



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE FLUID MECHANICS N6

11 August 2023

This marking guideline consists of 9 pages.

QUESTION 1

- 1.1 1.1.1 Its diameter
 $d = 0,08 \times 4$
 ↳ 320 mm (1)
- 1.1.2 Its wetted perimeter
 $P = \pi \times 0,32$ alternatively $P = 2 \times \pi \times 0,16$
 ↳ 1,005 m (1)
- 1.1.3 Its friction head
 $\sin 10 = \frac{h_f}{25}$
 $h_f = 4,341 \text{ m}$ (1)
- 1.1.4 Its hydraulic gradient
 $i = \sin 10^\circ$ alternatively $i = \frac{4,341}{25}$
 ↳ 0,174 (1)
- 1.1.5 Its rubbing surface area
 $S = \pi \times 0,32 \times 25$
 ↳ 25,133 m² (1)
- 1.1.6 Its friction factor if it is old and encrusted, rounded off to 5 decimal places
 $f = 0,01 \left(1 + \frac{1}{40d} \right)$
 ↳ $0,01 \left(1 + \frac{1}{40 \times 0,32} \right)$ ✓
 $f = 0,01078$ ✓ (2)
- 1.1.7 The velocity of oil
 $v = \sqrt{\frac{h_f 2gd}{4fl}}$
 ↳ $\sqrt{\frac{4,341 \times 2 \times 9,81 \times 0,32}{4 \times 0,01078 \times 25}}$ ✓
 ↳ 5,028 m/s ✓ (2)
- 1.1.8 The delivery of oil (1)
 $Q = v \times \frac{\pi}{4} d^2$
 ↳ $5,028 \times \frac{\pi}{4} (0,32)^2$ ✓

$$0,404 \text{ m}^3/\text{s}$$

1.1.9 The density of oil

$$\rho = 0,9 \times 1000$$

$$0,900 \text{ kg/m}^3 \quad \checkmark$$

(1)

1.1.10 The Chezy's constant

$$C = \sqrt{\frac{2g}{f}}$$

$$0,01078 \quad \checkmark$$

$$42,659 \quad \checkmark$$

(2)

1.2 1.2.1 The velocity of flow in the bigger pipe.

$$v_1 = \frac{4 \times 0,25}{\pi \times (0,5)^2} \quad \checkmark$$

$$1,273 \text{ m/s} \quad \checkmark$$

(2)

1.2.2 The velocity of flow in the smaller pipe.

$$v_2 = \frac{4 \times 0,25}{\pi \times (0,3)^2}$$

$$3,537 \text{ m/s} \quad \checkmark$$

(1)

1.2.3 The friction head in the system

$$h_{fr} = \left(\frac{4flv^2}{2gd} \right)_1 + \left(\frac{4flv^2}{2gd} \right)_2$$

$$0,01 \times 25 \times (1,273)^2 + \frac{4 \times 0,02 \times 13 \times (3,537)^2}{2 \times 9,81 \times 0,3}$$

$$2,375 \text{ m} \quad \checkmark$$

(3)

1.2.4 The total losses in the system

$$\text{Total Losses} = 2,375 + \frac{0,5(3,537)^2}{2 \times 9,81} \quad \checkmark$$

$$2,694 \text{ m} \quad \checkmark$$

(2)

1.2.5 The pressure reading on the gauge attached to the smaller pipe.
Consider only the exit pipe friction losses.

(3)

$$\frac{Pr_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{Pr_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + \text{Losses}$$

$$\frac{150}{9,81} + \frac{1,273^2}{2 \times 9,81} = \frac{Pr_2}{9,81} + \frac{3,537^2}{2 \times 9,81} + 9,835 + \frac{4 \times 0,02 \times 13 \times (3,537)^2}{2 \times 9,81 \times 0,3}$$

