Method and Techniques in Geothermal Power Plant Training

TOOLS IN GEOTHERMAL POWER PLANTS

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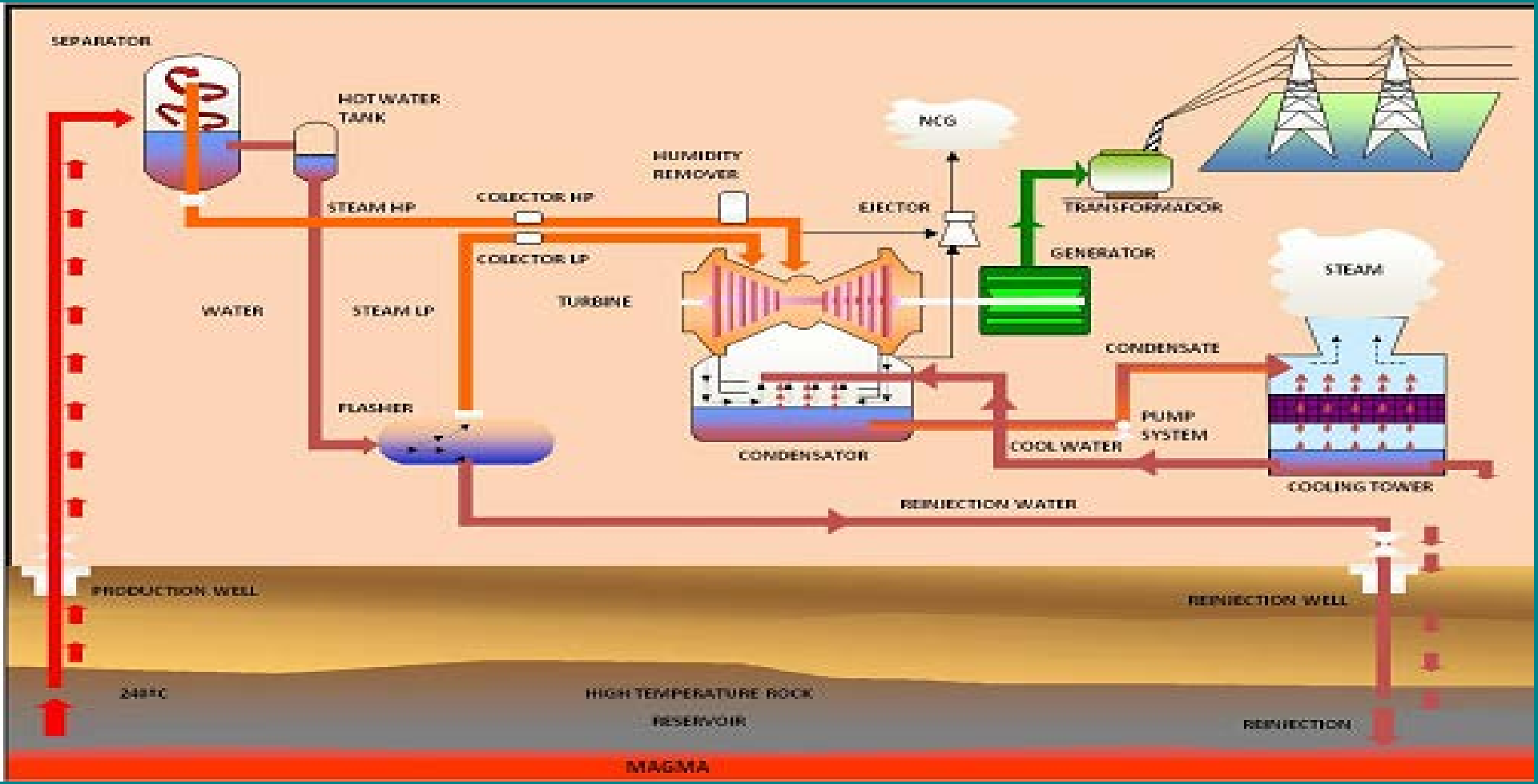

