higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# NATIONAL CERTIFICATE (VOCATIONAL)

## INSTRUMENTATION TECHNOLOGY
### NQF LEVEL 2

(6060452)

**21 November 2023 (Y-paper)**
**13:00–16:00**

**This question paper consists of 7 pages and 1 formula sheet.**



Copyright reserved

# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
INSTRUMENTATION TECHNOLOGY
NQF LEVEL 2
TIME: 3 HOURS
MARKS: 150

---

---

**INSTRUCTIONS AND INFORMATION**

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use only a black or blue pen.
5. Write neatly and legibly.

---

Copyright reserved 

## QUESTION 1: PROCESS CONTROL PRINCIPLES

1.1 The area safety classifications in the process industry takes into consideration the hazardous material in the surrounding atmosphere.

1.1.1 Define the term *hazardous atmosphere*. (2)

1.1.2 Explain the following area safety classifications as used in the process industry:

- Class
- Division
- Group (6)

1.2 List FOUR common types of process variables that are measured in a process environment. (4)

1.3 Explain what a fieldbus is. (3)
**[15]**

## QUESTION 2: PRESSURE MEASUREMENT

2.1 Pressure is reported in many units as well as on different scales.

List FOUR types of pressure. (4)

2.2 A manometer is a device for measuring pressure.

2.2.1 Name TWO types of liquids commonly used in manometers. (2)

2.2.2 Make a neat and labelled sketch of an equal-leg U-tube manometer. (6)

2.2.3 A well-type manometer is used to measure the difference between two pressures. The mercury rises 150 mm in the narrow leg. The diameter of the cistern is 100 mm and that of the narrow leg is 20 mm.
Take g = 10 m/s$^2$. (7)

2.3 Mechanical pressure-sensing elements include the bellows, the diaphragm, and the Bourdon tube. Each of these devices converts a fluid pressure into a force.

2.3.1 Make a neat and labelled sketch of a C-type Bourdon tube. (6)

2.3.2 Pressure is often given in *in. WC*. What does *in. WC* stand for? (1)

Copyright reserved 

2.4 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–F) next to the question number (2.4.1–2.4.5) in the ANSWER BOOK.

| COLUMN A | | COLUMN B | |
|---|---|---|---|
| 2.4.1 | A process whereby a portion of a liquid converts to a vapour as it passes through a control valve because the pressure has dropped to below the vapour pressure of the liquid | A | linear valve |
| | | B | flashing |
| | | C | cavitation |
| 2.4.2 | A process whereby vapour bubbles in a flowing liquid collapse inside a control valve as the pressure begins to increase | D | on/off actuator |
| | | E | diaphragm |
| 2.4.3 | A device used to position a valve mechanism in one of two extreme positions | F | pneumatics |
| 2.4.4 | A valve that allows flow to increase at the same rate as an opening | | |
| 2.4.5 | Powered by air | | |

(5 × 1) (5)

2.5 List SIX problems commonly associated with positioners. (6)

**[37]**

Copyright reserved

## QUESTION 3: CONTROL VALVES

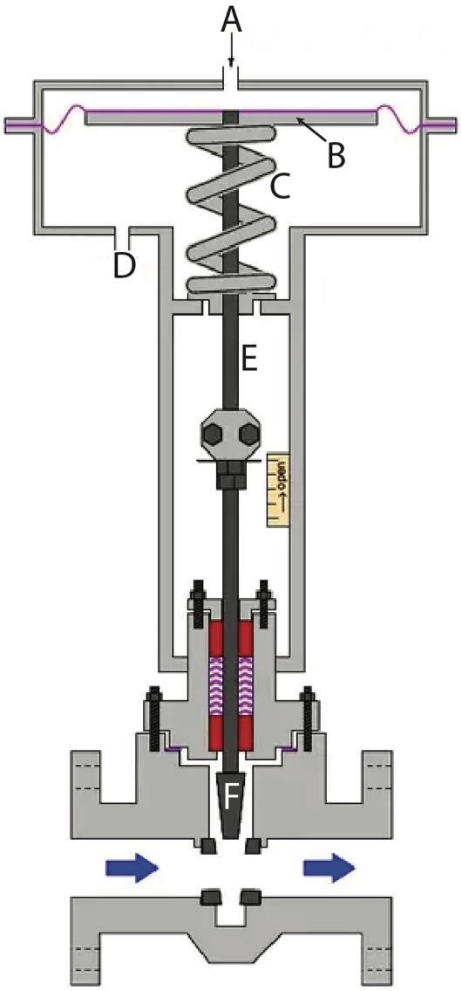
3.1 Answer the following questions:

3.1.1 What is the purpose of a positioner? (4)

3.1.2 What is a valve stem? (2)

3.2 Make a neat, labelled sketch of a weir diaphragm valve. (6)

3.3 Study the diagram below and answer the following questions:




3.3.1 Which type of valve is depicted in the sketch? (1)

3.3.2 Which type of actuator action is depicted in the sketch? (2)

3.3.3 Label the parts marked A, B, C, D, E and F. (6)

3.3.4 Explain the operating principle of this valve. (4)

3.4 Control valves are subject to a number of common problems.

List FIVE such problems. (5)

**[30]**

Copyright reserved

## QUESTION 4: TEMPERATURE MEASUREMENT

4.1 Temperature is one of the most important of the measured variables encountered in the industrial environment.

4.1.1 What are the FOUR most common temperature scales? (4)

4.1.2 Convert 32 °F to degrees Rankine. (2)

4.2 Phenomena that govern the behaviour of a thermocouple are the Seebeck effect, the Peltier effect, and the Thomson effect.

4.2.1 Describe these phenomena. (6)

4.2.2 List THREE materials that are commonly used as sensing elements in resistance temperature detectors. (3)

4.3 Explain how the principles of thermal expansion are applied in the construction and operation of a bimetallic expansion thermometer. (7)

4.4 A resistance thermometer has a resistance of 100 Ω at 0 °C. At 80 °C its resistance is 106 Ω. Calculate the temperature coefficient of the sensing element. (3)

4.5 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (4.5.1–4.5.5) in the ANSWER BOOK.

4.5.1 The theory of resistance states that when temperature increases, metals expand and that when temperature decreases, metals shrink.

4.5.2 A bimetallic is a device that detects or measures and records a physical property.

4.5.3 A thermocouple is a thermoelectric device for measuring the difference in temperature between two points.

4.5.4 A sensor consists of two metals.

4.5.5 Thermometry is the measurement of temperature.

(5 × 1) (5)

**[30]**

Copyright reserved

## QUESTION 5: FLOW MEASUREMENT

5.1 Explain how you will go about doing the following:

5.1.1 Zero-checking an orifice plate flowmeter. (3)

5.1.2 Calibrating an orifice plate flowmeter. (3)

5.2 Explain the operating principle of a positive displacement flowmeter. (5)

5.3 List FOUR common types of positive displacement flowmeters. (4)

5.4 Explain the difference between *laminar* and *turbulent flow.* (7)

5.5 The operating principles of all differential pressure flowmeters are based on the equation developed by Daniel Bernoulli.

5.5.1 Explain the operating principles of differential pressure flowmeters. (4)

5.5.2 Make a neat, labelled sketch of a Pitot tube. (6)

5.6 Fill in the table below indicating fault-finding in a rotameter.

| PROBLEM | CAUSE | SOLUTION |
|---|---|---|
| When the flowmeter is started up, there is no accurate indication. | Float does not move when there is fluid. | 5.6.1 … (2) |
| Flowmeter seems to be inaccurate. | Process operating condition is not the same as the design condition. | 5.6.2 … (2) |
| Fluctuating indication | Pulsating of flow rate. | 5.6.3 … (2) |

(6)

**[38]**

**TOTAL: 150**

Copyright reserved

**FORMULA SHEET**

**INSTRUMENTATION TECHNOLOGY**

(1)

$$V = 1{,}274\left[\frac{Q}{d^2}\right]$$

(2)

$$R_T = R_0[1 + \alpha T]$$

(3)

$$\Delta P = P_2 - P_1 = \rho g h$$

(4)

$$\Delta \mathrm{P} = \rho \mathrm{gh}\left[\frac{\mathrm{A}_2}{\mathrm{A}_1} + 1\right]$$

(4)

$$d = \frac{\mathrm{A}_2}{\mathrm{A}_1} \times h$$

(5)

$$P = \frac{Mg}{A}$$

(6)

$$K = \frac{5}{9}[°F + 459{,}67]]$$

(7)

$$℃ = \frac{5}{9}[°\mathrm{F} - 32]$$

(8)

$$K = °C + 273$$

(9) °R = °F + 459.67

Copyright reserved