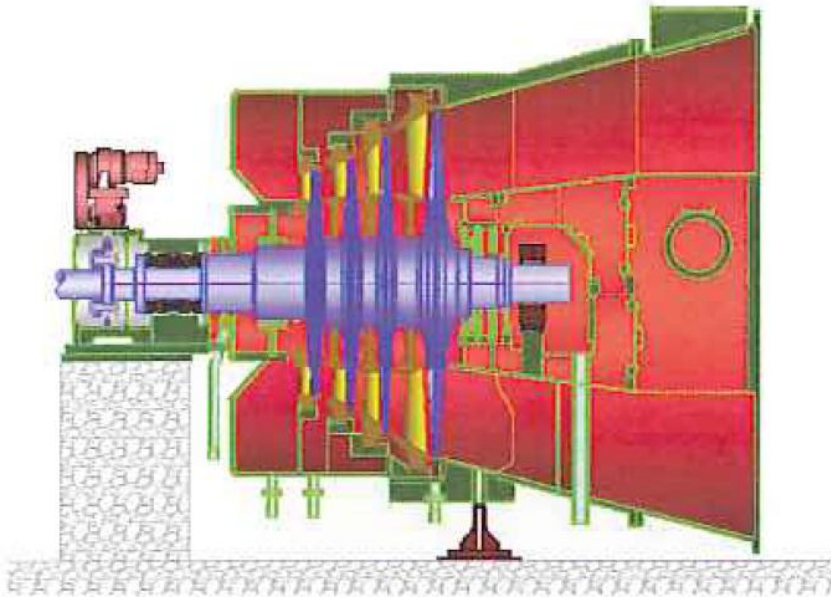
Single and double flow turbines

single flow

20 - 70 MW

Double flow

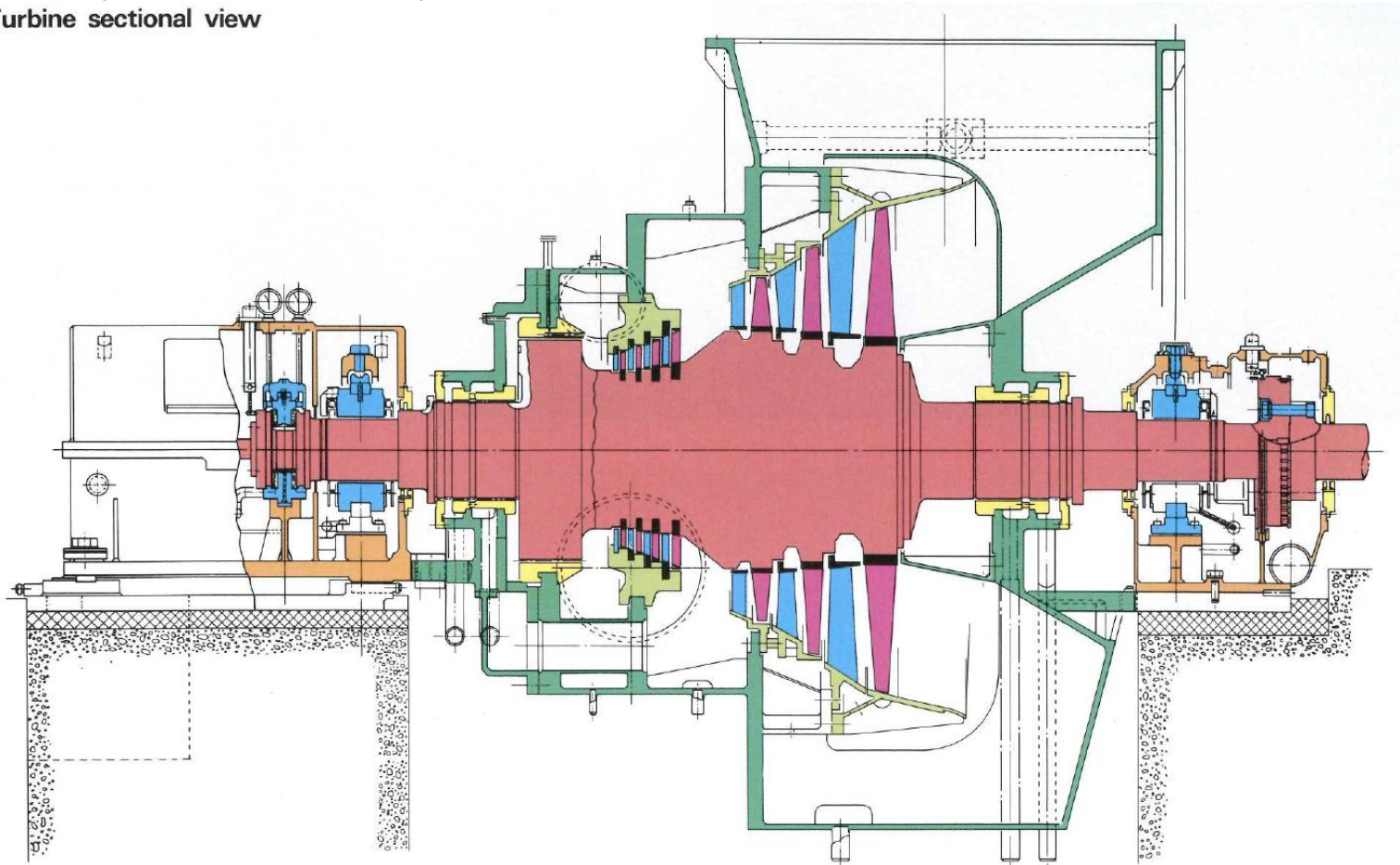
40 - 140 MW



Double pressure

6,3/1,4 bara -> 0,1 bara

Turbine sectional view

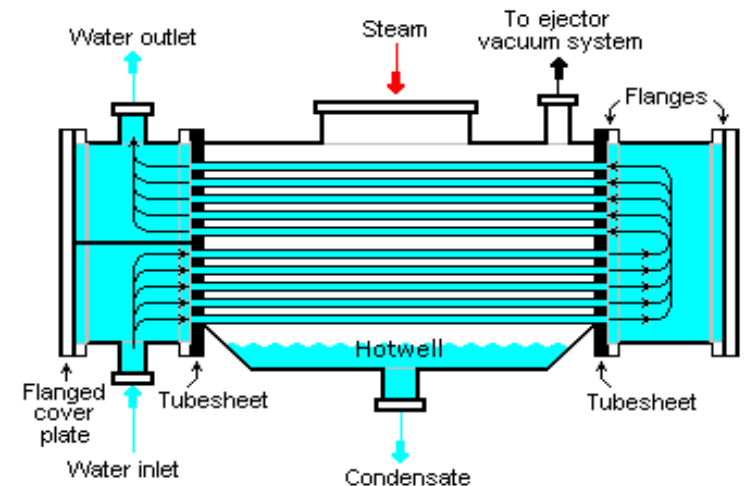
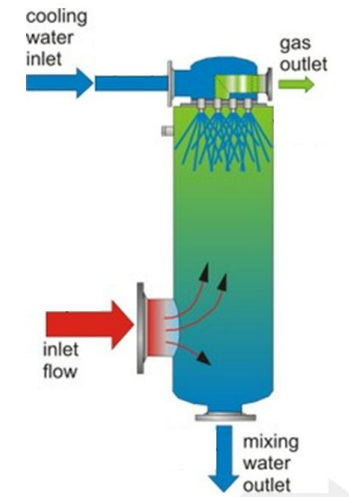