SEPARATOR
HOT WATER TANK
STEAM HP
COLECTOR HP
HUMIDITY REMOVER
NCG
EJECTOR
TRANSFORMADOR
GENERATOR
COLECTOR LP
TURBINE
STEAM
WATER
STEAM LP
CONDENSATE
FLASHER
PUMP SYSTEM
COOL WATER
CONDENSATOR
COOLING TOWER
REINJECTION WATER
PRODUCTION WELL
REINJECTION WELL
240°C
HIGH TEMPERATURE ROCK
RESERVOIR
REINJECTION
MAGMA

Pressure Measuring Instruments

- Common methods for measuring pressure
- Direct-measuring pressure instruments

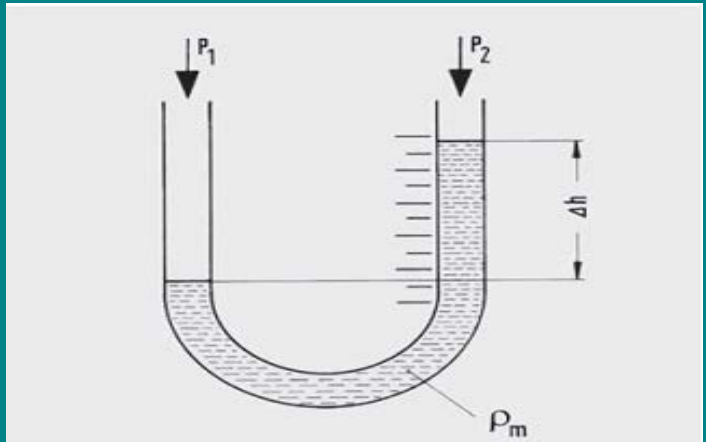


Figure 1.6 U-tube manometer

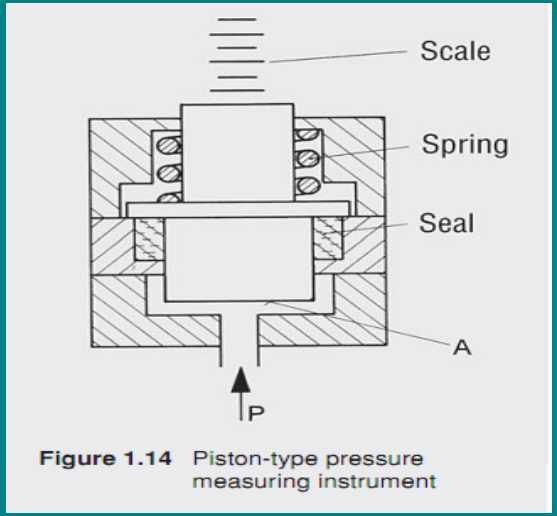


Figure 1.14 Piston-type pressure measuring instrument

Pressure Measurement Tools

- Indirect-measuring pressure measuring instruments
- Electrical pressure sensors and pressure measuring instruments: Sensor types with strain gauges dan silicon sensors

