



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N6

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This marking guideline consists of 7 pages.

QUESTION 1

- 1.1 1.1.1 $V_2 = 9V_1 \checkmark$
- $$\frac{\Delta P}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} + z_2$$
- $$\frac{60}{9,81} \checkmark = \frac{(9V_1)^2}{2 \times 9,81} - \frac{(V_1)^2}{2 \times 9,81} + 0,39 \frac{(9V_1)^2}{(2 \times 9,81)} \checkmark$$
- $$120 = 111,59V_1^2 \checkmark$$
- $$V_1 = 1,0369 \text{ m/s} \checkmark$$
- $$V_2 = 9,332 \text{ m/s} \checkmark \quad (6)$$
- 1.1.2 $D = \sqrt{\frac{4 \times 0,04}{\pi \times 1,0369}} \checkmark$
- $$= 221,16 \text{ mm} \checkmark$$
- $$d = 73,72 \text{ mm} \checkmark \quad (3)$$
- 1.1.3 $\frac{\Delta P}{\rho g} = \frac{111,59V_1}{2\rho} \checkmark$
- $$\Delta P = \frac{111,59(1,0369)^2 \times 850}{2} \checkmark$$
- $$\Delta P = 50,999 \text{ kPa} \checkmark \quad (3)$$
- 1.2 1.2.1 $V_1 \times A_1 = V_2 \times A_2 \quad (14)$
- $$V_1 = V_2 \times \left(\frac{d_2}{d_1}\right)^2$$
- $$V_1 = V_2 \times \left(\frac{80}{100}\right)^2 \checkmark$$
- $$V_1 = 0,64 V_2 \checkmark$$
- $$\text{Entry} = \frac{0,5 V_1^2}{2g} \checkmark = 0,0255 V_1^2 \checkmark$$
- $$\text{Pipe friction}_1 = \frac{4 f l V_1^2}{2 g d} = \frac{4 \times 0,02 \times 200 \times V_1^2}{2 \times 9,81 \times 0,08} \checkmark = 10,194 V_1^2 \checkmark$$
- $$\text{Sudden Enlargement} = \frac{(V_1 - V_2)^2}{2g} = \frac{(V_1 - 0,64 V_1)^2}{2 \times 9,81} \checkmark = 0,0066 V_1^2 \checkmark$$

PRODUCTION AND QUALITY CONTROL N5

$$\text{Pipe friction}_2 = \frac{4 f l V_2^2}{2 g d} = \frac{4 \times 0,02 \times 450 \times 1,5625 V_1^2}{2 \times 9,81 \times 0,12} \checkmark = 23,891 V_1^2 \checkmark$$

$$\text{Exit} = \frac{V_2^2}{2 g} = \frac{(1,5625 V_1)^2}{2 \times 9,81} \checkmark = \underline{0,1244} V_1^2 \checkmark$$

$$\sum V_1^2 \checkmark = 34,2415 V_1^2 \checkmark$$

$$1.2.2. \quad 35 = 34,2415 V_1^2$$

$$V_1 = 1,011 \text{ m/s} \checkmark$$

$$Q = 1,011 \times \frac{\pi}{4} (0,08)^2 \checkmark$$

$$= 5,082 \text{ l/s} \checkmark$$

(3)
[29]**QUESTION 2**

$$2.1. \quad \frac{b}{2} = x = \frac{d}{\tan 60^\circ}$$

$$b = 1,154 d \checkmark$$

$$A = d (b + 0,577 d) \checkmark$$

$$= d (1,154 d + 0,577 d) \checkmark$$

$$= 1,732 d^2 \checkmark$$

$$P = 2 (1,154 d) + 1,154 d \checkmark$$

$$= 3,464 d \checkmark$$

$$m = \frac{1,732 d^2}{3,464 d}$$

$$= 0,5 d \checkmark$$

(7)

$$2.2 \quad 2.2.1 \quad C_c = \frac{A_A}{A_{th}}$$

$$C_c = \frac{d_{jet}^2}{d_{ori}^2}$$

$$= \frac{0,019^2}{0,02^2} \checkmark$$

$$= 0,903 \checkmark$$

(2)

$$2.2.2 \quad F = \rho Q V_A$$

(3)

