higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE (VOCATIONAL)

INSTRUMENTATION TECHNOLOGY
NQF LEVEL 2

21 November 2023

This marking guideline consists of 7 pages.

Copyright reserved

QUESTION 1: PROCESS CONTROL PRINCIPLES

1.1 1.1.1 Hazardous locations are areas where flammable liquids, gases or vapours or combustible dusts are present in sufficient quantities✓ to produce an explosion or a fire.✓ (2)

1.1.2
- The *Class* defines the general nature (or properties) of the hazardous material in the surrounding atmosphere, which may or may not be present in sufficient quantities to cause an explosion.
- The *Division* defines the probability of the hazardous material being able to produce an explosive or ignitable mixture.
- The *Group* defines the type of hazardous material in the surrounding atmosphere. (3 × 2) (6)

1.2
- Pressure
- Temperature
- Flow
- Level (4)

1.3 A fieldbus is an industrial network system✓ designed for immediate,✓ distributed control.✓ (3)

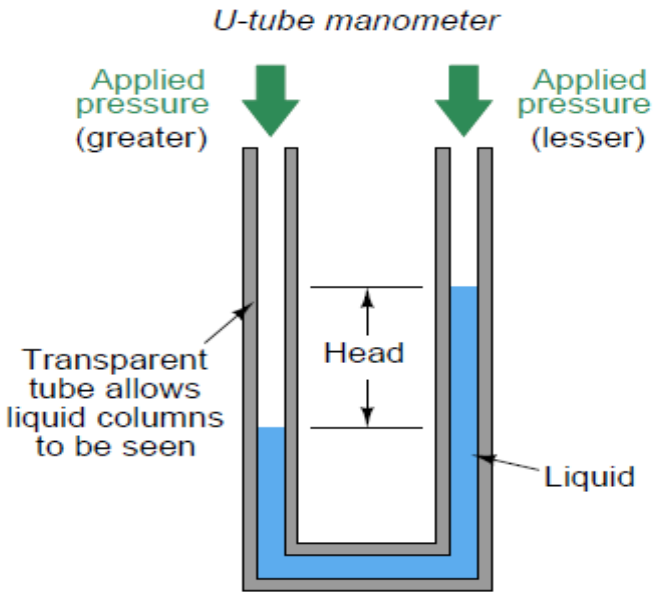
[15]

QUESTION 2: PRESSURE MEASUREMENT

2.1
- Absolute pressure
- Gauge pressure
- Vacuum pressure
- Differential pressure (4)

2.2 2.2.1
- Mercury
- Water (2)

2.2.2



(ONE mark for each correct label and ONE mark for sketch) (6)

Copyright reserved

2.2.3

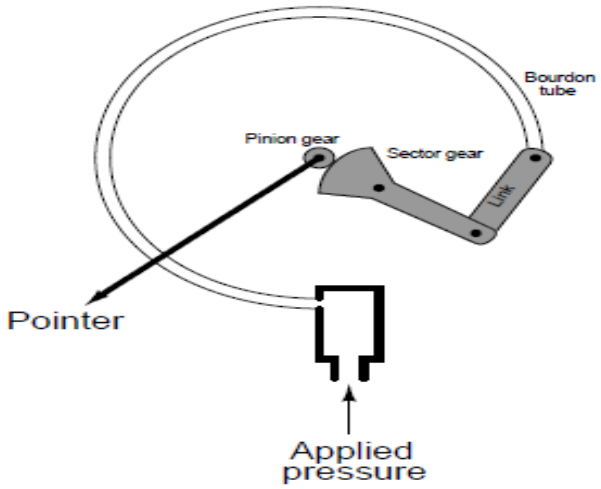
$$A_1 = \frac{\pi d^2}{4} = \frac{\pi(0{,}02)^2}{4} = 3{,}14 \times 10^{-4} m^2 ✓✓$$

$$A_2 = \frac{\pi D^2}{4} = \frac{\pi(0{,}1)^2}{4} = 7{,}85 \times 10^{-3} m^2 ✓✓$$

$$\Delta P = \rho g h \left[\frac{A_1}{A_2} + 1\right]$$

$$\Delta P = 13600 \times 10 \times 0{,}15 ✓$$
$$= 20400 \times 1{,}04 ✓$$
$$= 21216 Pa ✓$$
$$= 21{,}216 KPa ✓$$ (7)