Power Plant – Turbine / generator

- Rotor
 - Turbine blade size is over 30"
 - Corrosion protection on the last stages
- Turbine drain
- Double steam inlet – Stem free test
- Generator
 - Overpressure in generator housing

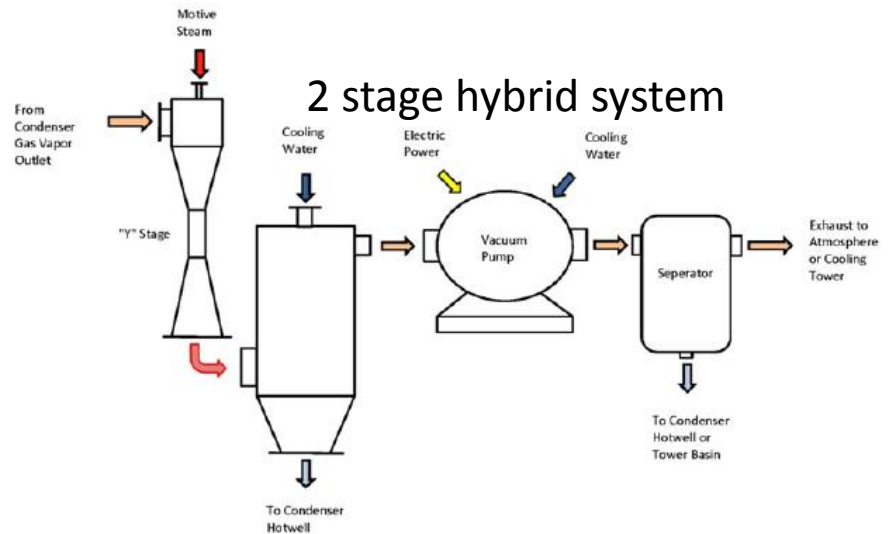
Power Plant - Heat Exchangers

- Evaporators/recuperators
 - Conventional shell and tube or plate heat exchangers
 - Hybrid
- Condensers
 - Direct contact
 - Indirect contact
 - Shell and tube
 - Special cooling section for gas



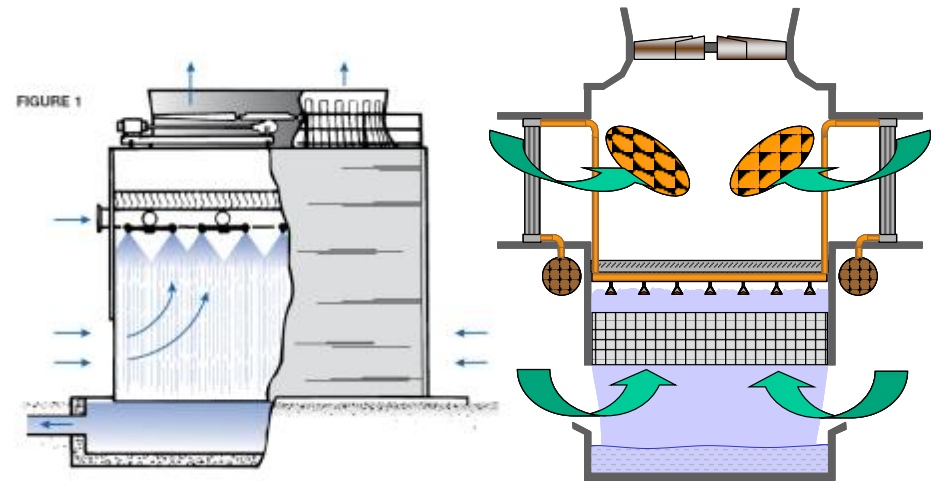
Power Plant - Gas extraction system

- Type
 - Compressors
 - Vacuum pumps
 - Ejectors
- Selection
 - Gas content
 - Condenser pressure
 - Cost evaluation
 - Price of electricity/steam



Power Plant - Cooling Tower

- Type
 - Wet
 - Hybrid
 - Dry
- Selection
 - Cost efficiency
 - Availability of water
 - Visual impact



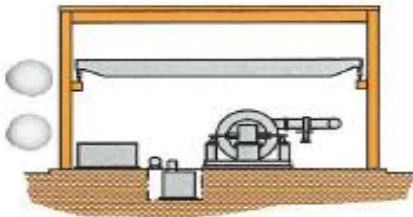
Wet CT

Hybrid CT

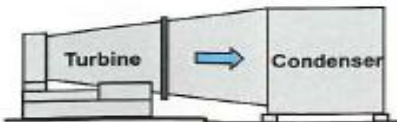
Power Plant - Layout

Axial Exhaust

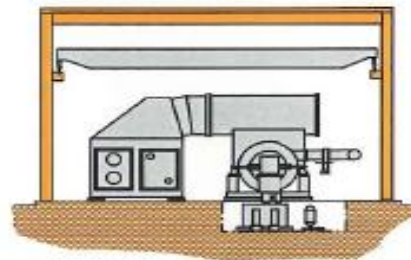
- Total concrete required and complexity of the foundation design are also significantly reduced



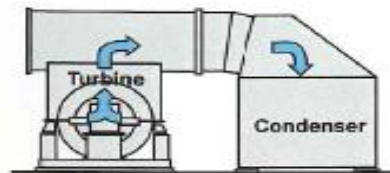
- Axial diffuser effectively transforms exhaust velocity into pressure, thereby minimizing exhaust loss



