



# higher education & training

Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

## **MARKING GUIDELINE**

**NATIONAL CERTIFICATE**

**FLUID MECHANICS N5**

**6 APRIL 2018**

**This marking guideline consists of 10 pages.**

**QUESTION 1**

1.1 Kinematic viscosity is the ratio between the dynamic viscosity and the density of fluid and is measured in  $m^2/s$ . (2)

1.2 The high viscosity will cause the oil to have a large shear resistance to motion resulting in a high power loss. (2)

1.3.1 *radial clearance*

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

$$= \frac{120,2 - 120}{2}$$

$$= 0,1 \text{ mm} \quad \checkmark$$

*tangential velocity*

$$v = \frac{\pi d N}{60}$$

$$= \frac{\pi \times 0,12 \times 1100}{60} \checkmark$$

$$= 6,9115 \text{ m/s} \checkmark$$

*shear stress*

$$\tau = \frac{\mu v}{t} = \frac{0,42 \times 6,9115}{0,1} \checkmark$$

$$= 29,028 \text{ kPa} \checkmark$$

*shear force*

$$F = \tau A$$

$$= 29,028 \times \pi \times 0,12 \times 0,1 \checkmark$$

$$= 1094,342 \text{ N} \checkmark$$

$P = Fv$

$$= 1094,342 \times 6,9115 \checkmark$$

$$= 7,564 \text{ kW} \quad (9)$$

1.3.2 *rotational frequency*

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

$$= \frac{0,42 \times v}{100 \times 10^{-6}} \times \pi \times 0,12 \times 0,1 \quad \checkmark$$

$$\therefore F = 158,33627v \quad \checkmark$$

$$\begin{aligned}
 P &= Fv \\
 3\,000 &= 158,33627v \times v \checkmark \\
 \therefore v &= 4,353 \text{ m/s } \checkmark \\
 v &= \pi dn \\
 n &= \frac{4,353}{\pi \times 0,12} \\
 &= 11,546 \text{ r/s } \checkmark
 \end{aligned}
 \tag{5}$$

1.3.3

$$\begin{aligned}
 \nu &= \frac{\mu}{\rho} \\
 &= \frac{0,42}{900} \checkmark \\
 &= 466,667 \times 10^{-6} \text{ m}^2/\text{s } \checkmark
 \end{aligned}
 \tag{2}$$

**[20]**

## QUESTION 2

2.1 A hydraulic accumulator is a device which can be used as a storage chamber in which fluid energy is stored as potential energy and from which it can be released during high demand in a fluid system.  $\checkmark$  (3)

2.2 The presence of air in a hydraulic will result in the increase of free play and distortion to the pipes and cylinders due to expansion, thus affecting the movement of the actuator.  $\checkmark$  (2)

2.3.1 *if no air is present and cylinder expansion is disregarded*

*thus,  $K_e = K_l = 3\text{GPa}$*   $\checkmark$

$$P = \frac{4 \times 3\,000}{\pi \times 0,08^2} \checkmark \quad \checkmark$$

$$= 596,83104 \text{ kPa } \checkmark$$

$$\varepsilon = \frac{\Delta l}{l} = \frac{P}{K_e} = \frac{596,83104 \times 10^3}{3 \times 10^9} \checkmark$$

$$= 198,94368 \times 10^{-6} \checkmark$$

$$\therefore \Delta l = 198,94368 \times 10^{-6} \times 0,25$$

$$= 49,736 \times 10^{-6} \text{ m}
 \tag{6}$$

2.3.2 if air is present and cylinder expansion is considered

$$K_{cyl} = \frac{E}{2,5} = \frac{110 \text{ GPa}}{2,5} = 44 \text{ GPa} \quad \checkmark$$

$$K_{air} = P\alpha = 596,83104 \times 1,4 \checkmark$$

$$= 835,56346 \text{ KPa} \checkmark$$

$$\frac{1}{K_e} = \frac{1}{K_{cyl}} + \frac{1}{K_l} + \frac{V_{air}}{V_{total} K_{air}} \quad \checkmark$$

$$= \frac{1}{44 \times 10^9} + \frac{1}{3 \times 10^9} + \frac{3}{100 \times 835,56346 \times 10^3} \quad \checkmark$$

$$= 36,25998 \times 10^{-9} \quad \checkmark$$

$$\therefore K_e = 27,57862 \text{ MPa} \quad \checkmark$$

$$\varepsilon = \frac{\Delta l}{l} = \frac{P}{K} = \frac{596,83104 \times 10^3}{27,57862 \times 10^6} = 21,64108 \times 10^{-3}$$

$$\Delta l = 21,64108 \times 10^{-3} \times 0,25$$

$$= 5,41 \text{ mm}$$

(9)  
[20]

