higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

5 August 2021

This marking guideline consists of 11 pages.

QUESTION 1

1.1 The purpose of bearing lubrication is to prevent direct metallic (metal to metal) contact between different rotating and sliding components in a mechanical mechanism. (2)

1.2
- Eliminates rapid material expansion due to the rise in temperature
- Increases the expected life span of the material
- Reduction of friction and wear
- Dissipation of friction heat
- Prevents metal decay due to corrosion
- Protects against harmful elements
- Power loss due friction (Any 2 × 1) (2)

1.3 The tendency to resist sliding layers of fluid measured in Pa.s. ✓ The kinetic viscosity is the ratio of the absolute viscosity to the mass✓ density measured in m^2/s. ✓ (3)

1.4 1.4.1

$$from, F = \frac{\mu A v}{t}$$

$$t = \frac{D-d}{2}$$

$$= \frac{0,1503-150}{2} \quad \surd$$

$$= 150 \times 10^{-6} m \quad \surd$$

$$A = \pi DL$$

$$= \pi \times 0,15 \times 0,17 \quad \surd$$

$$= 80,111 \times 10^{-3} m^2 \quad \surd$$

$$v = \pi DN$$

$$= \pi \times 0,15 \times 20 \quad ✓$$

$$= 9,425 m/s \quad ✓$$

$$F = \frac{\mu A v}{t}$$

$$= \frac{0,02 \times 80,111 \times 10^{-3} \times 9,425}{150 \times 10^{-6}} \quad ✓$$

$$= 100,673 N \quad ✓$$

$$P = Fv$$

$$= 100,673 \times 9,425 \quad ✓$$

$$= 0,949 kW \quad ✓$$

(8)

1.4.2

$$\upsilon = \frac{\mu}{\rho}$$
$$= \frac{0{,}02}{830} \checkmark$$
$$= 24{,}096 \times 10^{-6} m^2/s \checkmark$$
(2)

1.4.3

$$from, P = Fv$$
$$t = 150{,}3 - 150 \checkmark$$
$$= 300 \times 10^{-6} m \checkmark$$

$$P = \frac{0{,}02 \times 80{,}111 \times 10^{-3} \times 5}{300 \times 10^{-6}}$$
$$= 0{,}0267 kW \checkmark$$
(3)
[20]

QUESTION 2

2.1 2.1.1

$$P_c = P_p ... Pascal's\ law$$
$$\frac{F_c}{A_c} = \frac{F_p}{A_p} \quad \surd$$
$$F_p = \frac{d_c^2}{d_c^2} F_c \quad \surd$$
$$= \frac{0{,}68^2}{0{,}0425^2} \times (2550) \checkmark$$
$$= 652{,}8 kN \checkmark$$
(3)

2.1.2

$$SV_c = SV_p$$
$$A_c \times SL_c = nA_p \times SL_p \quad \surd$$
$$n = \frac{d_c^2}{d_p^2} \times \frac{SL_c}{SL_p} \quad \surd$$
$$= \frac{0{,}68^2}{0{,}0425^2} \times \frac{3{,}4}{0{,}425} \checkmark$$
$$= 2048\ strokes \checkmark$$
(3)

2.1.3

$$WD = F_P \times sl$$
$$= 652{,}8 \times 3{,}4 \checkmark$$
$$= 2219{,}52 J \checkmark$$
(2)

2.1.4

$$P = \frac{WD}{time}$$
$$= \frac{2219,5}{51} \checkmark$$
$$= 43,52W \checkmark$$

(2)

2.2 2.2.1

$$SV = A \times SL$$
$$= \frac{\pi}{4} \times 0,06^2 \times 0,17 \checkmark$$
$$= 480,664 \times 10^{-3} m^3 \checkmark$$

(2)

2.2.2

$$P = \frac{F}{A}$$
$$= \frac{4 \times 3,4 \times 10^3}{\pi \times 0,06^2} \checkmark$$
$$= 1,203 MPa \checkmark$$

(2)

2.2.3

$$K_{air} = P\gamma$$
$$= 1,203 \times 1,4 \quad \surd$$
$$= 1,684 MPa \quad \surd$$

(1)