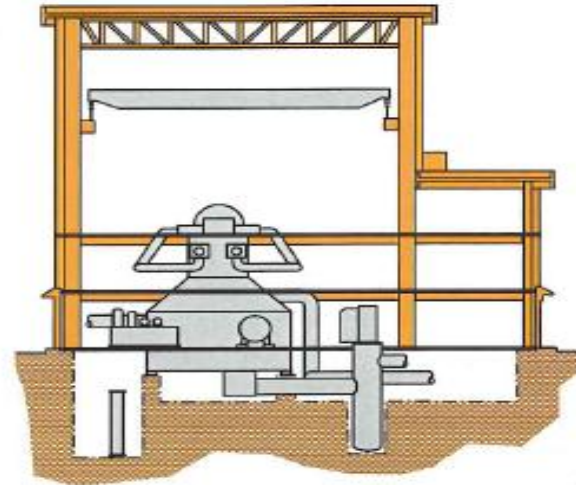
Top Exhaust



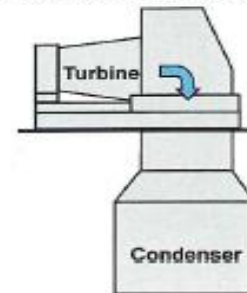
- Triple turning of the exhaust flow creates the biggest loss