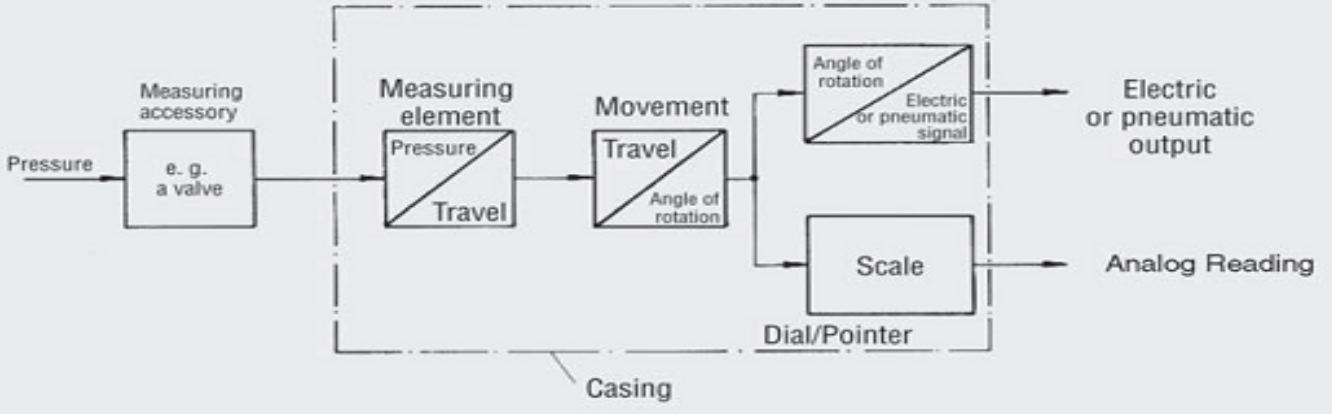
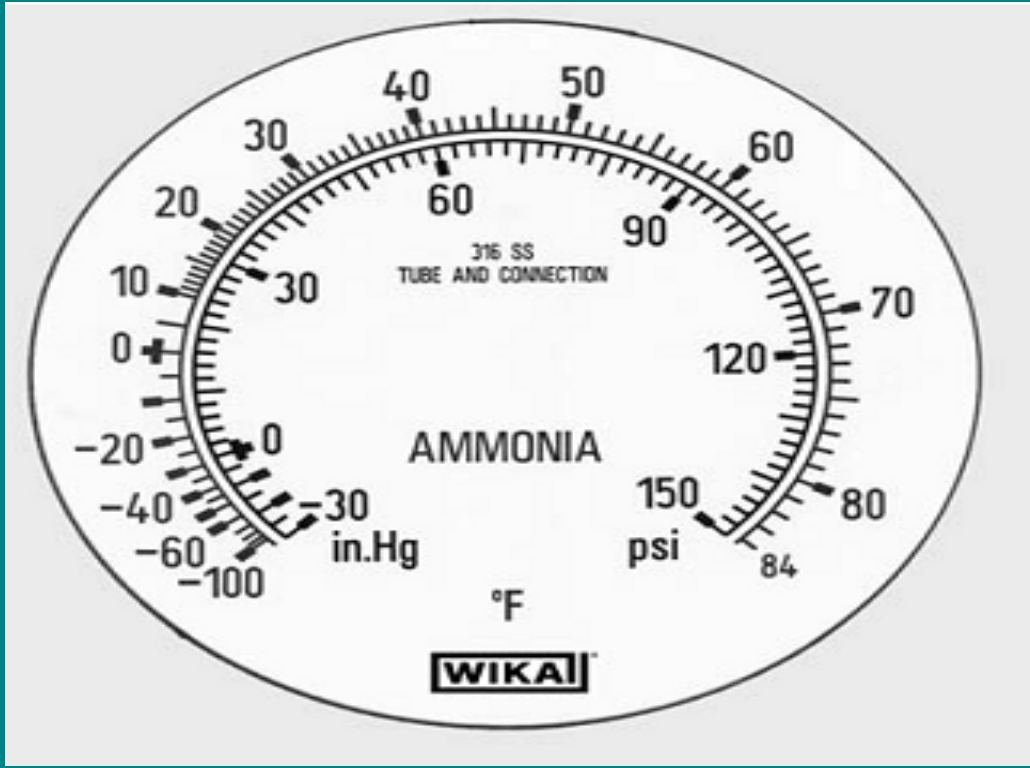


Figure 1.19 Flow chart of signal ouput, analog and digital, for instruments with flexible elements

Pressure Measurement Tools (1)



Accuracy Measuring Points

- ASME B40.1 Accuracy measuring points
  - ASME Grades 2A, 3A, or 4A 10
  - ASME Grades B, A, or 1A 5
  - ASME Grades C & D 4

The beginning and end of the range are considered as measuring points.

The following list shows the uses of gauges with each accuracy grade by application type.

ASME Grades 2A, 3A & 4A: for precise measurements in the laboratories and workshops

ASME Grades A & 1A: for industrial pressure measurement on machinery and production lines.