✓

$$Pr_2 = 26,391 \text{ kPa}$$

1.3 The coefficient of friction according to Chezy's formula.

$$i = \frac{h_f}{L} \quad m = \frac{d}{4} \quad A = \frac{\pi}{4} (0,4)^2$$

$$\hookrightarrow \frac{10}{1500} = 6,667 \times 10^{-3} \quad \checkmark \quad \hookrightarrow \frac{0,4}{4} = 0,1 \text{ m} \quad \checkmark \quad \hookrightarrow 0,1257 \text{ m}^2 \quad \checkmark$$

$$Q = AC \sqrt{mi}$$

$$0,0163 = 0,1257 \times C \sqrt{0,1 \times 6,667 \times 10^{-3}}$$

$$C = 5,024 \quad \checkmark$$

$$C = \sqrt{\frac{2g}{f}}$$

$$5,024 = \sqrt{\frac{2 \times 9,81}{f}}$$

$$f = 0,777 \quad \checkmark$$

(6)

[30]

QUESTION 2

2.1 2.1.1 The value of the angle y

$$y = \tan^{-1} \left(\frac{4}{2,5} \right)$$

$$\hookrightarrow 57,995^\circ \quad \checkmark$$

(1)

2.1.2 The dimension x

$$A = \left(\frac{1}{2} \times 5 \times 4 \right) \times 5x \quad \checkmark$$

$$\hookrightarrow 10 + 5x \quad \checkmark$$

$$r = \sqrt{4^2 + 2,5^2} \quad \text{alternatively} \quad \sin 57,995^\circ = \frac{4}{r}$$

$$\hookrightarrow 4,717 \text{ m} \quad \checkmark$$

$$\hookrightarrow 4,717 \text{ m} \quad \checkmark$$

$$P = 2(4,717) + 2x$$

$$\hookrightarrow 9,434 + 2x \quad \checkmark$$

$$1,2 = \frac{10 + 5x}{9,434 + 2x} \quad \checkmark$$

$$1,321 = 2,6x$$

$$x = 507,991 \text{ mm} \quad \checkmark$$

(6)

$$2.1.3 \quad A = 10 + 5(0,50799) \quad \checkmark$$

$$\hookrightarrow 12,54 \text{ m}^2$$

$$Q = AC\sqrt{mi}$$

$$Q = 12,54 \times 65 \sqrt{1,2 \times \frac{3}{1000}}$$

$$\hookrightarrow 48,906 \text{ m}^3/\text{s} \quad (3)$$

$$2.2 \quad 2.2.1 \quad V_{th} = \sqrt{2 \times 9,81 \times 4}$$

$$\hookrightarrow 8,859 \text{ m/s} \quad \checkmark$$

$$0,98 = \frac{V_A}{8,859} \quad \checkmark$$

$$V_A = 8,6817 \text{ m/s} \quad \checkmark$$

$$V_A = \sqrt{\frac{gx^2}{2y}}$$

$$8,6817 = \sqrt{\frac{9,81 \times x^2}{2 \times 1,5}}$$

$$x = 4,801 \text{ m} \quad \checkmark \quad \checkmark$$

$$2.2.2 \quad Q_{th} = \sqrt{2 \times 9,81 \times 4} \times 1,963 \times 10^{-3}$$

$$\hookrightarrow 0,0174 \text{ m}^3/\text{s} \quad \checkmark$$

$$C_d = \frac{Q_A}{Q_{TH}} \quad \checkmark$$

$$0,87 = \frac{Q_A}{0,0174} \quad \checkmark$$

$$\hookrightarrow 0,0151 \text{ m}^3/\text{s} \quad \checkmark$$

$$F = \rho Q_A V_A$$

$$\hookrightarrow 10^3 \times 0,0151 \times 8,6817 \quad \checkmark$$

$$\hookrightarrow 131,381 \text{ N} \quad \checkmark$$

(2 × 5) (10)

$$2.3 \quad P_r = \frac{kSv^2}{a}$$

$$a = \frac{\pi(0,85)^2}{4}$$

$$\hookrightarrow 0,567 \text{ m}^2$$

$$208 = \frac{0,00335 \times S \times 20,226^2}{0,567} \quad \checkmark$$

$$S = 85,784 = \pi \times x \times 0,85 \times L$$

$$L = 32,125 \text{ m} \quad \checkmark$$

$$v = \frac{11,5}{0,567}$$

$$\hookrightarrow 20,226 \text{ m/s}$$

(3)
[23]