Down Exhaust

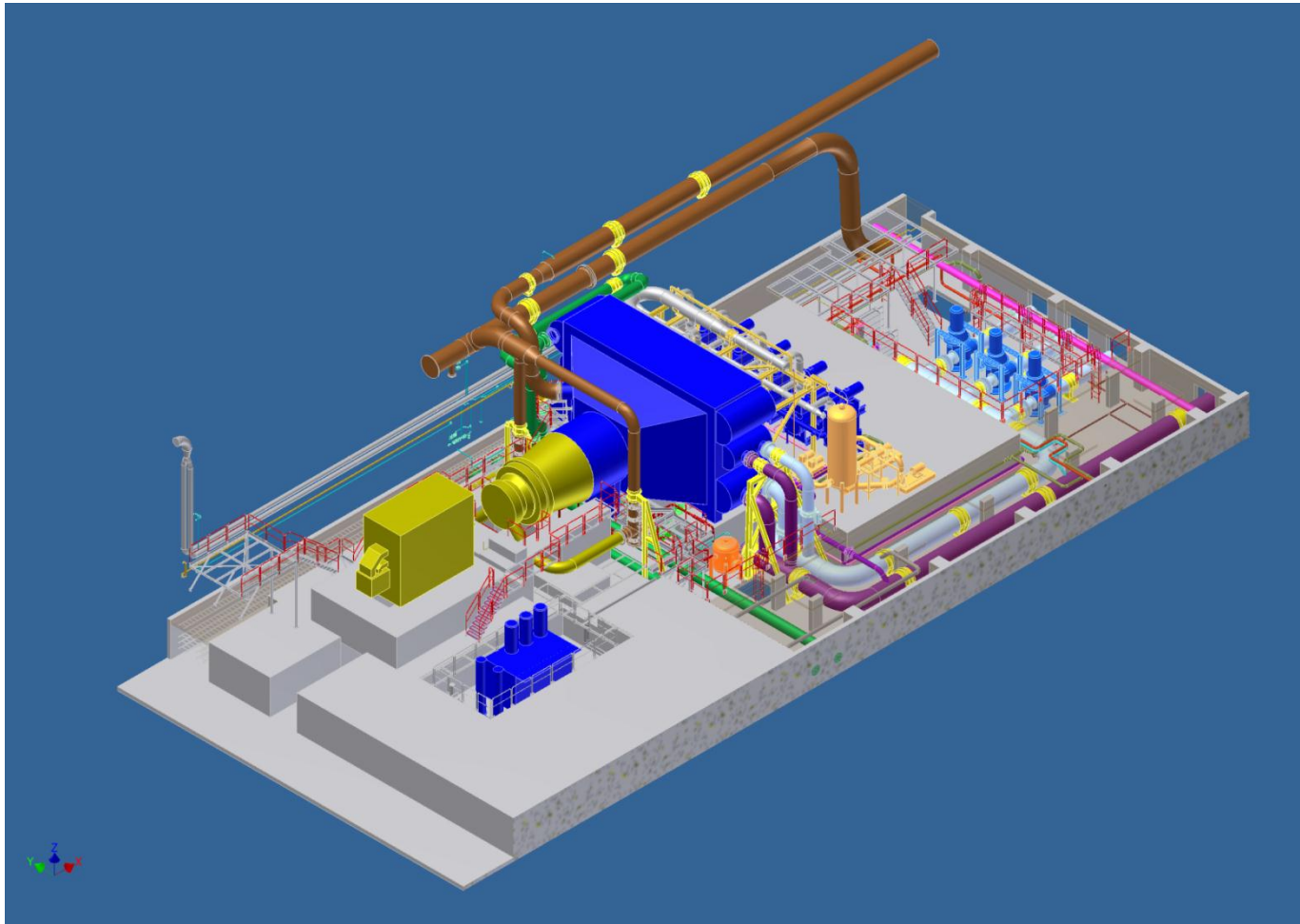


- Conventional design with single turning produces moderate exhaust loss





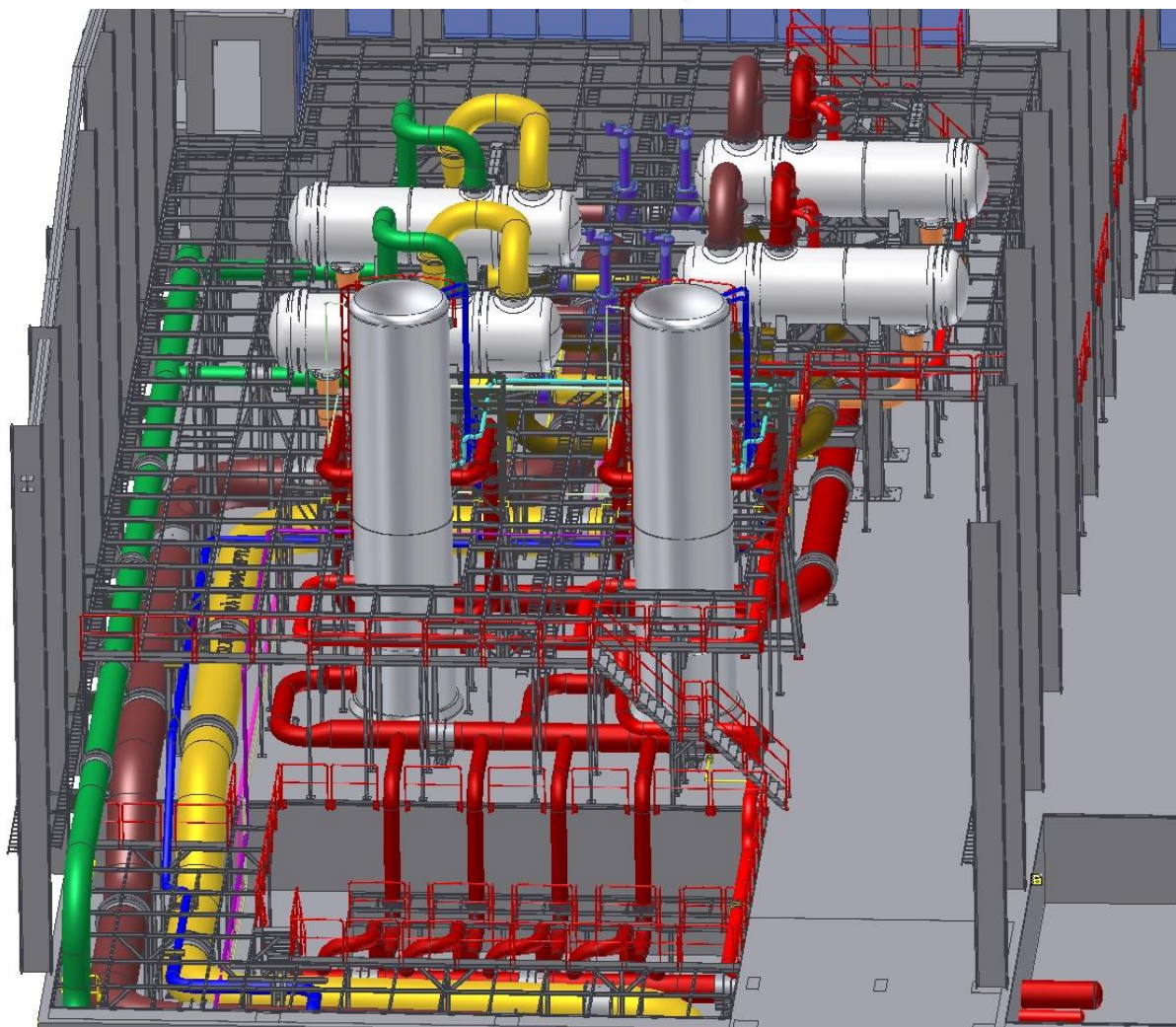
Layout – 45 MW unit at Hellisheiði



Power Plant – Building

- Turbine hall
 - Conventional steel structure
- Connecting buildings
 - Housing electrical rooms
 - Concrete building to achieve higher tightness
- Earthquake requirements

Layout – 133 MW hot water plant at Hellisheiði



Example

- Selection of gas extraction system
- Assumptions
 - Gas content 1% gas
 - Steam consumption 83 kg/s
 - Price of steam 500.000 EUR/kg/s
 - Price of electricity 300.000 EUR/100 kW

Example, continued

- Vacuum pumps
 - Electrical consumption 1200 kW
 - Capital cost 400.000 EUR
- Ejectors
 - Steam consumption 5 kg/s
 - Capital cost 100.000 EUR
- Hybrid system
 - Electrical consumption 300 kW
 - Steam consumption 2 kg/s
 - Capital cost 200.000 EUR

Example, continued

- Evaluation formula
 - $CC + EC * PE + SC * PS$
 - Capital Cost (CC)
 - Electrical Consumption (EC)
 - Price of Electricity (PE)
 - Steam Consumption (SC)
 - Price of Steam (PS)

- Vacuum pumps:
 - $400.000 + 1200 * 300.000 / 100 = 4.000.000$ EUR
- Ejectors
 - $100.000 + 5 * 500.000 = 2.600.000$ EUR
- Hybrid system
 - $200.000 + 2 * 500.000 + 300 * 300.000 / 100 = 2.100.000$ EUR
- Hybrid system would be selected.

Please note that numbers are fictive.

Operation and maintenance

- In this session operation and maintenance of geothermal power plants with emphasis on the geothermal part of the plant is introduced. Photographs of extreme conditions will be shown.

Geothermal Power Plants

Included in Operation & Maintenance

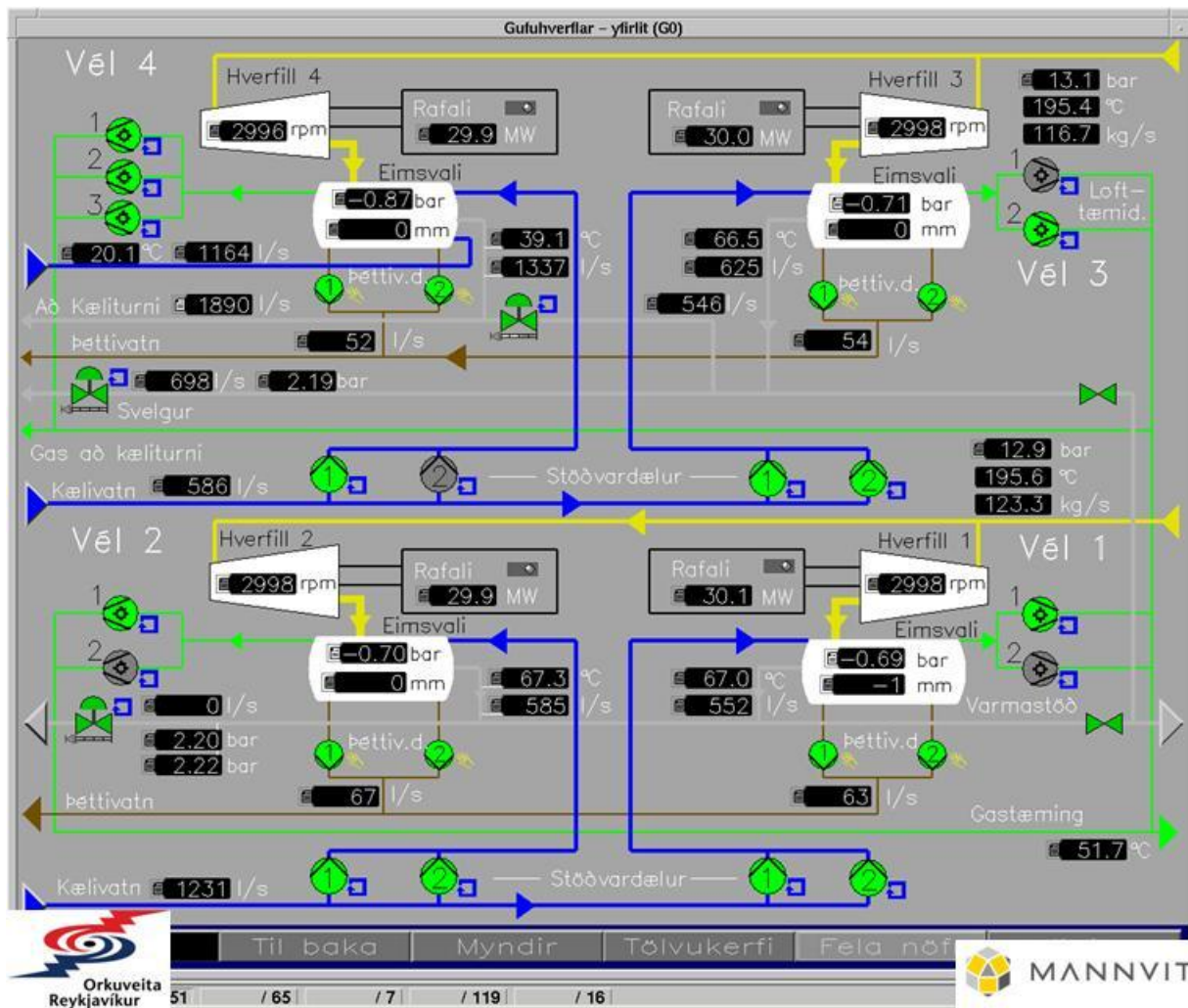
- Central operation centers
- Observation of machinery
- Security
- Operation supplies (chemical for cooling water, inhibitors, oil, filters for air cleaning, cleaning products, binary fluid)