ASME Grades B, C & D: for simple monitoring applications without precise requirements

Temperature Measuring Instruments

Temperature Measuring Instruments (1)

- Measuring methods for measurement of thermodynamic temperatures

Method	Physical principle	Measuring range [K]	Uncertainty [mK]
Gas thermometer	ideal gas behavior	2.4 to 700	0.3 to 15
Acoustic thermometer	sound velocity in the ideal gas	2 to 20	0.3 to 1
Thermal noise thermometer	noise of an electrical resistance	3 to 1100	0.3 to 100
Spectral pyrometer	spectral radiation density of a cavity radiator	700 to 2500	10 to 2000
Total radiation pyrometer	total radiation of a cavity radiator	220 to 420	0.5 to 2

Temperature measuring instruments and special temperature measuring methods

Temperature measuring instruments and special temperature measuring methods (1)

Measuring instrument	Temperature range from [°F]	Temperature range to [°F]	Error limits	Remote measurement, recording possible?	Special features
Mechanical contact thermometers					
Liquid glass thermometer: thermometric liquid non-wetting	(-72)**-36**	**1200**(1800)	see calibration error limits ASME B40.3	no	no additional equipment required.
Liquid glass thermometer: thermometric liquid wetting	-330	410			
Dial thermometers					
Liquid spring thermometer	-30	930	1 to 2 % of the Indication range	yes	no additional equipment required.
Vapour pressure spring thermometer	(-330)-60	660 (1300)	1 to 2% of the scale length	yes	
Rod expansion thermometer	32	1800	1 to 2% of the Indication range	no	
Bimetallic thermometer	-60	750	1 to 3% of the Indication range	recording possible	
Electrical contact thermometer					
Thermocouples					
Cu-CuN type U, T	-330	750 (1100)	0.75% of required value of temperature, minimum	yes	versatile, signal processing only with additional equipment
Fe-CuNi type L, J	-330	1300 (1650)			
NiCr-Ni type K, N	0	1800 (2400)			
PtRh-PT type R, S	0	2400 (2900)	0.5% of required value of temperature, minimum	yes	
$PtRH_{20}$-$PtRh_s$ type B	0	2700 (3300)			
Resistance thermometers with metal measuring resistors					
Pt resistance thermometer	(-480)-330	1550 (1800)	0.54°F to 8.6°F depending on temperature	yes	
Ni resistance thermometer	-75	480	0.7°F to 3.8°F depending on temperature	yes	

Temperature measuring instruments and special temperature measuring methods (2)

Resistance thermometer with semiconductor measuring resistors					
Hot conductor resistance thermometer, thermistors	(-150)-40 -75 -150	350 (750) 400 750	depending on temp. 0.2 to 2°F 0.1 to 4.5°F	yes	
Cold conductor resistance thermometer	40	400	3.5 to 18°F	yes	Use as limit value switch from from 80°F to 350°F
Silicon measuring resistors	-95	350	0.4 to 1.8°F	yes	
Semiconductor diode/ integrated temperature sensor	-95	320	depending on temp. 0.18 to 5.5°F	yes	
Cryodiodes	-460	270	up to 0.018°F	yes	
Radiation thermometers	-150	6300 (9000)	0.5 to 1.5% of the temperature, but at least 0.1 to 3.5°F in the range from -150 to 750°F	yes	non-contact, low reaction setting times: 0.1 ms to 10 s
Spectral pyrometer	70	6300 (9000)			
Bandpass pyrometer	-150	3600			
Total radiation pyrometer	-150	3600			
Ratio pyrometer	300	5400			
Thermographic equipment	-60	2700			Measurement of temperature distribution, temperature differences can be resolved to 0.2 °F
Seger cone	1100	3600			indicate whether specific temperatures reached or exceeded
Temperature characteristic bodies	212	2900	approx. 12°F		
Quartz thermometer	-110	480	resolution 0.18 (0.018)°F		digitizable measuring signal, resolution 0.1 mK
Thermal noise thermometer	-450	1800	1‰		high cost equipment
Ultrasonic thermometer		6000	approx. 1%		
Gas thermometer	-450	2000	according to type		scientific thermometer
Optical measuring method					suitable temperature fields
Temperature measuring colours	100	2500	approx. 9°F		
Liquid crystals	-4	160	approx. 2°F		suitable for temperature fields, reversible color change
Fibre-optic luminescent thermometer		750	1°F	yes	not affected by electro-magnetic interference, simple explosion protection