2.3 2.3.1



(½ mark for each correct label and THREE marks for sketch) (6)

2.3.2 Inches of water column. (1)

2.4 2.4.1 B
2.4.2 C
2.4.3 D
2.4.4 A
2.4.5 F

(5 × 1) (5)

2.5
- Faulty connections
- Circuit failure
- Air leaks
- Incorrect or faulty power supply
- Incorrect current
- Failure of the circuit board
- Incorrect air supply pressure
- Incorrect calibration
- Block output connection
- Obstruction
- Incorrect operation parameters

(Any 6 × 1) (6)

[37]

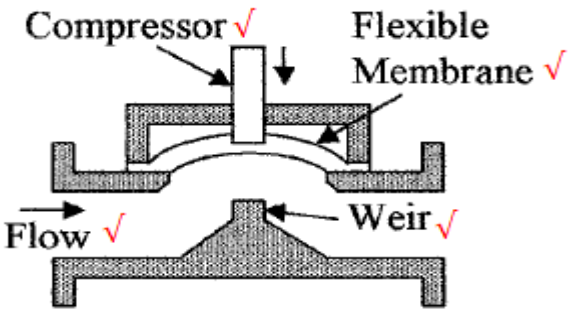
Copyright reserved

QUESTION 3: CONTROL VALVES

3.1 3.1.1 A positioner is a motion control device✓ designed to actively compare stem position against the control signal✓, adjusting pressure to the actuator diaphragm or piston until the correct stem position is reached.✓✓ (4)

3.1.2 A valve stem is a valve component consisting of a metal shaft that transmits the force of the actuator to the valve plug. (2)

3.2



(ONE mark for each correct label and TWO marks for sketch) (6)

3.3 3.3.1 Gate valve body. (1)

3.3.2 Direct-acting actuator. (2)

3.3.3 A – Input port/Air input
B – Diaphragm
C – Spring
D – Vent
E – Stem
F – Plug (6)

3.3.4
- An increase of input air pressure will act on the diaphragm, which converts air pressure to mechanical energy.
- Air pressure acting against the diaphragm moves the valve against the spring and the rubber diaphragm at the very top.
- In sliding-stem valves, a direct-acting actuator pushes down on the stem with increasing pressure.
- The plug moves to close the flow. (4)

3.4
- Valve seat leakage
- Mechanical friction
- Flashing
- Cavitation
- Choked flow
- Valve noise
- Erosion
- Chemical attack (Any 5 × 1) (5)

[30]

Copyright reserved

QUESTION 4: TEMPERATURE MEASUREMENT

4.1 4.1.1
- Celsius scale
- Kelvin scale
- Fahrenheit scale
- Rankine scale (4)

4.1.2 R = °F + 459.67
R = 32 + 459.67✓
R = 491.67✓ (2)

4.2 4.2.1
- The *Seebeck effect* is a thermoelectric effect whereby continuous current is generated in a circuit where the junctions of two dissimilar conductive materials cool off as it gives up energy to the moving charges and warms up as it absorbs energy.
- The *Peltier effect* is a thermoelectric effect whereby heating and cooling occurs at the junctions of two dissimilar conductive materials when a current flows through the junctions.
  Or heat is either given off or absorbed at the dissimilar material junctions, depending on the direction of electron flow.
- The *Thomson effect* is a thermoelectric effect whereby heat is generated or absorbed when an electric current passes through a conductor in which there is a temperature gradient. (3 × 2) (6)

4.2.2
- Platinum wire
- Nickel
- Copper (3)

4.3 When one metal has a greater coefficient of thermal expansion than another metal,✓ the difference in expansion can be used as a measure of temperature.✓ The metals are welded together and rolled to rigorous specifications to make the bimetallic element.✓ A bimetallic element is a strip usually wound into a spiral or helix✓ to allow movement for a given change in temperature.✓ When the helix or spiral is heated, it unwinds because the metal with the greater coefficient expands more than the other metal.✓ A pointer can be attached to the helix by means of a shaft that moves as the helix unwinds to indicate the temperature on a calibrated circular temperature scale.✓ (7)