QUESTION 3

- 3.1 3.1.1
$$h_f = \frac{4fL}{2gd} \left(\left(\frac{D}{d} \right)^2 \frac{\omega R}{\pi} \right)^2$$

$$\hookrightarrow \frac{4 \times 0,007 \times 45}{2 \times 9,81 \times 0,25} \left(\left(\frac{0,4}{0,25} \right)^2 \frac{2 \times N}{60} \times \frac{0,6}{2} \right)^2$$

$$\hookrightarrow 168,349 \times 10^{-6} N \quad \checkmark \quad (2)$$
- 3.1.2 $Q = ALSEN / 60$

$$\hookrightarrow \frac{\pi}{4} (0,4)^2 \times 0,6 \times 2 \times 2 \times \frac{N}{60} \quad \checkmark$$

$$\hookrightarrow 5,02656 \times 10^{-3} N \quad \checkmark \quad (2)$$
- 3.1.3 $P = \rho g Q H_f$

$$3 \times 10^3 = 10^3 \times 9,81 \times 5,02656 \times 10^{-3} N \times 168,349 \times 10^{-6} N^2 \quad \checkmark$$

$$N = 71,229 \text{ r/min} \quad \checkmark \quad (2)$$
- 3.1.4 $\omega = \frac{2\pi N}{60}$

$$\hookrightarrow \frac{2\pi \times 71,229}{60} \quad \checkmark$$

$$\hookrightarrow 7,459 \text{ rad/s} \quad (2)$$
- 3.1.5
$$h_f = \frac{4fL}{2gd} \left(\left(\frac{D}{d} \right)^2 \omega R \right)^2$$

$$\hookrightarrow \frac{4 \times 0,007 \times 45}{2 \times 9,81 \times 0,25} \left(\left(\frac{0,4}{0,25} \right)^2 \frac{2\pi \times N}{60} \times \frac{0,6}{2} \right)^2$$

$$\hookrightarrow 1,6615 \times 10^{-3} N^2 \quad \checkmark \quad (2)$$
- 3.1.6 $Q = ALSEN / 60$

$$\hookrightarrow \frac{\pi}{4} (0,4)^2 \times 0,6 \times 2 \times 2 \times \frac{N}{60}$$

$$\hookrightarrow 5,02656 \times 10^{-3} N \quad \checkmark \quad (1)$$

3.1.7

$$P = \rho g Q \frac{2}{3} H_f$$

$$13 \times 10^3 = 10^3 \times 9,81 \times 5,02656 \times 10^{-3} N \times \frac{2}{3} \times 1,6615 \times 10^{-3} N^2$$

$$N = 61,972 \text{ r/min}$$

✓

(2)

3.1.8

$$\omega = \frac{2\pi N}{60}$$

$$\hookrightarrow \frac{2\pi \times 54,137}{60}$$

$$\hookrightarrow 6,4897 \text{ rad/s}$$

✓

(2)

3.2

3.2.1

Diameter at suction

$$Q = Va$$

$$0,14 = 1,2 \times \frac{\pi}{4} \times (d)^2$$

✓

$$\hookrightarrow 385,415 \text{ mm}$$

✓

Diameter at delivery

$$Q = Va$$

$$0,14 = 2,9 \times \frac{\pi}{4} \times (d)^2$$

✓

$$\hookrightarrow 247,925 \text{ mm}$$

✓

(4)