Temperature measuring instruments and special temperature measuring methods

Figure 2.83 Gas pressure spring thermometer with fixed connection

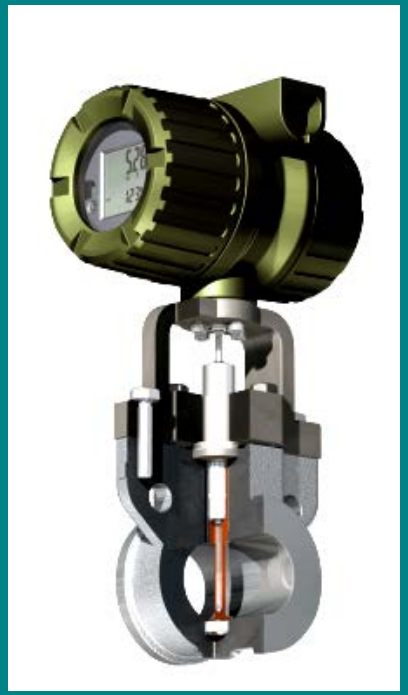
Figure 2.84 Gas pressure spring thermometer with long-distance line

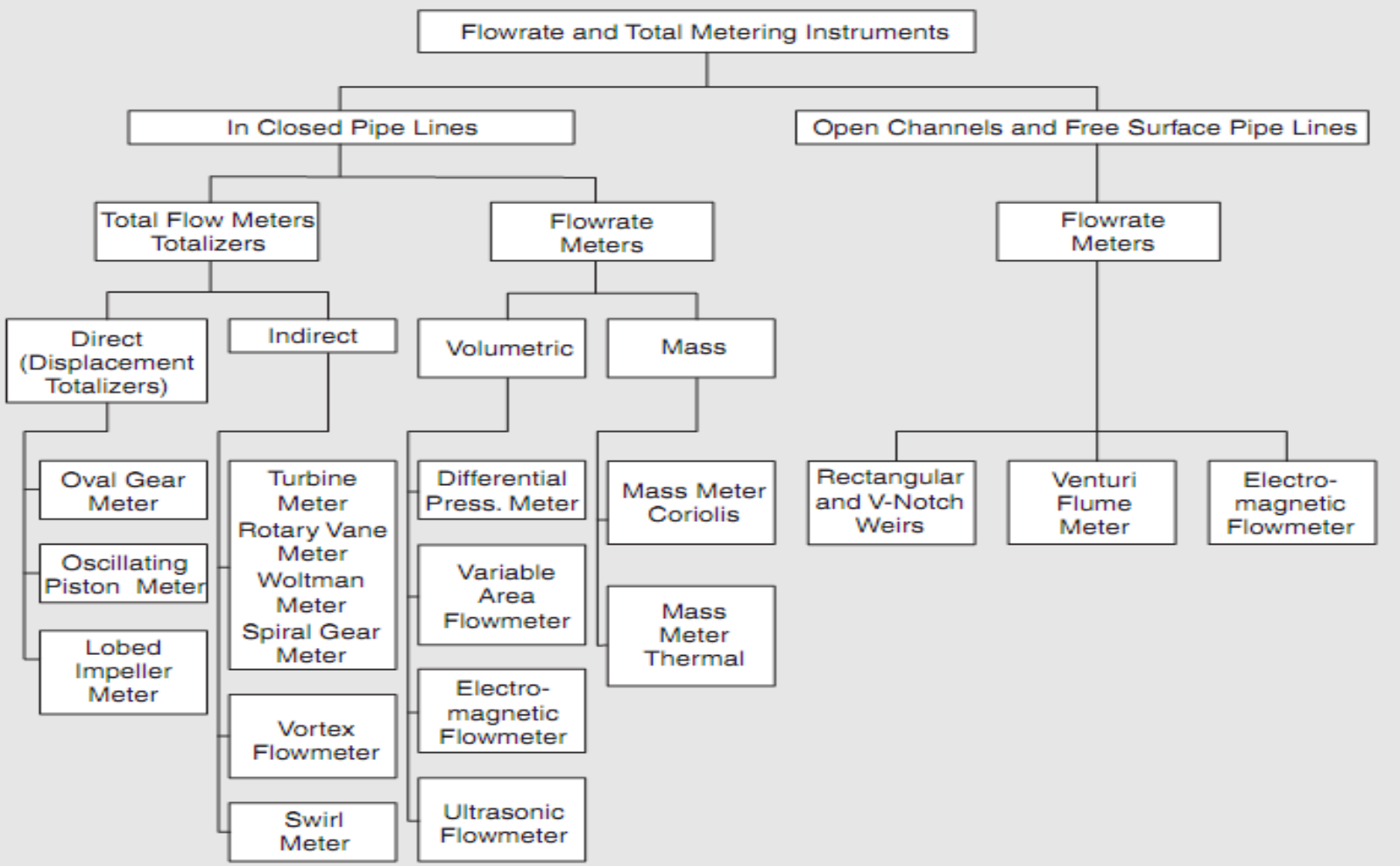
Figure 3.13 A digital indicator

FLOW MEASUREMENT

Flow Measurement (1)

Flow Measurement (2)




Flowrate and Total Metering Instruments
In Closed Pipe Lines
Open Channels and Free Surface Pipe Lines
Total Flow Meters Totalizers
Flowrate Meters
Flowrate Meters
Direct (Displacement Totalizers)
Indirect
Volumetric
Mass
Oval Gear Meter
Oscillating Piston Meter
Lobed Impeller Meter
Turbine Meter
Rotary Vane Meter
Woltman Meter
Spiral Gear Meter
Vortex Flowmeter
Swirl Meter
Differential Press. Meter
Variable Area Flowmeter
Electro-magnetic Flowmeter
Ultrasonic Flowmeter
Mass Meter Coriolis
Mass Meter Thermal
Rectangular and V-Notch Weirs
Venturi Flume Meter
Electro-magnetic Flowmeter

USM – ULTRASONIC BOLT LOAD MEASUREMENT

USM-3 Ultrasonic Bolt Meter

Measurement of Silica

Measurement of Silica (1)

- Carryover of impurities has posed a greater risk of corrosion to turbine blades and other downstream piping and equipment.
- The most popular method for the measurement of silica is the heteropoly blue (also called molybdate or molybdenum blue) colorimetric method

Shimadzu Model UV-1201 UV/VIS spectrophotometer

Other tools

TABLE 1: Information about the systems, equipments and components

Main systems	Main equipments	Main components
Steam conduction and transmission (gathering system)	Wellhead, separator station, steam transmission and water transmission	Master valves, flow control valve, two-phase pipeline Separator vessel, pressure relief device, level control Steam pipe, condensate drains, steam pressure, controllers, steam driers, steam flow meters Hot water pipeline, hot water pressure relieves. Humidity separators