Geothermal Power Plants

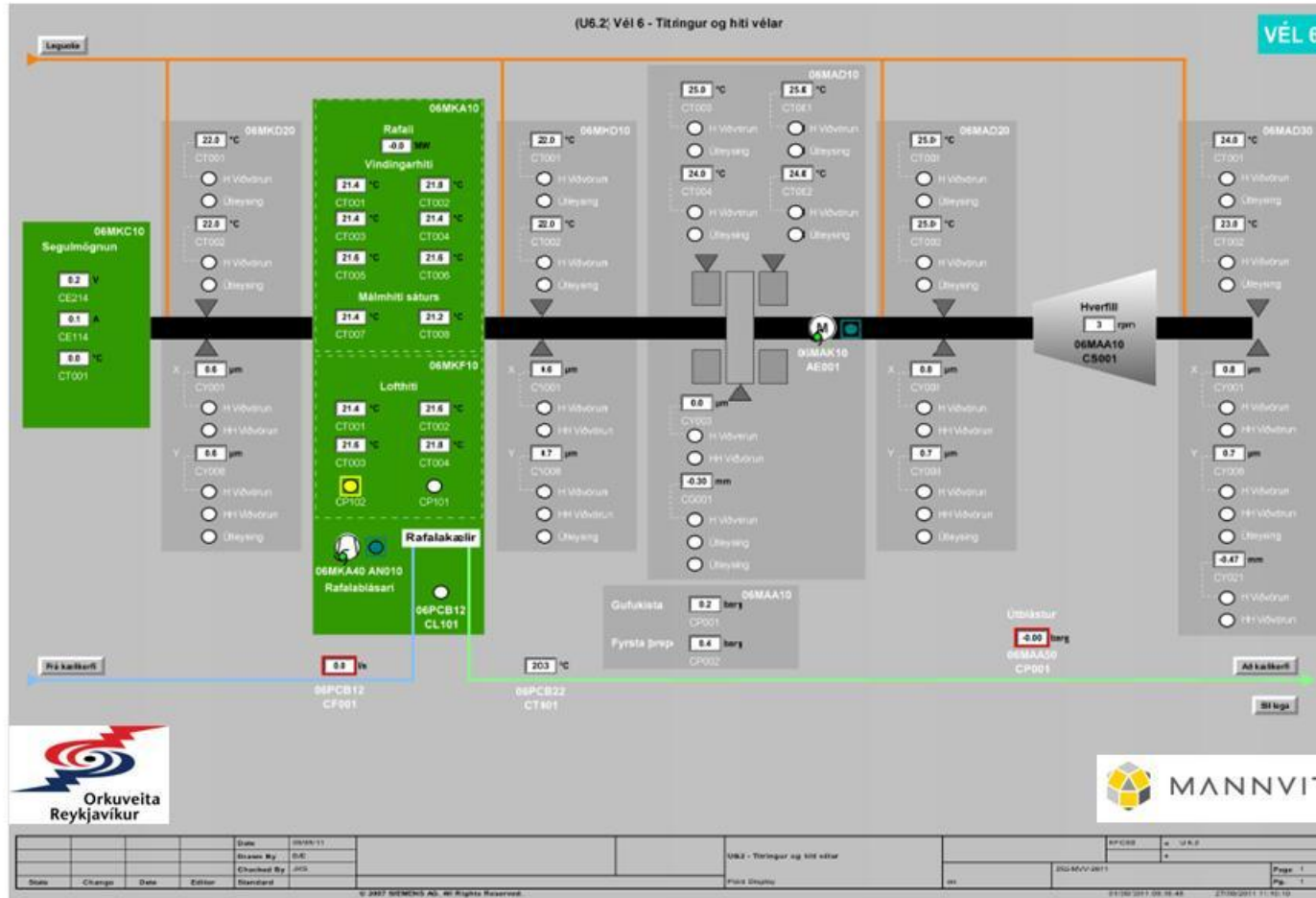
Operation & Maintenance

- Maintenance – work (rotor and generator every 15 years)
- Maintenance – supplies
- Monitoring of the reservoir and area
- Drilling for maintaining steam