3.2.2

$$\text{No of stages} = \frac{240}{120}$$

$$\hookrightarrow 2 \text{ stages}$$

✓

(1)

[20]**QUESTION 4**

4.1

4.1.1

$$V_{Ai} = \sqrt{2gh}$$

$$\hookrightarrow \sqrt{2 \times 9,81 \times (36 \times 0,905)}$$

✓

$$\hookrightarrow 25,283 \text{ m/s}$$

✓

(11)

$$V_i = 12 \sin 55$$

✓

$$\hookrightarrow 9,829 \text{ m/s}$$

✓

$$V_{wi} = \sqrt{(25,283)^2 - (9,829)^2}$$

✓

$$\checkmark 23,294 \text{ m/s} \quad \checkmark$$

$$x = 12 \cos 55$$

$$\checkmark 6,883 \text{ m/s}$$

$$U_i = V_{wi} - x$$

$$\checkmark 23,294 - 6,883$$

$$\checkmark 16,411 \text{ m/s}$$

$$U_i = \frac{\pi D N}{60}$$

$$16,411 = \frac{\pi \times D \times 255}{60}$$

$$D = 1,229 \text{ m}$$

$$4.1.2 \quad V_i = V_o = 9,829 \text{ m/s}$$

$$V_{ro} = 0,93 V_{ri}$$

$$\checkmark 0,93(12)$$

$$\checkmark 11,16 \text{ m/s} \quad \checkmark$$

$$\beta_o = \sin^{-1} \left(\frac{V_o}{V_{ro}} \right)$$

$$\checkmark \sin^{-1} \left(\frac{9,829}{11,16} \right) \quad \checkmark$$

$$\checkmark 61,74^\circ \quad \checkmark$$

(3)

$$4.2 \quad 4.2.1 \quad h = 341 \times 0,88 = 300,08 \text{ m}$$

$$V_i = \sqrt{2 \times 9,81 \times 341 \times 0,88}$$

$$\checkmark 76,73 \text{ m/s} \quad \checkmark$$

$$\eta = \frac{U_i}{gh} (V_i - U_i) [1 + n \cos(180^\circ - y)] \times 100 \%$$

$$0,93 = \frac{40}{9,81 \times 300,08} (76,73 - 40) [1 + 0,92 \cos(180^\circ - y)]$$

✓

$$180^\circ - y = 20,205^\circ$$

$$y = 159,795^\circ \quad \checkmark$$

(4)

$$4.2.2 \quad P = \rho Q U (V - U) [1 + \cos(180^\circ - \theta)]$$

$$Q = \frac{4000 \times 10^3}{10^3 \times 40 (76,73 - 40) [1 + 0,92 \cos(180^\circ - 20,205)]}$$

$$\hookrightarrow 2,248 \text{ m}^3/\text{s} \quad \checkmark \quad (2)$$

$$4.2.3 \quad h_f = 341 - 300,08 \text{ alternatively } h_f = 341 \times 0,12$$

$$\hookrightarrow 40,92 \text{ m} \quad \checkmark \quad (1)$$

$$4.2.4 \quad h_f = \frac{f L Q^2}{3 d^5}$$

$$40,92 = \frac{f \times 1000 \times (2,248)^2}{3 \times (0,9)^5} \quad \checkmark$$

$$f = 0,0322 \quad \checkmark \quad (2)$$

$$4.2.5 \quad U_i = \frac{\pi D N}{60}$$

$$40 = \frac{\pi \times D \times 380}{60}$$

$$D = 2,01 \text{ m} \quad \checkmark \quad (2)$$

4.2.6

$$\frac{Q}{\text{No of jets}} = Va$$
$$\frac{2,248}{3} = 76,73 \times \frac{\pi}{4} \times (d_{jet})^2 \quad \checkmark$$
$$d_{jet} = 111,509 \text{ mm}$$

(2)

[27]**TOTAL: 100**