Turbine and auxiliaries	Inlet devices steam turbine oil system	Steam strainer, emergency and governor valves Rotor, nozzles, diaphragms, bearings, casing, packing gland seals Oil pumps, servomotors, oil pipes.
Cooling system	Cooling towers and water pumps condenser	Fans, motors, gear reducers, structure, fills, cold water ponds, strainers Large hot well pumps and motors, auxiliary pumps Condenser heat exchangers, nozzles, gas cooling
Gas extraction system	Steam jet ejector and vacuum pump	Control valves, isolating valves, nozzles, intercoolers Vacuum pump and motor, water seal pump and motor gear reducer box.
Generator and electrical	Generator, transformers and protection	Rotor, stator, exciter, bearings, coolers Step up transformers, station transformers Relays, switchgears,

No	Predictive Maintenance	Applications
1	Vibration analysis	Misalignment, out of balance weights, wear of bearings etc
2	Thermography analysis	Overloading, excessive friction or wear, abnormal electric resistance
3	Oil analysis	Contamination, breakdown of lubrication properties, signs of wear
4	Current measurement	Electric overloads, faulty bearings, current leakage
5	Visual inspection	General defects that can be detected by human senses of sight, hearing and feeling
6	Insulation tests	Check status of electric insulation
7	Power rate	Bearing failures, damaged turbine blades, vacuum loss
8	Voltage measurement	Brush failure, excitation faulty, insulation failure

Case Study

- Steam Inlet Pressure - 6.2 to 4.8 bar – Steam cleaning system and control valve
- Condenser Vacuum gets worse

Case Study

- Bad Quality steam?
- Deposition of Impurities ? Silica?