Operating Console



Turbine Monitoring



Wellhead



Enclosure Wellheads



Leakage in Wellhead



Leakage in Wellhead



Leakage in Wellhead



Leakage in Wellhead



Leakage in Wellhead



Well Discharge in Winter



Well Discharge in Winter



Wellhead Master Valve



Well Cleaning during Discharging



Steam Separator for 60 kg/sek



Cooling Tower in Winter



Turbine Rotor



Cleaning of Rotor



Scaling on Rotor



Scaling in Stationary Diaphragms



Erosion in Stationary Diaphragms



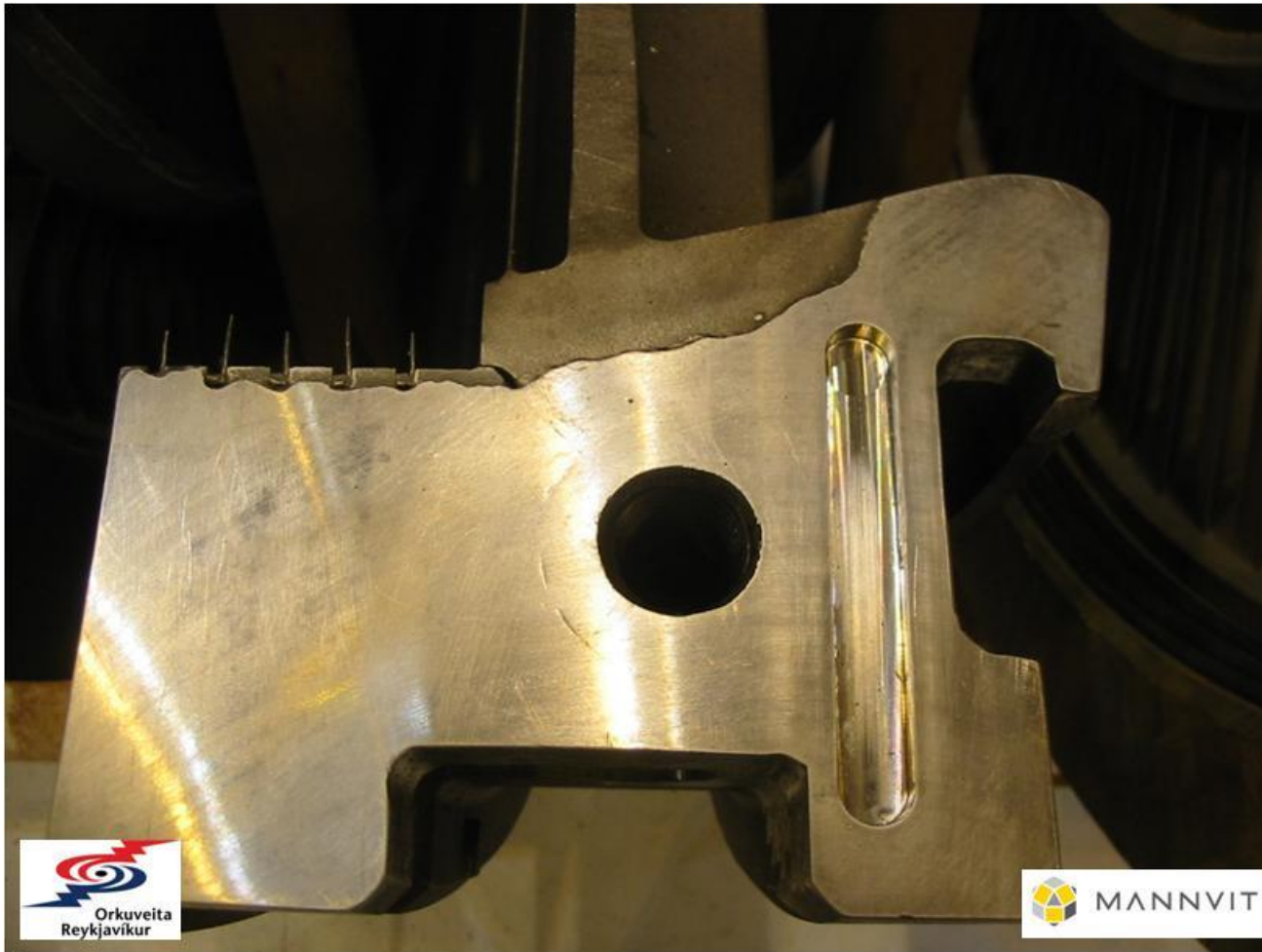
Erosion in Stationary Diaphragms



Erosion in Stationary Diaphragms



Diaphragm Repaired by Welding



Diaphragms Repaired by Welding



Erosion of Rotor



Damages Caused by Drainage



Improvement of Drains in Turbine



Drains in Turbine



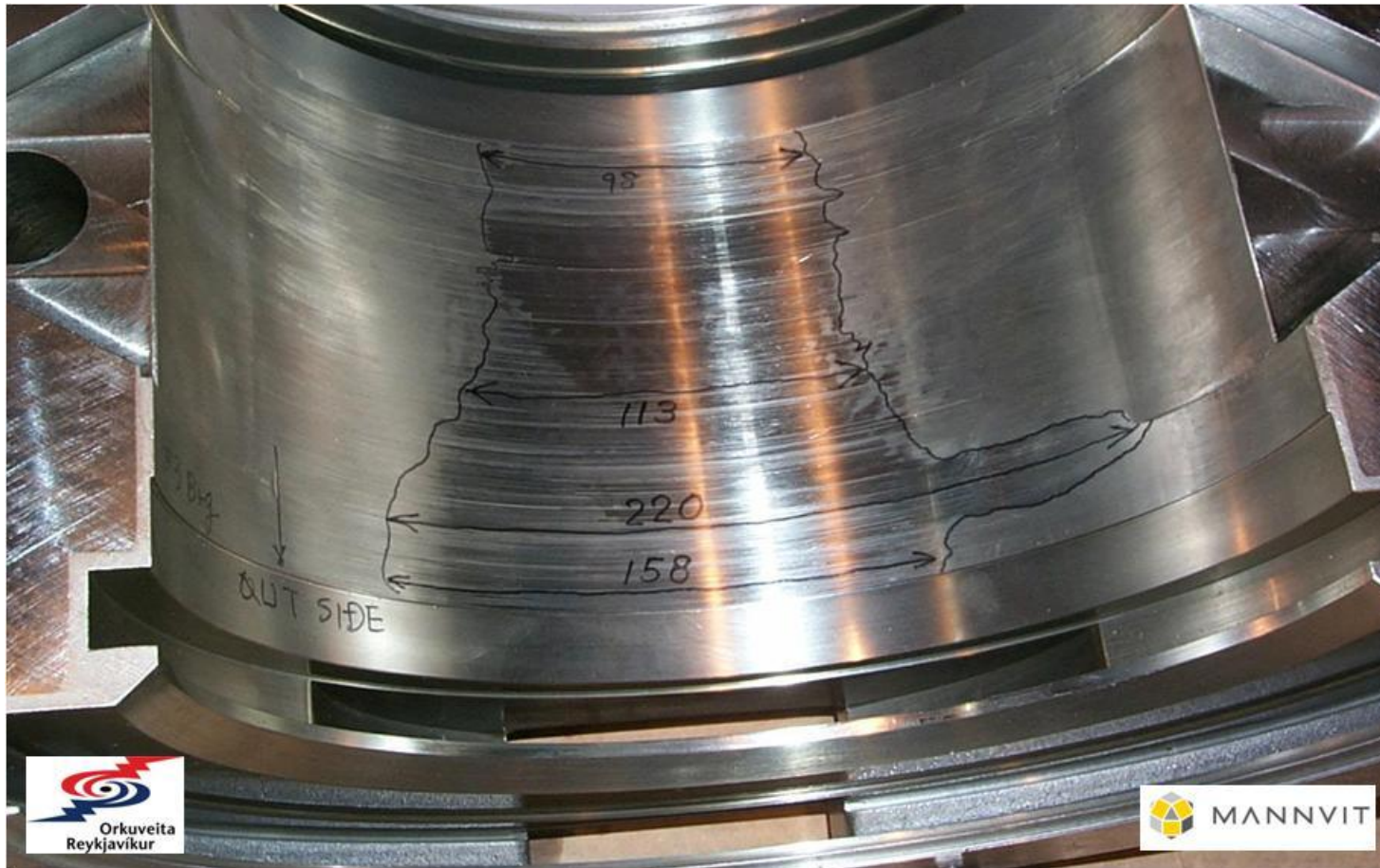
Shut Down Valve Axle



Shut Down Valve End Bearing



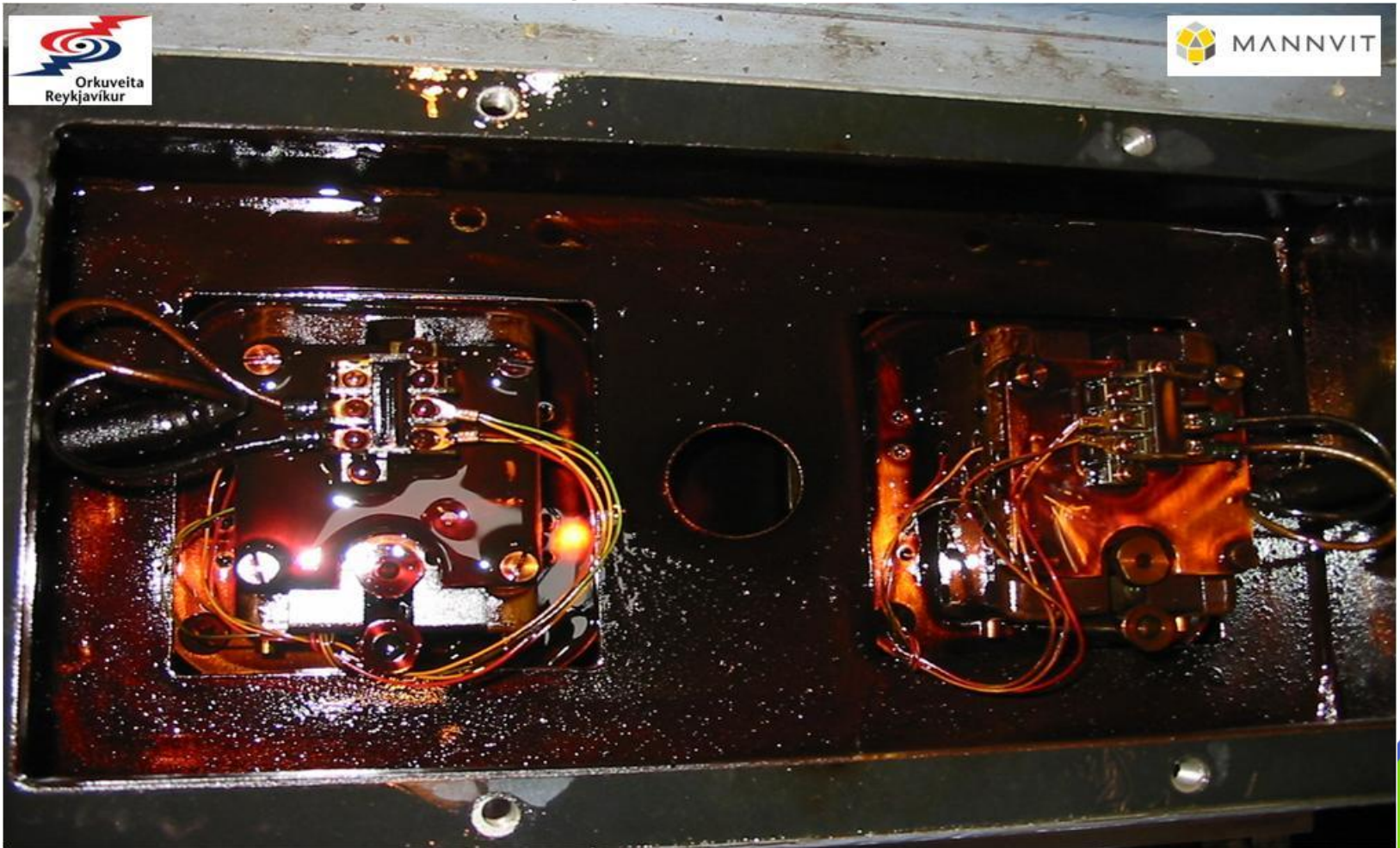