PRODUCTION AND QUALITY CONTROL N5

$$= 1\,000 \times 0,12 \checkmark \times \frac{0,12 \times 4}{\pi \times 0,019^2} \checkmark$$

$$= 50,788 \text{ kN} \checkmark$$

$$2.2.3 \quad v = \sqrt{\frac{gx^2}{2y}}$$

$$4,232 = \sqrt{\frac{9,81 \times 4,2^2}{2 \times 2}} \checkmark$$

$$= 6,577 \text{ m/s} \checkmark \quad (2)$$

$$2.3 \quad Q = 1,84 (L - 0,1nH)H^{1,5}$$

$$= 1,84 (5 - 0,1 \times 2 \times 0,24)0,24^{1,5} \checkmark$$

$$= 0,206 \text{ m}^3/\text{s} \checkmark \quad (2)$$

$$2.4 \quad Q = \frac{2}{3} C_d \sqrt{2g} \times L \times H^{1,5}$$

$$0,206 = \frac{2}{3} C_d \sqrt{2 \times 9,81} \times 5 \times 0,24^{1,5} \checkmark$$

$$C_d = 0,119 \checkmark \quad (2)$$

[18]

QUESTION 3

3.1	3.1.1	$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2} \right)^2$ $\frac{100}{125} = \left(\frac{1000}{N_2} \right)^2 \checkmark$ $N_2 = 1118,03 \text{ r/min} \checkmark$	(2)
	3.1.2	$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$ $Q_2 = 45 \left(\frac{1118,03}{1000} \right) \checkmark$ $= 50,311 \text{ l/s} \checkmark$	(2)

3.1.3

$$P_i = \frac{\rho g Q h}{\eta}$$

$$= \frac{1000 \times 9,81 \times 0,045 \times 100}{0,8} \checkmark$$

$$= 55,181 \text{ kW} \checkmark$$

$$P_{out} = \frac{\rho g Q h}{\eta}$$

$$= \frac{1000 \times 9,81 \times 0,0503 \times 125}{0,8} \checkmark$$

$$= 77,1 \text{ kW} \checkmark$$

(4)

3.2

3.2.1

- Piston pump > The piston length is longer than its stroke
- Plunger pump > The piston length is shorter than its stroke

3.2.2.

- Single-acting > During one/a single stroke only one action occurs (say suction)
- Double-acting > During one/a single stroke both actions occur simultaneously (delivery and suction)

3.2.2

- Centrifugal > Uses the impeller to suck and deliver through a centrifugal force
- Positive displacement > Uses the piston/plunger through positive displacement for suction and delivery

(2 × 3)

(6)

3.3

3.3.1

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

$$= \frac{2\pi \times 60}{60} \checkmark$$

$$= 6,283 \text{ m/s} \checkmark$$

$$Q = C_d A L S E \frac{N}{60}$$

$$= 0,94 \frac{\pi}{4} (0,13)^2 \times 0,25 \times 2 \times 1 \times \frac{60}{60} \checkmark$$

$$= 0,00624 \text{ m}^3/\text{s} \checkmark$$

$$h_{fr} = \frac{f l Q^2}{3 d^5}$$

$$= \frac{0,02 \times 42 \times 0,00624^2}{3(0,055)^5} \checkmark$$

$$= 21,732 \text{ m} \checkmark$$

$$\begin{aligned}
 h_{f2} &= \frac{4fl}{2gd} \left[\left(\frac{D}{d} \right)^2 \omega R \right]^2 \\
 &= \frac{4 \times 0,02 \times 4}{2 \times 9,81 \times 0,045} \left[\left(\frac{0,13}{0,045} \right)^2 \frac{2\pi \times 60}{60} \times \frac{0,25}{2} \right]^2 \checkmark \\
 &= 15,5719 \text{ m } \checkmark \\
 P_i &= \frac{\rho g Q \left(h_s + h_{f1} + \frac{2}{3} h_{f2} \right)}{\eta} \\
 &= \frac{10^3 \times 9,81 \times 0,00624 \times \left[0 + 21,732 + \frac{2}{3} \times 15,571 \right]}{0,94} \checkmark \\
 &= 2,0855 \text{ kW } \checkmark
 \end{aligned}$$