### QUESTION 3

3.1 3.1.1 hydrostatic force

$$F_h = \rho g \bar{y} A$$

$$\bar{y} = \frac{2,3}{2} = 1,15 \text{ m} \quad \checkmark$$

$$A = 2,3 \times 3,5$$

$$= 8,05 \text{ m} \quad \checkmark$$

$$F_{hydro} = 9810 \times 8,05 \times 1,15$$

$$= 90,81608 \text{ kN} \quad \checkmark$$

force on bolts

$$\sum M_{bolt} = 0$$

$$\sum M_{bolt} (CW) = \sum M_{bolt} (ACW)$$

$$F_{bolt} \times h_{bolt} = F_{hydro} \times h_{hydro} \quad \checkmark$$

$$F_{bolt} = \frac{90,81608 \times 0,66667}{1} \quad \checkmark$$

$$= 60,544 \text{ kN} \quad \checkmark$$

$$\begin{aligned} \sum M_{hinge} &= 0 \\ \sum M_{hinge} (CW) &= \sum M_{hinge} (ACW) \\ F_{hinge} \times h_{hinge} &= F_{hydro} \times h_{hydro} \quad \checkmark \\ F_{bolt} &= \frac{90,81608 \times 0,3333}{1} \quad \checkmark \\ &= 30,272 \text{ kN} \quad \checkmark \end{aligned} \tag{8}$$

$$\begin{aligned} 3.1.2 \quad F_{hydro} &= 9\,810 \times 12 \times 8,05 \quad \checkmark \\ &= 947,646 \text{ kN} \quad \checkmark \end{aligned} \tag{2}$$

3.2      3.2.1      *volume of seawater displaced*

$$\begin{aligned} F_{buoyancy} &= F_{ship} \\ \rho g V_{displaced} &= m_{ship} g \quad \checkmark \\ V_{displaced} &= \frac{50\,000}{1035} \quad \checkmark \\ &= 48,309 \text{ m}^3 \quad \checkmark \end{aligned} \tag{3}$$

3.2.2      *volume of fresh water displaced*

$$\begin{aligned} F_{buoyancy} &= F_{ship} \\ \rho g V_{displaced} &= m_{ship} g \\ V_{displaced} &= \frac{50\,000}{1\,000} \quad \checkmark \\ &= 50 \text{ m}^3 \quad \checkmark \end{aligned} \tag{2}$$

3.2.3      *volume of seawater displaced*

$$\begin{aligned} V_{displaced} &= (48,309 \times 30\%) + 48,309 = 62,8017 \text{ m}^3 \\ F_{buoyancy} &= F_{ship} \\ \rho g V_{displaced} &= m_{ship} g \quad \checkmark \\ &= 1\,035 \times 62,8017 \quad \checkmark \\ \therefore m &= 64,1876 \text{ tons} \quad \checkmark \end{aligned} \tag{5}$$

**[20]**

**QUESTION 4**

4.1.1 
$$Q = \frac{V}{t}$$

$$= \frac{3}{4\,500} \checkmark$$

$$= 666,667 \text{ m}^3/\text{s} \checkmark \quad (2)$$

4.1.2 
$$Q = Av$$

$$v = \frac{4Q}{\pi d^2}$$

$$= \frac{4 \times 666,667 \times 10^{-6}}{\pi \times (0,03)^2} \checkmark$$

$$= 0,943 \text{ m/s} \checkmark \quad (2)$$

4.1.3 
$$\overset{0}{W} = \frac{mg}{t} = \overset{0}{m} g = \rho Qg$$

$$= (1\,000 \times 0,95) \times 9,81 \times 666,667 \times 10^6 \checkmark$$

$$= 6,213 \text{ N/s} \checkmark \quad (3)$$

4.1.4 
$$R_e = \frac{\rho v d}{\mu}$$

$$= \frac{950 \times 0,943 \times 0,03}{0,065} \checkmark$$

$$= 413,469 \checkmark$$

$$R_e < 2\,100 \checkmark$$

$$\Rightarrow \text{flow is laminar} \checkmark \quad (4)$$

4.2 4.2.1 A stream line: at any given instant of time the position of successive molecules can be coupled up by a curve which is tangential to the direction of the motion at that instant. (2)

4.2.2 A stream tube: it is an imaginary boundary defined by stream lines drawn to enclose a tubular region of a fluid. No fluid flows across the boundary of such a tube. (2)

