

Department Of Mechanical Engineering

Instrumentation & Measurement

Course No. **361**

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Assignment

Important Measuring Instruments of Boiler

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# Important Measuring Instruments of Boiler

A steam generator or **boiler** is, usually, a closed vessel made of steel. Its function is to transfer the heat produced by the combustion of fuel (solid, liquid or gaseous) to water, and ultimately to generate steam. The steam produced may be supplied:

- to an external combustion engine, i.e. steam engines and turbines,
- at low pressures for industrial process work in cotton mills, sugar factories, breweries, etc. and
- for producing hot water, which can be used for heating installations at much lower pressures.

## Measurement Criteria

Although basically same, all type of boilers does not require same type of instruments. Measuring instrument may vary on use and construction of particular boilers. Several general measurement criteria are:

- ❑ Temperature of input water
- ❑ Temperature of output steam
- ❑ Temperature of boiler body
- ❑ Temperature of furnace
- ❑ Pressure of output steam
- ❑ Pressure inside the boiler
- ❑ Discharge of input water
- ❑ Discharge of output steam
- ❑ Water level indicator

In most cases some mechanical technique is employed to check the boundary condition of the system, thus keeping the boiler operation safe & sound. Seven of the above are discussed below.

# Temperature of Input Water

## Input

Preheated water

## Suitable Device

Liquid in glass thermometer

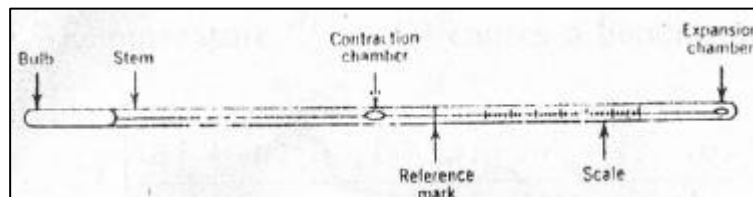
## Reasons for Choice

- Cheap
- Easy to operate
- Temperature is easily readout

## Limitations

- Not very accurate
- Data can not be collected for future use

## Schematic



## Sensor

Mercury, temperature converted into displacement

## Signal Conditioning

None

## Readout

Graduated tube

## Alternative Device

Complex or costly devices may be used

# Temperature of Output Steam

## Input

Hot steam in gaseous form having high pressure

## Suitable Device

Pressure type thermometer

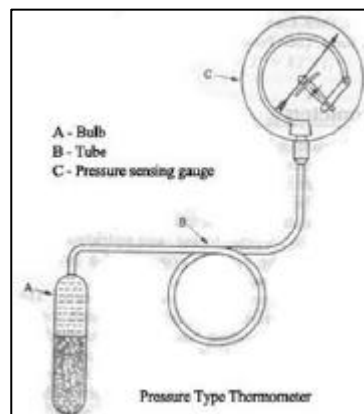
## Reasons for Choice

- Cheap
- Easy to operate
- Temperature is easily readout

## Limitations

- Not very accurate
- Data can not be collected for future use
- Error may cause by elevation difference

## Schematic



## Sensor

Primary liquid, vapour

## Transducer

Secondary-Bourdon tube & gear linkage.