Case Study

- turbine washing which employed condensate water from the condenser outletTurbine washing cleaned the deposit from the turbine by means of water injection into the steam line

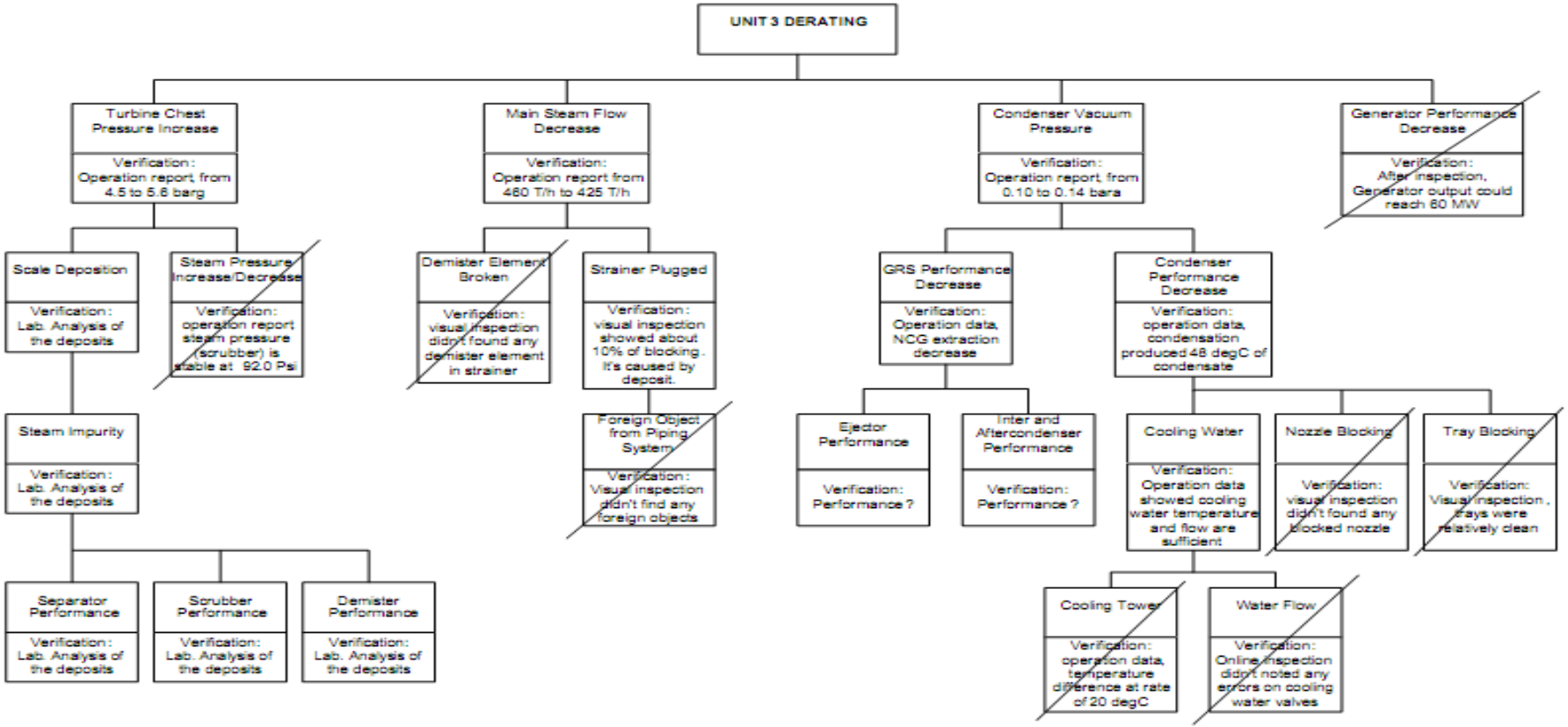


Figure 1: Root cause analyses of de-rating.

Thank you