2.2.4

$$from, \frac{1}{K_e} = \frac{1}{K_l} + \frac{1}{K_c} + \frac{V_{air}}{V_{total} K_{air}} \quad \surd$$
$$= \frac{1 \ \surd}{2,035 \times 10^9} + \frac{2,5 \ \surd}{8,8 \times 10^9} + \frac{3,44 \times V_{total}}{100 V_{total} \times 1,684 \times 10^6}$$
$$= 491,40049 \times 10^{-12} + 284,09091 \times 10^{-12} + 20,427553 \times 10^{-9} \quad \surd$$
$$\frac{1}{K_e} = 21,203044 \times 10^{-9} \quad \surd$$
$$K_e = 47,143 MPa \quad \surd$$

(3)

2.2.5

$$from, P = K_e \times \frac{\Delta V}{V_{total}}$$
$$P = K_e \times \frac{A \times \Delta L}{A \times SL} \quad \surd$$
$$\Rightarrow \Delta L = \frac{1,203 \times 10^6}{47,143 \times 10^6} \times 0,17 \quad \surd$$
$$= 4,336 mm \checkmark$$

(2)

[20]

QUESTION 3

3.1 3.1.1

$$\bar{y} = \frac{d}{2}$$
$$= \frac{1,45}{2} \quad \surd$$
$$= 0,725m \quad \surd$$
$$P = \rho g \bar{y}$$
$$= 0,963 \times 1000 \times 9,81 \times 0,725 \quad ✓$$
$$= 6,849kPa \quad ✓$$

(3)

3.1.2

$$F = PA$$
$$= 6,849 \times \frac{\pi}{4} \times 1,45^2 \quad ✓$$
$$= 11,31kN \quad ✓$$

(2)

3.1.3

$$I_G = \frac{\pi D^4}{64}$$
$$= \frac{\pi \times 1,45^4}{64} \quad ✓$$
$$= 216,991 \times 10^{-3} m^4 \quad ✓$$

(2)

3.1.4

$$\bar{h} = \bar{y} + \frac{I_G \sin^2 \theta}{A \bar{y}}$$
$$\surd \quad ✓$$
$$= 0,75 + \frac{216,991 \times 10^{-3}}{\frac{\pi \times 1,45^2}{4} \times 0,75}$$
$$= 0,75 + 0,175208 \quad \surd$$
$$= 925mm \quad ✓$$

(3)

3.2 3.2.1

$$F_b = W_m$$
$$\rho g V_{displaced} = W_m \quad \surd$$
$$as, V_{displaced} = 0,925 \times \frac{\pi}{6} \times 0,05^3 \quad \surd$$
$$= 60,54111 \times 10^{-6} m^3 \quad ✓$$
$$thus, W_m = 1260 \times 9,81 \times 60,54111 \times 10^{-6} \quad ✓$$
$$= 784,324 \times 10^{-3} N \quad ✓$$

(4)

3.2.2 $W_m = \rho g V_m$

$748,324 \times 10^{-3} = \rho \times 9,81 \times \frac{\pi \times 0,05^3}{6}$ ✓

$\rho = 1165,499 kg/m^3$ ✓ (2)

3.2.3 $F_b = W_m + W_{added}$

$\rho g V_{\substack{fully \\ displaced}} = W_m + W_{added}$ √

$1260 \times \overset{\surd}{9,81} \times \frac{\pi}{6} \times 0,05^3 = \overset{\surd}{7}84,\overset{\surd}{3}24 \times 10^{-3} + \overset{\surd}{9},81 m_{added}$

$808,999378 \times 10^{-3} - 748,324 \times 10^{-3} = 9,81 m_{added}$ √

$m_{added} = \frac{60,675378 \times 10^{-3}}{9,81}$

$m_{added} = 6,185 \times 10^{-3} kg$ ✓ (4)

[20]

QUESTION 4

4.1 4.1.1 It is the path line or route followed by the fluid particles in motion which may never intersect each other,✓ where the line is instantaneous tangent to the velocity vector in the streamline at that particular point.✓

4.1.2 It is the imaginary boundary✓ or region of the fluid in motion restricted or confined by streamlines that are drawn to form a tubular region of fluid called a tube of flow, of which the fluid flowing never intersects these lines.✓

4.1.3 It is the path or route which a fluid particle follows in a fluid flow, where the path of each particle will be determined by the streamline route over a period of time.✓

4.1.4 This is the type of flow that is accompanied by indiscriminate✓ eddy currents causing the fluid particles to flow in a disorderly manner in relation to its path line.✓