## Signal Conditioning

None

## Readout

Scale & pointer

## Alternative Device

Complex or costly devices may be used

# Boiler Body Temperature

## Input

Temperature from boiler body

## Suitable Device

Platinum alloy type thermocouple

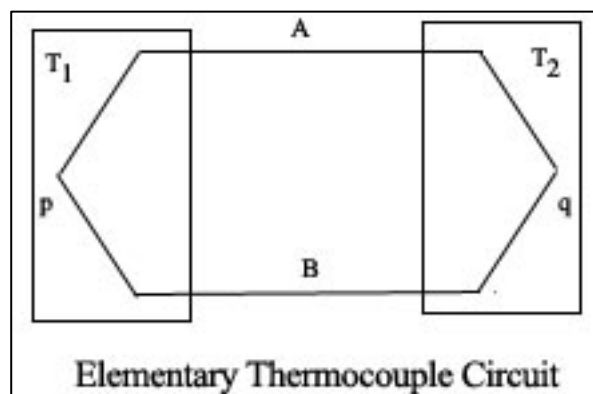
## Reasons for Choice

- Quite accurate
- Simple
- Easy digital readout
- Good range

## Limitations

- Response may slow depending on the choice of proper thermocouple

## Schematic



## Sensor

Metal wire

## Transducer

Sensitive voltmeter

## Signal Conditioning

Voltage Amplifier

## Readout

Digital display

## Alternative Device

Different type's commercial thermocouples are available. Depending on the boiler type suitable device should be chosen.

# Furnace Temperature

## Input

Temperature of the burning fuel of the furnace

## Suitable Device

Optical pyrometer

## Principle

- Pyrometers are essentially photo detectors designed specially for temperature measurement. It works on the principle of Wein's displacement law.
- With the increase of temperature a surface gradually becomes dark red, orange and finally white in color.

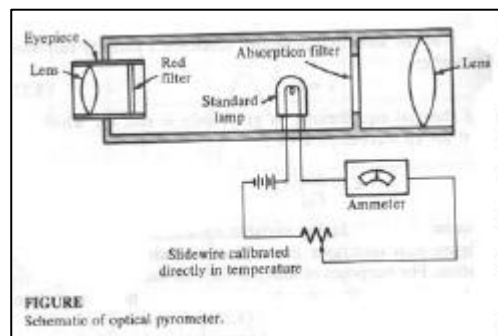
## Reasons for Choice

- Can measure temperature without contact of the burning fuel
- Simple
- Cheap

## Limitations

- Needs experienced user
- Accurate measure is not available
- Output is analog

## Schematic



## Sensor

Thermopile, thermistor or RTD

## Signal Conditioning

None

## Readout

Lens and mirror system

# Pressure of output steam

## Input

Output steam high pressure

## Suitable Device

Bourdon tube pressure gauge

## Principle

- This transducer operates on the principle that the deflection or deformation accompanying a balance of pressure and elastic forces may be used as a measure of pressure.
- A tube of oval section is initially coiled into a circular arc of radius  $R$
- The included angle of the arc is usually less than  $360^\circ$ .
- For increased sensitivity the tube may be formed into helix of several turns.

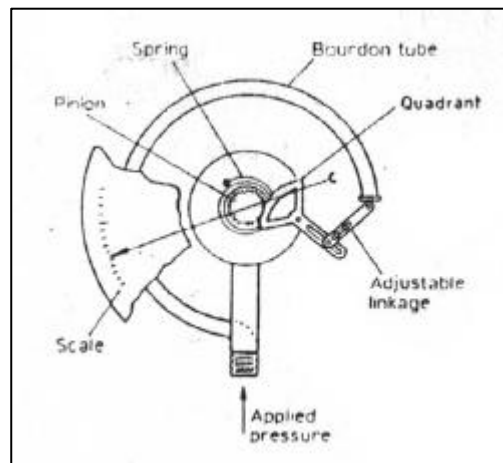
## Reasons for Choice

- Very simple
- Cheap
- Direct readout

## Limitations

- Accurate measure is not available
- Output is analog
- Temperature may effect

## Schematic



## Sensor

Primary-Bourdon tube, pressure to mechanical displacement

## Transducer

Secondary-Linkage gearing, mechanical displacement to rotary displacement

## Signal Conditioning

None

## Readout

Scale & pointer

# Discharge of Input Water

## Input

Flow of input water

## Suitable Device

Flow obstruction meter, Venturi type

## Principle

- The pressure drop across the meter is proportional to the square of the flow rate.

