higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# MARKING GUIDELINE

## NATIONAL CERTIFICATE

## INDUSTRIAL INSTRUMENTS N4

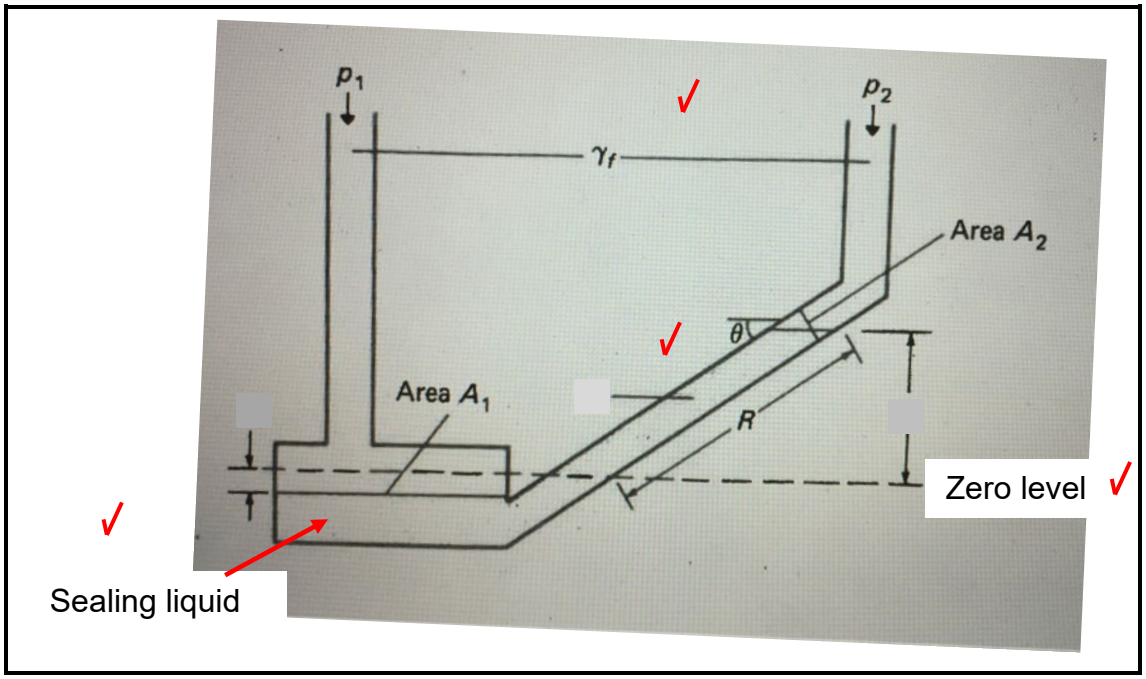
**1 December 2022**

**This marking guideline consists of 8 pages.**

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## QUESTION 1: PRESSURE MEASUREMENT

1.1




(4)

1.2 To measure low pressure differences accurately. (2)

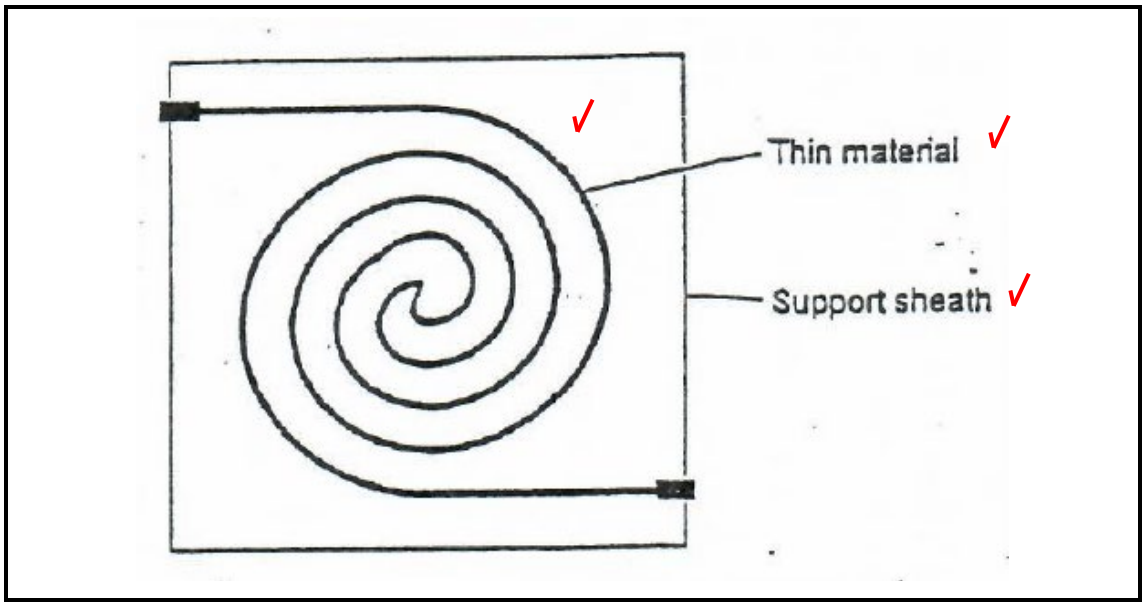
1.3 Given: h = 35 cm = 0,35 m
g = 9,8 m/s²
ρ = 13 600 kg/m³ (Mercury)