(10)

3.3.2

$$\begin{aligned}
 Q_2 &= 2 Q_1 \\
 &= 2(0,00624) \\
 &= 0,0125 \text{ m}^3/\text{s} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 h_{f1} &= \frac{f l Q^2}{3 d^5} \\
 &= \frac{0,02 \times 42 \times 0,0125^2}{3 (0,055)^5} \checkmark \\
 &= 86,607 \text{ m } \checkmark
 \end{aligned}$$

$$\begin{aligned}
 P_i &= \frac{\rho g Q \left(h_s + h_{f1} + \frac{2}{3} h_{f2} \right)}{\eta} \\
 &= \frac{10^3 \times 9,81 \times 0,0125 \times \left[0 + 21,732 + \frac{2}{3} \times 86,607 \right]}{0,94} \checkmark \\
 &= 18,795 \text{ kW } \checkmark
 \end{aligned}$$

(5)

[29]**QUESTION 4**

$$4.1.1 \quad P_r = \rho g h$$

$$h = \frac{1,4 \times 10^6}{1000 \times 9,81} \checkmark$$

$$= 142,712 \text{ m } \checkmark$$

PRODUCTION AND QUALITY CONTROL N5

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

$$i \frac{\pi \times 1,6 \times 250}{60} \checkmark$$

$$= 20,944 \text{ m/s} \checkmark$$

$$\begin{aligned}
 V &= C_v \sqrt{2gh} \\
 &= 0,96 \sqrt{2 \times 9,81 \times 142,712} \checkmark \\
 &= 50,798 \text{ m/s} \checkmark \\
 A_{jet} &= \frac{\pi \times 0,112^2}{60} \\
 &= 9,852 \times 10^{-3} \text{ m}^2 \checkmark \\
 Q &= V_i A \\
 &= 50,798 \times 9,852 \times 10^{-3} \checkmark \\
 &= 0,5 \text{ m}^3/\text{s} \checkmark \\
 P_{out} &= \rho Q U (V - U)(1 + n \cos \theta) \\
 &= 10^3 \times 0,5 \times 20,944 (50,798 - 20,944)(1 + 0,91 \cos 19^\circ) \checkmark \\
 &= 581,626 \text{ kW} \checkmark
 \end{aligned} \tag{11}$$

$$\begin{aligned}
 4.1.2 \quad \eta &= \frac{U}{gh} (V - U)(1 + n \cos \theta) \times 100\% \\
 &= \frac{20,944}{9,81 \times 142,712} (50,798 - 20,944)(1 + 0,91 \cos 19^\circ) \times 100\% \checkmark \\
 &= 83,089\% \checkmark
 \end{aligned} \tag{2}$$

$$\begin{aligned}
 4.1.3 \quad P &= \rho g Q h \\
 &= 1\,000 \times 9,81 \times 0,5 \times 142,712 \checkmark \\
 &= 700 \text{ kW} \checkmark
 \end{aligned} \tag{2}$$

- 4.2
- Outward (radial) flow
 - Inward flow
 - Parallel (radial) flow
 - Mixed flow
- (4)

$$\begin{aligned}
 4.3 \quad S &= 4b \times L \\
 &= 4b \times 50 \\
 &= 200b \checkmark
 \end{aligned} \tag{5}$$

$$a_{duct} = b^2$$

$$\begin{aligned}
 V &= \frac{Q}{a} \\
 &= \frac{9,2}{b^2} \checkmark
 \end{aligned}$$

$$P_r = \frac{k S V^2}{a}$$

$$\begin{aligned}
 200 &\hat{=} \frac{0,003 \times 200 b \times 9,2}{b^4} \checkmark \\
 b^3 &= 0,0276 \checkmark
 \end{aligned}$$

b = 166, 132 mm✓

[24]

TOTAL: 100