Turbine and Generator Bearings



Oil filter



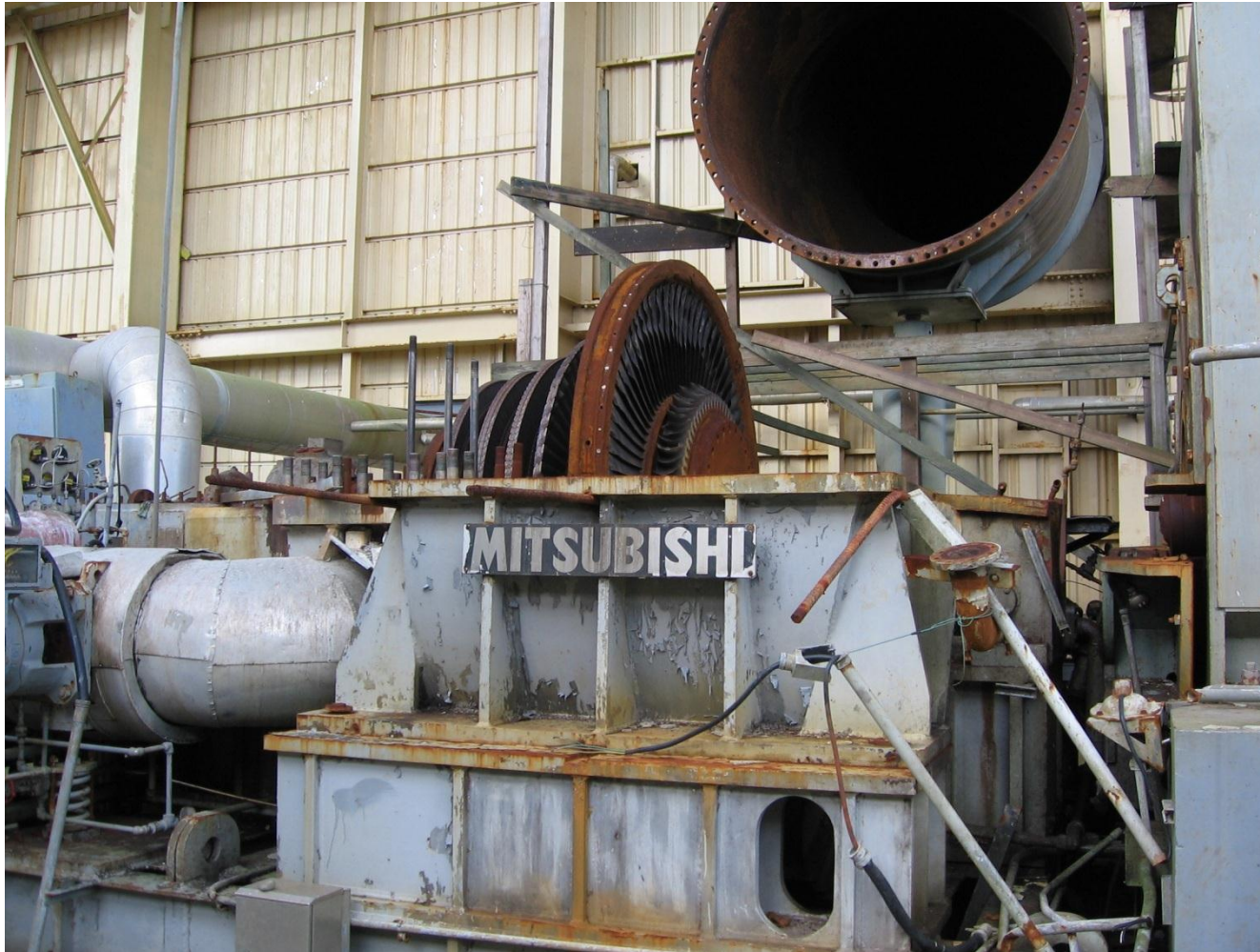
Oil System





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Broken turbine blades



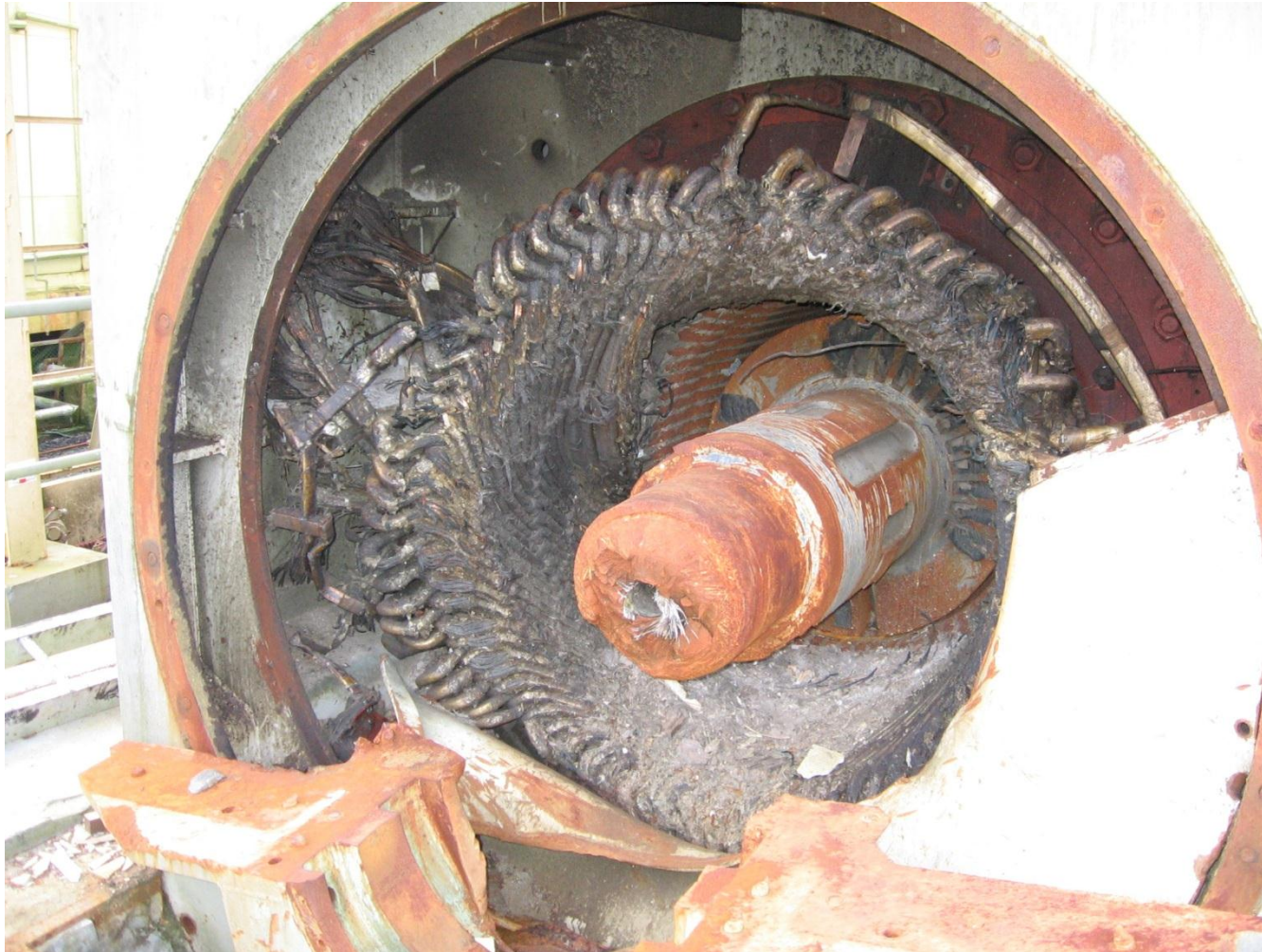
Damaged turbine housing

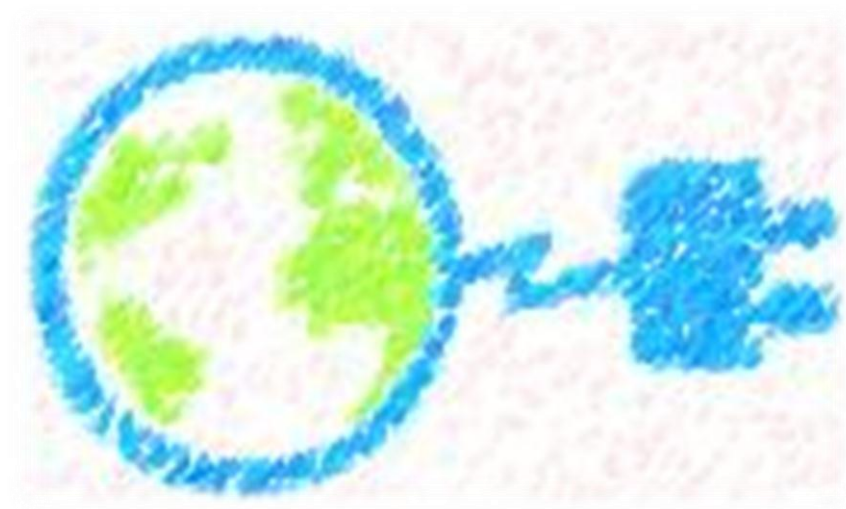




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Generator broken





Thank You!
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