$P_1 - P_2 = \rho g h$ ✓
= 13 600 kg/m³ × 69,8 m/s²✓ × 0,35 m✓ (Convert cm to m)
= 46 648 Pa✓

= 46,648 kPa✓ (5)

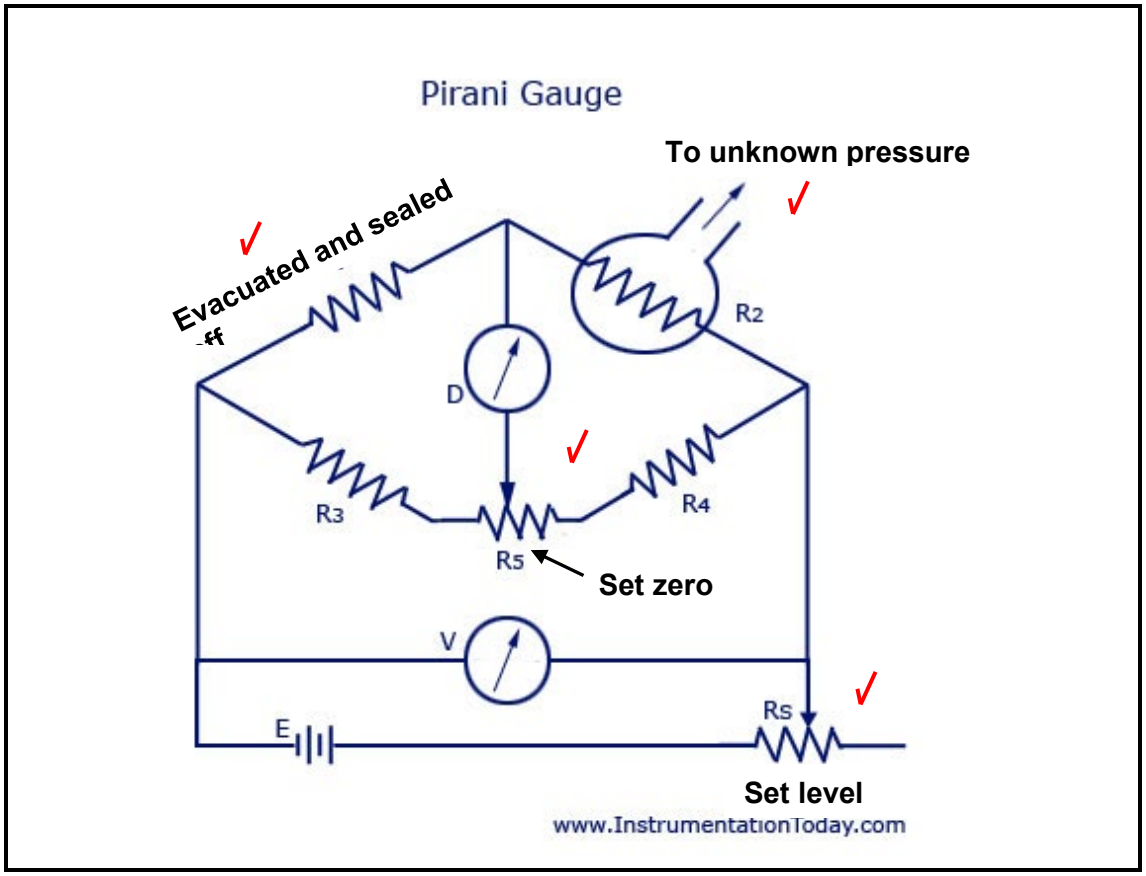
1.4
- Gas from the pressure that must be measured forces itself into the gauge and fills the entire apparatus. The movable container, which is filled with mercury, is slowly lifted. Mercury rises in the tube and seals a fixed volume of gas (volume of the ball and the right-hand side closed capillary tube) which is then compressed.✓
- The mercury rises higher in the left-hand side capillary tube and is brought to a standstill on a zero-scale level (just above the top of the right-hand side closed capillary tube).✓
- The compressed volume is, according to Boyle's Law, read off as a measure of the original absolute pressure.✓ (3)