4.2.3 A path line: this is the path followed by a molecule. (1)

4.2.4 Lamina flow: this is the flow when each particle flows smoothly alongside its neighbours without interfering with the adjacent paths; in this case the stream lines do not intersect at any given unit of time. (2)

4.2.5 Turbulent flow: this is when flow is accompanied by an indiscriminate eddy current; in this case the stream lines intersect at random. (2)

**QUESTION 5**

5.1 5.1.1 The rota-flow meter is used to measure the flow of a fluid. (1)

5.1.2 The pitot tube is used to measure the velocity of a fluid. (1)

5.2 *mean velocity*

$$v_{mean} = \frac{4Q}{\pi d^2}$$

$$= \frac{4 \times 50 \times 10^{-3}}{\pi \times 0,15^2} \checkmark$$

$$= 4,42097 \text{ m/s} \checkmark$$

*maximum velocity*

$$v_{mean} = 0,75 v_{max} \checkmark$$

$$\therefore v_{max} = \frac{4,42097}{0,75} \checkmark$$

$$= 5,89463 \text{ m/s} \checkmark$$

*head of air*

*from :*

$$v_{max} = \sqrt{2gh_a}$$

$$h_a = \frac{5,89463^2}{19,62} \checkmark$$

$$\therefore h_a = 1,77098 \text{ m} \checkmark$$

*manometric head of water*

$$h_a = h_w \left[ \frac{\rho_w}{\rho_a} - 1 \right]$$

$$h_w = \frac{h_a}{\left[ \frac{\rho_w}{\rho_a} - 1 \right]} \checkmark$$

$$h_w = \frac{1,77098}{\left[ \frac{1000}{1,3} - 1 \right]} \checkmark$$

$$= 2,305 \text{ m}$$

(10)

5.3 *head loss for fittings*

$$\text{from : } h_l = \frac{kv^2}{2g}$$

$$\text{and : } h_f = \frac{4fv^2}{2gd}$$

$$\text{since : } \frac{l}{d} = \frac{k}{4f}$$

$$\text{thus : } h_{\text{valve}} = \frac{4fv^2}{2g} \times \frac{l}{d}$$

$$= \frac{4 \times 0,007 \times 3^2}{19,62} \times 8 \quad \checkmark$$

$$= 102,752 \text{ mm} \quad \checkmark$$

$$h_{\text{filter}} = \frac{4fv^2}{2g} \times \frac{l}{d}$$

$$= \frac{4 \times 0,007 \times 3^2}{19,62} \times 6 \quad \checkmark$$

$$= 77,064 \text{ mm} \quad \checkmark$$

$$P_{\text{valve}} = \rho gh_{\text{valve}}$$

$$= 920 \times 9,81 \times 102,752 \times 10^{-3} \quad \checkmark$$

$$= 927,36 \text{ Pa} \quad \checkmark$$

$$P_{\text{valve}} = \rho gh_{\text{valve}}$$

$$= 920 \times 9,81 \times 77,064 \times 10^{-3} \quad \checkmark$$

$$= 695,518 \text{ Pa} \quad \checkmark$$

(8)  
[20]

**QUESTION 6**

6.1 Refer to the attached velocity diagram.  
 Up to 4 marks will be deducted for incorrect usage of scale.



VELOCITY  
 DIAGRAM.pdf

(8)

6.2 6.2.1 The moving blade inlet and outlet angle

$$\alpha = 36^{\circ} \checkmark$$

$$\phi = 42^{\circ} \checkmark$$

6.2.2 The relative velocities at the inlet and outlet of the moving blade

$$v_{ri} = 32 \text{ m/s} \checkmark$$

$$v_{ro} = 28 \text{ m/s} \checkmark$$

6.2.3 The angle and velocity of the water exiting the turbine

$$\beta = 73,5^{\circ} \checkmark$$

$$v_{exit} = 19 \text{ m/s} \checkmark$$

6.2.4 The total whirl or vortex velocity

$$\Delta v_w = v_{wi} + v_{wo}$$

$$= 5,6 + 40,8 \checkmark$$

$$= 46,4 \text{ m/s} \checkmark$$

6.2.5 the power generated by the turbine

$$P = m \Delta v_w u$$

$$= 25,3 \times 46,4 \times 20 \checkmark$$

$$= 23,478 \text{ kW} \checkmark$$

6.2.6 The turbine overall efficiency

$$\eta = \frac{2 \Delta v_w u}{v_i^2} \times 100\%$$

$$= \frac{2 \times 46,4 \times 20}{45^2} \times 100\% \checkmark$$

$$= 91,654\% \checkmark$$

(6 × 2) (12)  
**[20]**

**TOTAL: 100**