- Discharge is calculated using  $Q_{actual} = \frac{CA_2}{\sqrt{1-\beta^4}} \sqrt{\frac{2}{\rho} \Delta P}$

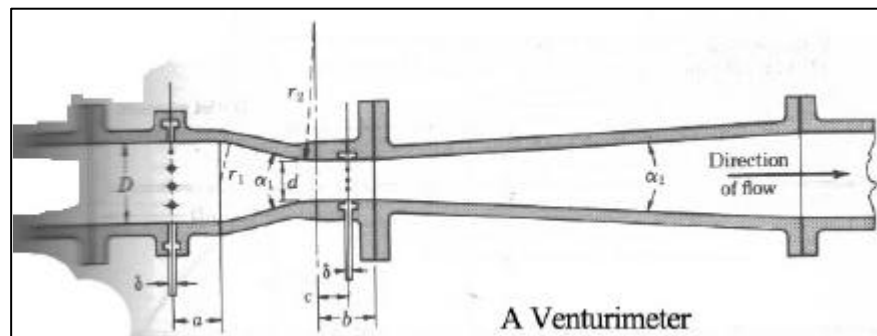
## Reasons for Choice

- Very simple
- Good pressure recovery
- Resistance to abrasion

## Limitations

- Costly than other obstruction meters
- Greater space requirement
- Output is analog

## Schematic



## Sensor

Pressure sensor manometer

## Readout

Manual, form the manometer reading

# Discharge of Output Steam

## Input

Flow of output steam

## Suitable Device

variable area meter, Rotameter

## Principle

- The flowing fluid changes the position of a float, piston, or vane to open a larger area for the passage of the fluid.
- The position of the float varies directly with the flow rate.
- Its exact position is at the point where the differential pressure between the upper and lower surfaces balance the weight of the float.

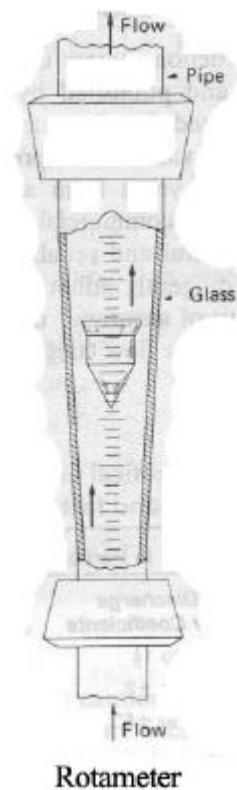
## Reasons for Choice

- Cheap
- Usable for gaseous fluid
- Uniform scale over the range of the instrument
- Fixed pressure loss at all flow rates

## Limitations

- Meter must be installed vertically
- For high pressure its expensive

## Schematic



## Sensor

The weight

## Readout

Direct scale readout

# Water Level Indicator

## Input

Water level inside the boiler

## Suitable Device

Capacitive transducer; in most cases a mechanical arrangement is used to operate as indicator as well as safety device.

## Principle

- Physical variable to be measured changes the capacitance
- Capacitance may be measured using bridge circuit
- Capacitance may be given by  $C = 0.0885e \frac{A}{d}$
- Output impedance, Z of a capacitor is given by:  $\Rightarrow Z = \frac{1}{2\pi fC}$

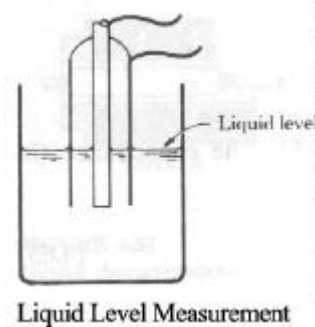
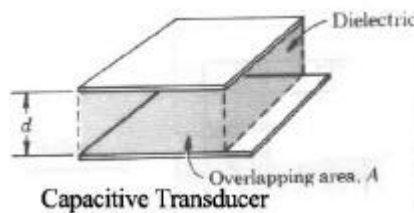
## Reasons for Choice

- Cheap
- Easy readout

## Limitations

- Response may not be linear
- Complex circuitry may make it costly

## Schematic



## Sensor

Dielectric

## Readout

Reading from suitable circuit construction