1.5




(3)

1.6

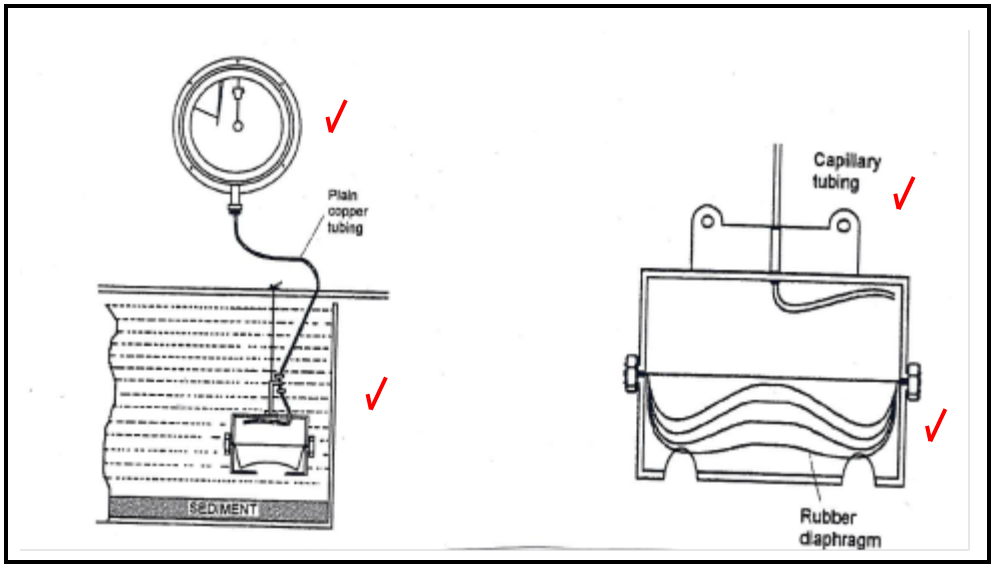



The Pirani vacuum meter is used to measure absolute low pressures by means of a filament element whose resistance changes as a result of temperature change.✓ Initially, the bridge circuit is in balance and the meter reading is zero. Current flow from the battery heats up the filaments. When the measuring cell is connected to the unknown pressure (vacuum), the amount of gas in the measuring cell is reduced.✓

Less heat from the measuring cell's filament is conducted away and the filament will increase in temperature.✓ Because temperature has a direct influence on the resistance of a conductor, the resistance of the filament will increase. This brings the bridge circuit into imbalance and the meter needle will deflect to indicate the value of the vacuum.✓ (8)
**[25]**