4.1.5 This is the type of flow that is not accompanied by indiscriminate eddy currents,✓ causing the fluid particles to flow in an orderly manner without interfering with their adjacent path line.✓

(5 × 2) (10)

4.2 4.2.1

$$Q = \frac{volume}{time}$$

$$= \frac{93,45 \times 10^{-3}}{21,96} \quad \surd$$

$$= 4,256 \times 10^{-3} m^3 / s \quad \surd$$

(1)

4.2.2

$$Q = Av$$

$$4,256 \times 10^{-3} = \frac{\pi}{4} \times 0,0549^2 v \quad \surd$$

$$v = \frac{4,256 \times 10^{-3}}{2,367198 \times 10^{-3}} \quad \surd$$

$$= 1,798 m / s \quad \checkmark$$

(2)

4.3 4.3.1

$$from, Q = Av$$

$$v_{\phi 425} = \frac{4 \times \frac{10540 \times 10^{-3}}{60}}{\pi \times 0,425^2} \quad \checkmark$$

$$= 1,238 m / s \quad \checkmark$$

(2)

4.3.2

$$v_{\phi 425} = \frac{4 \times \frac{10540 \times 10^{-3}}{60}}{\pi \times 0,2125^2} \quad \checkmark$$

$$= 4,953 m / s \quad \checkmark$$

(2)

4.3.3

$$\frac{P_1}{\rho g} + \frac{v_1}{2g} + Z_1 - \sum h_{losses} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2$$

$$\frac{1351,5 \times 10^3}{9810} + \frac{1,238^2}{19,62} + 0 = \frac{P_2}{\rho g} + \frac{4,953^2}{19,62} + (-6,8) \quad \surd \quad \surd$$

$$\frac{P_2}{9810} = 137,76758 + 0,0781164 + 6,8 - 1,250367 \quad \checkmark$$

$$P_2 = 1,407 MPa \quad \checkmark$$

(3)

[20]

QUESTION 5

5.1 An orifice is an opening or hole in the bottom side of the tank used to discharge fluid at a given unit of time. (2)

5.2 5.2.1 $\textit{with the aid of Bernoulli's theorem}:$

$$v_{orifice} = \sqrt{2gh}$$
$$= \sqrt{19,62 \times 59,4} \checkmark$$
$$= 34,138 m/s \checkmark$$
(2)

5.2.2 $from, Q = Av_{jet}$

$$v_{jet} = \frac{4 \times 4,774 \times 10^{-3}}{\pi \times 0,0134^2} \checkmark$$
$$= 33,852 m/s \checkmark$$
(2)

5.2.3

$$C_c = \frac{A_j}{A_t}$$
$$= \frac{d_j^2}{d_o^2} \checkmark$$
$$= \left(\frac{0,0134}{0,0145}\right)^2 \checkmark$$
$$= 0,854 \checkmark$$
(2)

5.2.4

$$C_v = \frac{v_j}{v_o}$$
$$= \frac{33,852}{34,138} \checkmark$$
$$= 0,992 \checkmark$$
(2)

5.2.5

$$C_q = C_v \times C_c$$
$$= 0,992 \times 0,854 \checkmark$$
$$= 0,847 \checkmark$$

$\textit{Alternatively}:$

$$C_q = \frac{Q_j}{Q_o}$$
$$= \frac{4,774}{\frac{34,138 \times \pi \times 0,0145^2}{4}} \checkmark$$
$$= 0,847 \checkmark$$
(2)

5.2.6

$$h_{loss} = h\left(1 - C_v^2\right)$$
$$= 59,4\left(1 - 0,992^2\right) \checkmark \checkmark$$
$$= 0,947m \checkmark$$

Alternatively:

$$h_{loss} = h - \frac{v_j^2}{2g} \checkmark$$
$$= 59,4 - \frac{33,852^2}{19,62}$$
$$= 0,992m \checkmark$$

(3)

5.3 *with the aid of Bernoulli's equation*:

$$\Delta h = \frac{P_1 - P_2}{\rho g}$$
$$= \frac{6,8 \times 10^3}{9,81 \times 880} \checkmark$$
$$= 787,69345mm \checkmark$$
$$from, Q = C_Q \times a \frac{\sqrt{2g\Delta h}}{\sqrt{1 - \frac{a^2}{A^2}}}$$
$$= 0,715 \times \frac{\pi}{4} \times 0,2135^2 \times \frac{\sqrt{19,62 \times 787,69345 \times 10^{-3}}}{\sqrt{1 - \frac{\left(\frac{\pi \times 0,2135^2}{4}\right)^2}{\left(\frac{\pi \times 0,34^2}{4}\right)^2}}} \checkmark$$
$$= \frac{0,0255972 \times 3,931227}{0,8445195} \checkmark$$
$$= 120,899 l/s \checkmark$$