4.4 $R_T = R_0(1+\propto T)$
$106 = 100(1 + 80 \times \propto)$✓
$\Rightarrow \alpha = \frac{106-100}{8000}$✓
$= 7{,}5 \times 10^{-4}\Omega/\Omega^0C$✓ (3)

4.5 4.5.1 True
4.5.2 False
4.5.3 True
4.5.4 False
4.5.5 True
(5 × 1) (5)
[30]

Copyright reserved

QUESTION 5: FLOW MEASUREMENT

5.1.1 In order to zero-check an orifice plate flowmeter, you can usually check if the indicator of the orifice plate flowmeter✓ indicates zero✓ when the is no flow.✓ (3)

5.1.2 An orifice plate flowmeter is usually pre-calibrated by its manufacturer in a workshop✓ by simulating, first, 50% and then 100% of the flow rate in an isolated system.✓ (3)

5.2 A positive-displacement flowmeter is a flowmeter that admits fluid into chambers of known volume and then discharges it.✓ The chambers are arranged in such a way that while one is filling, the other is emptied.✓ This action is registered by a counting mechanism.✓ The number of times the chambers are filled during a given interval are counted.✓ The total flow for a given interval is determined by reading the counters.✓ (5)

Or

A positive-displacement flowmeter is a cyclic mechanism built to pass a fixed volume of fluid through with every cycle. Every cycle of the meter's mechanism displaces a precisely defined ('positive') quantity of fluid so that a count of the number of mechanism cycles yields a precise quantity for the total fluid volume passed through the flowmeter.

5.3
- Nutating-disc meter
- Rotating-impeller meter
- Sliding-Vane meter
- Oscillating-Piston meter (4)

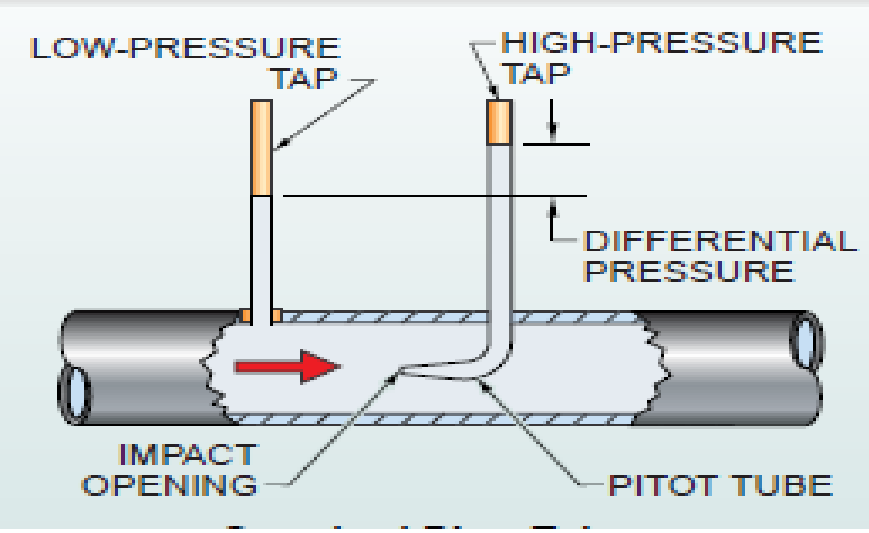
5.4 Laminar flow is smooth fluid flow with a flow profile that is parabolic in shape✓ with no mixing between the streamlines.✓ A cross section of a laminar flow stream is a parabolic flow profile with the maximum velocity at the centre✓ and the minimum velocity at the pipe walls.✓

Turbulent flow is fluid flow of which the flow profile is a flattened parabola.✓ The streamlines are not present✓ and the fluid mixes freely.✓ (7)

5.5 5.5.1 A flow element creates a restriction that forces fluid to flow faster, thereby increasing the velocity head.✓ According to the Bernoulli equation, if the velocity head increases,✓ the static head must decrease because of applied pressure.✓ This pressure decrease is used to calculate flow.✓ (4)

Copyright reserved

5.5.2



(ONE mark for each correct label and TWO marks for sketch) (6)

5.6 5.6.1 Remove the vinyl protection tube. (2)

or

Check whether the flow rate is not too small.

5.6.2 Inspect the operating condition.

5.6.3 Install an adequate pulsation-absorbing device.

(2 × 2) (4)
[38]

TOTAL: 150

Copyright reserved