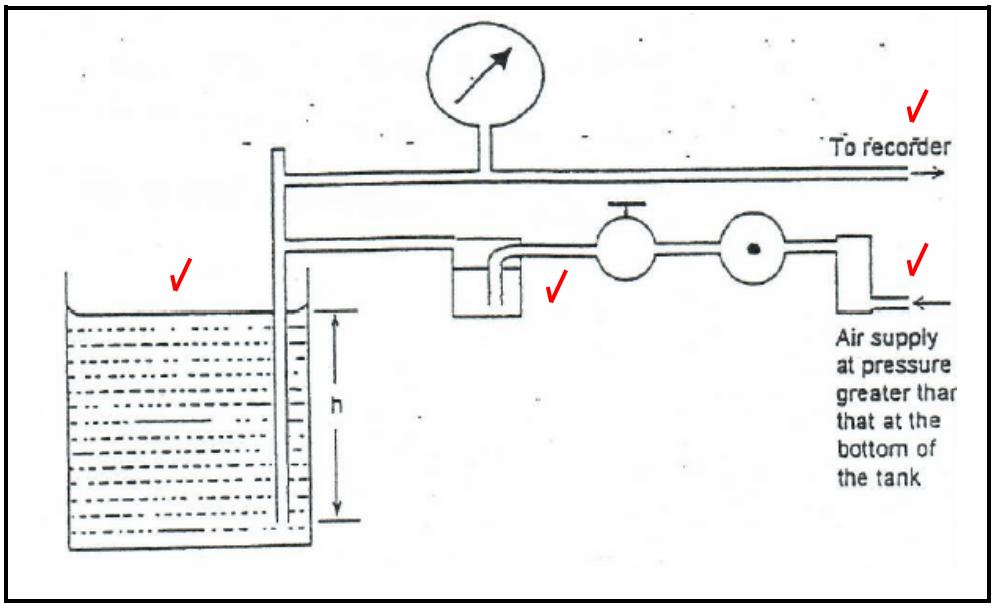
## QUESTION 2: LEVEL MEASUREMENT

2.1 2.1.1




(4)

2.1.2




(4)

2.2
- Simple
- Reliable
- Accurate
- Suitable for high temperatures and high pressures
- Compatible for measurement over a wide range (Any 2 × 1) (2)

**[10]**

## QUESTION 3: FLOW MEASUREMENT

3.1
- The diameter of the hole (in relation to the pipe diameter) must be such that it will produce a maximum pressure difference at maximum flowrate.
- The sharp edge of the orifice plate must face upstream.
- The material from which the orifice plate is manufactured must be strong enough to withstand the pressure difference.
- The orifice plate may not corrode in the medium which flowrate is to be measured. (4)

3.2
- Flange taps
- Radius taps
- Corner taps
- Vena contracta taps
- Pipe taps
- Plate taps (Any 4 × 1) (4)

3.3
- Small pressure loss
- Very useful for determining the flowrate of liquids containing solids (2)

3.4 The Pitot tube consists of a tube having a small opening facing the direction of fluid flow.✓ As the fluid approaches the opening (hole), the velocity will decrease until it reaches zero at the point where it impinges it.✓ There is no flow through the tube and the point of impact or zero velocity can be considered to be on the impact hole.✓ The high-pressure reading is taken at the impact hole. A static pressure tapping is taken upstream a little way from the tube. The low-pressure reading is taken at the static pressure tapping.✓ (4)

3.5
- Pressure energy – PV
- Kinetic energy ½ $mv^2$
- Potential energy $m \times g \times h$ (3)

3.6
- Linear output
- Accurate
- Digital indication
- Wide measuring range
- Easy installation
- Long intervals between calibrations
- Easy to maintain (Any 3 × 1) (3)

**[20]**

## QUESTION 4: TEMPERATURE AND TELEMETERING

4.1 Given: $R_o = 25,5\ \Omega$ at 0 °C
$\beta = 5,83 \times 10^{-7}\ \Omega/\Omega\ °C$
$\alpha = 3,958 \times 10^{-3}\ \Omega/\Omega\ °C$