(5)
[20]

QUESTION 6

6.1

$$from, \overset{0}{W} = \overset{0}{m}\, g$$

$$as, Q_{system} = Q_{in} = Q_{out} ...continuity\ of\ flow$$

$$\overset{0}{W} = \rho Q g$$

$$= 820 \times \frac{\pi}{4} \times 0,22^2 \times 2,356 \times 9,81 \quad ✓$$

$$= 720,433 N/s \quad ✓$$

(2)

6.2

$$Q_{system} = Q_{in} = Q_{out} ...continuity\ of\ flow$$

$$A_{in} v_{in} = A_{out} v_{out}$$

$$v_{out} = \frac{d_{in}^2}{d_{out}^2} \times v_{in} \surd$$

$$= \frac{0,22^2}{0,125^2} \times 2,356 \surd$$

$$= 7,298 m/s ✓$$

(2)

6.3

$$from, \overset{0}{m}_{system} = \overset{0}{m}_{in} = \overset{0}{m}_{out} ...continuity\ of\ flow$$

$$as, \overset{0}{m} = \rho Q$$

$$= 820 \times \pi \times \frac{0,22^2}{4} \times 2,356 ✓$$

$$= 73,439 kg/s ✓$$

(2)

6.4

Applying Bernoulii's equation between the bend inlet and outlet:

$$E_1 - H_{loss} = E_2$$

$$\frac{P_{in}}{\rho g} + \frac{v_{in}^2}{2g} + Z_{in} - H_{loss} = \frac{P_{out}}{\rho g} + \frac{v_{out}^2}{2g} + Z_{out} \surd$$

$$\Rightarrow \frac{P_{out}}{\rho g} = \frac{P_{in}}{\rho g} + \frac{v_{in}^2}{2g} + Z_{in} - \frac{v_{out}^2}{2g} - Z_{out} - H_{loss} \surd$$

$$\frac{P_{out}}{820 \times 9,81} = \frac{86,856 \times 10^3}{820 \times 9,81} + \frac{2,356^2}{19,62} + 0 - 1,35 - \frac{7,298^2}{19,62} - 1,063 \quad ✓$$

$$P_{out} = 820 \times 9,81 \times 5,952639 ✓$$

$$= 47,884 kPa ✓$$

(4)

6.5

$$F_{in} = \overset{0}{m}_{in}\, v_{in}$$

$$= 73,439 \times 2,356 \quad \surd$$

$$= 173,022 N \surd$$

(1)

6.6
$$F_{in} = P_{in} A_{in}$$
$$= 86,856 \times 10^3 \times \frac{\pi}{4} \times 0,22^2 \surd$$
$$= 3301,681 N \surd$$
(1)

6.7
$$F_{out} = \overset{0}{m}_{out} \, v_{out}$$
$$= 73,439 \times 7,298 \surd$$
$$= 535,956 N \surd$$
(1)

6.8
$$F_{out} = P_{out} A_{out}$$
$$= 47,884 \times 10^3 \times \frac{\pi}{4} \times 0,125^2 \surd$$
$$= 587,625 N \surd$$
(1)

6.9
$$F_x = F_{in} - F_{out} \cos\theta$$
$$= \left(173,022 \overset{\surd}{+} 3301,681\right) - \left(535,956 \overset{\surd}{+} 587,625\right) \cos 52$$
$$= 2782,95 N \checkmark$$
$$F_y = \left(535,956 + 587,625\right) \sin 52 \surd$$
$$= 885,394 N \surd$$
$$from, F_r^2 = F_x^2 + F_y^2$$
$$F_r = \sqrt{2782,95^2 + 885,394^2} \quad \surd$$
$$= 2920,4 N \quad \surd$$
(4)

6.10
$$\tan\theta = \frac{F_y}{F_x}$$
$$= \tan^{-1}\left(\frac{885,394}{2782,95}\right) \checkmark$$
$$= 17,648^0 \checkmark$$
(2)

[20]

TOTAL: 100