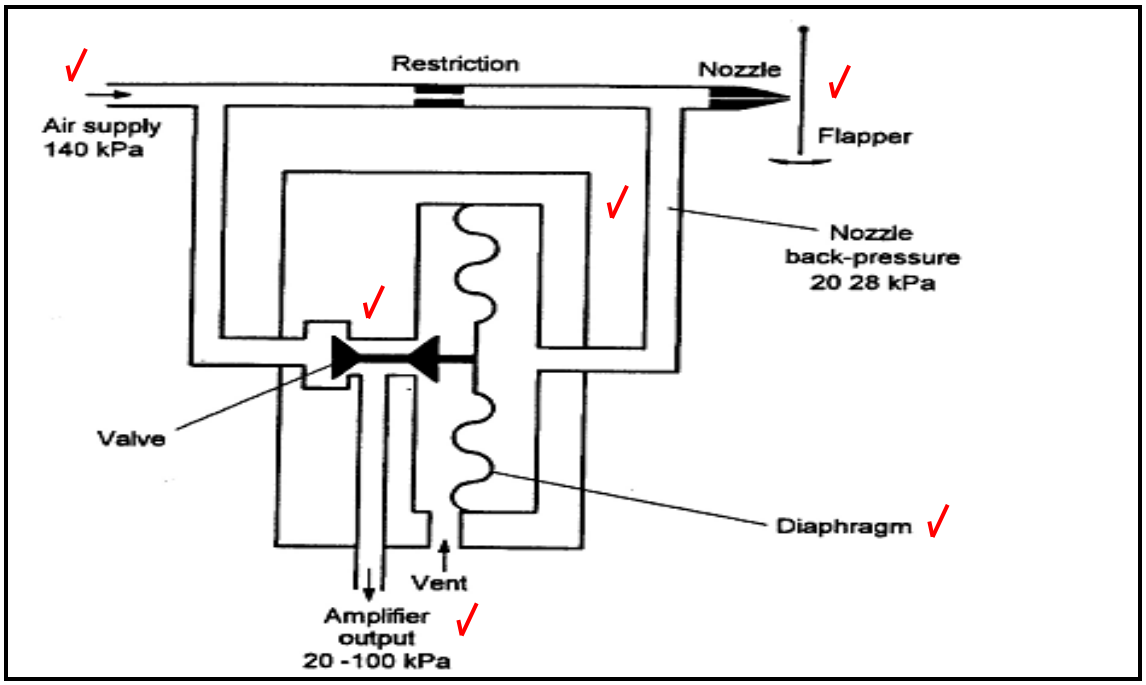
$R_t = R_o (1 + \alpha t + \beta t^2)$✓

$= 25,5 [1 + (3,958 \times 10^{-3} \times 500) + (5,83 \times 10^{-7} \times 500^2)]$✓

$= 79,68\ \Omega$✓

(3)

4.2



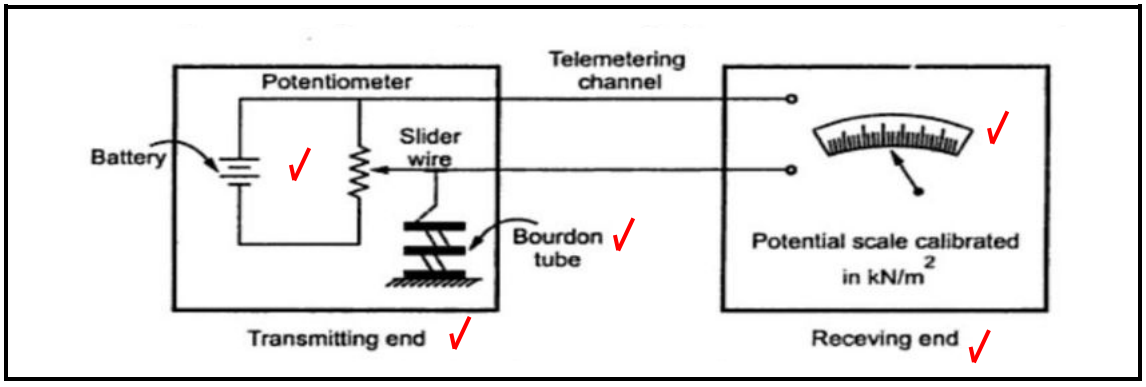

(6)

4.3
- Provides a greater volume of air.
- Provides higher speed and increased time response.
- Amplifies pressure.

**OR**

To increase power or energy gain✓ in order to operate the feedback bellows✓ and receiver of a flapper and nozzle system.✓ (3)

4.4




(5)

4.5 Total-radiation pyrometers cover the whole spectrum of heat radiation.✓ Optical pyrometers are those which measure the radiant flux given off✓ in a narrow band of the wavelength in the visible spectrum.✓ (3)

**[20]**

## QUESTION 5: AUTO CONTROL

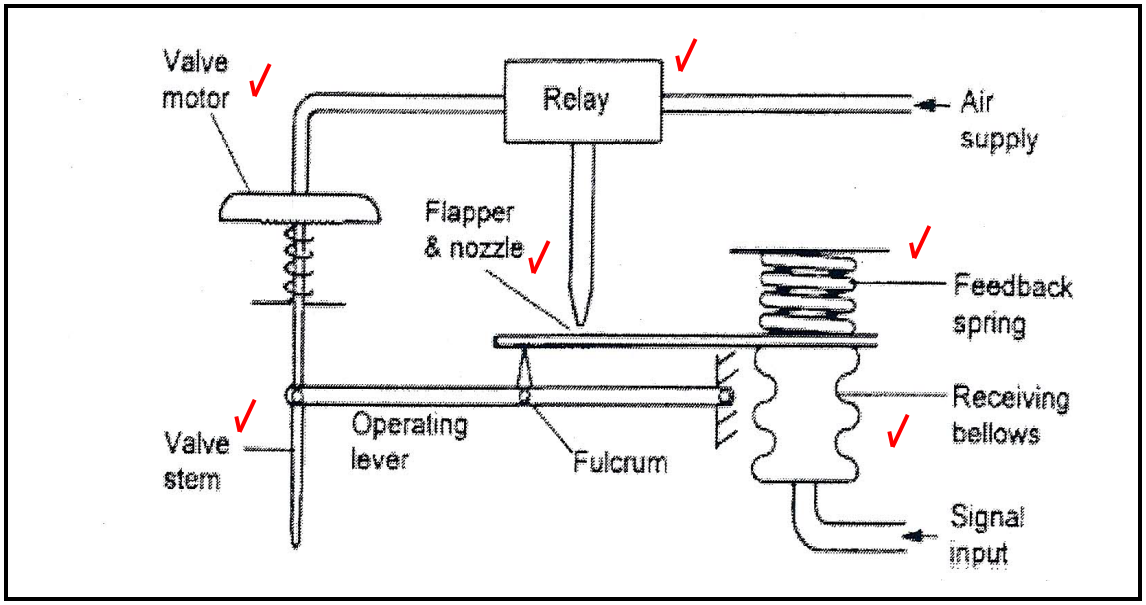
5.1 The method of making a process perform without the necessity of operator intervention.✓✓ (2)

5.2 A change in the amount of process variables which must be processed – e.g., change in flow or pressure.✓✓ (2)

5.3
- Distance velocity lag
- Transfer lag
- Process lag

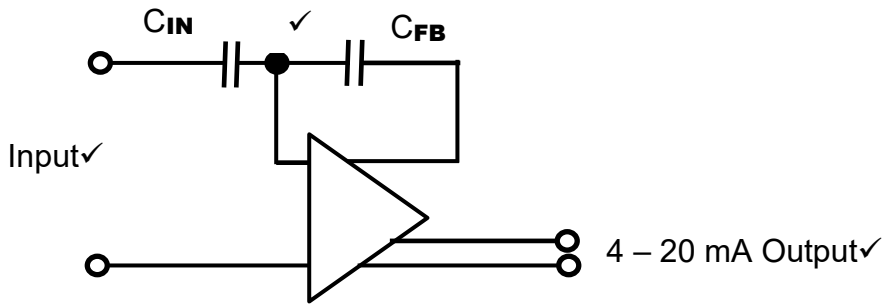
(Any 1 × 1) (1)

5.4




(6)

5.5




OPERATION:

The capacitors are equal in value. The amplifier has two outputs. One comprises a current signal ranging from 4 to 20 mA for control purposes.✓ The other is a voltage signal of ± 4 V for feedback purposes.✓ The two are proportional to one another, but are electrically isolated. With no input signal $V_B$, the feedback voltage is zero and the potential A, relative to earth, is also zero.✓ There will be an output signal, however, and this could conveniently be 12 mA, the half-way value between 4 and 20 mA.✓

If an error signal is impressed on the input, capacitor $C_{IN}$ is charged and a potential appears at point A, forming an input signal to the amplifier.✓ A feedback voltage is generated to $C_{FB}$ to counteract this, and the potential at A returns to zero. This is the same condition we had or the original output signal✓ of 12 mA. For as long as there is a sustained input signal to the amplifier, there is an equally sustained feedback voltage generated, and if this changes, so does the output current in proportion.✓ Thus, we have established a form of proportional control.✓ (8)

5.6 5.6.1 Proportional, integral and derivative action-position balance, or pneumatic three-term control-position balance. (2)

5.6.2 With an increase of the measured value, the flapper will move towards the nozzle, increasing the nozzle back pressure.✓ This results in a sharp increase of the output pressure due to the pressure drop across the derivative restriction, which is partially open.✓

With the derivative restriction partially open, air will flow into the proportional bellows at a rate which depends on the difference between the nozzle back pressure✓ and the pressure in the proportional bellows. Given time, the flow of air will equalise. This process continues until a balance is reached.✓ (4)

**[25]**

**TOTAL: 100**

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