



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

14 August 2024

This marking guideline consists of 6 pages.

QUESTION 1

- 1.1 1.1.1 C
 1.1.2 B

(2 × 1) (2)

- 1.2 • Oil firing
 • Gas firing
 • Solid coal or pulverised coal firing

(3)
[5]

QUESTION 2

2.1 $R = C_p - C_v$
 $R = 1,005 - 0,717 ✓$
 $R = 0,288 \frac{\text{kJ}}{\text{kg.K}} ✓$

(2)

2.2 $P_1 V_1 = mRT_1$
 $P_1 = \frac{mRT_1}{V_1} ✓$
 $\rho = \frac{m}{V}$
 $\rho = \frac{P_1}{RT_1} ✓$
 $\rho = \frac{101,325_1}{0,288 \times 273} ✓$
 $\rho = 1,289 \frac{\text{kg}}{\text{m}^3} ✓$

(4)

2.3 $\rho = \frac{m}{V} ✓$
 $V = \frac{1,1}{1,289} ✓$
 $V = 0,853 \text{ m}^3 ✓$

Alternative answer:

$P_1 V_1 = mRT_1 ✓$
 $V_1 = \frac{1,1 \times 0,288 \times 273}{101,325} ✓$
 $V_1 = 0,854 \text{ m}^3 ✓$

(3)

2.4 $P_2 V_2 = mRT_2 ✓$
 $V_2 = \frac{1,1 \times 0,288 \times 273}{780} ✓$
 $V_2 = 0,111 \text{ m}^3 ✓$

$$2.5 \quad WD = P_1 V_1 \ln \frac{V_2}{V_1} \checkmark$$

$$WD = (101,325 \times 0,853) \ln \frac{0,111}{0,853} \checkmark \checkmark$$

$$WD = 176,251 \text{ kJ} \checkmark$$

Alternative answer:

$$WD = mRT_1 \ln \frac{V_2}{V_1} \checkmark$$

$$WD = (1,1 \times 0,288 \times 273) \ln \frac{0,111}{0,853} \checkmark \checkmark$$

$$WD = 176,366 \text{ kJ} \checkmark$$

(4)

$$2.6 \quad \Delta S = m \left[R \ln \left(\frac{V_2}{V_1} \right) + C_v \ln \left(\frac{T_2}{T_1} \right) \right] \checkmark$$

$$\Delta S = (1,1) \left[(0,288) \ln \left(\frac{0,111}{0,853} \right) + 0 \right] \checkmark$$

$$\Delta S = -0,646 \frac{\text{kJ}}{\text{K}} \quad \checkmark$$

(4)
[20]

QUESTION 3

$$3.1 \quad 3.1.1 \quad h_f = C_p t_f$$

$$h_f = 4,2 \times 32 \checkmark$$

$$h_f = 134,4 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$h_{su} = h_g + C_p (t_{ss} - t_s) \checkmark$$

$$h_{su} = 2799 + (2,05)(268 - 217,2) \checkmark$$

$$h_{su} = 2903,14 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$\eta = \frac{m_s (h_{su} - h_f)}{m_f \text{ CV}} \times 100\%$$

$$92,2\% = \frac{m_s (2903,14 - 134,4)}{m_f \text{ 30 000}} \times 100\% \checkmark$$

$$\frac{m_s}{m_f} = 9,99 \text{ kg steam} \frac{\text{kg fuel}}{\text{kg fuel}} \checkmark$$

$$\begin{aligned}
 3.1.2 \quad \Delta h &= \frac{m_s}{m_f} (h_{su} - h_f) \\
 \Delta h &= 9,9(2903,14 - 134,4) \checkmark \checkmark \\
 \Delta h &= 27410,526 \frac{\text{kJ}}{\text{kg}} \checkmark \checkmark
 \end{aligned}
 \tag{4}$$

$$\begin{aligned}
 3.1.3 \quad EE &= \frac{m_s}{m_f} \frac{(h_{su} - h_f)}{2257} \\
 EE &= 9,9 \frac{(2903,14 - 134,4)}{2257} \checkmark \checkmark \\
 EE &= 12,145 \checkmark
 \end{aligned}
 \tag{3}$$

3.2 By interpolation from the steam table at $P = 1\,500\text{ kPa}$ and $1\,550\text{ kPa}$:
 $P = 1\,530\text{ kPa}$

$$\begin{aligned}
 h_f &= 845 - (845 - 852) \frac{(1\,500 - 1\,530)}{(1\,500 - 1\,550)} \\
 h_f &= 849,2 \text{ kJ/kg} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 h_{fg} &= 1\,945 - (1\,945 - 1\,939) \frac{(1\,500 - 1\,530)}{(1\,500 - 1\,550)} \\
 h_{fg} &= 1\,941,4 \text{ kJ/kg} \checkmark
 \end{aligned}$$

Enthalpy before throttling = enthalpy after throttling

$$h_1 \text{ at } 1\,530\text{ kPa} = h_2 \text{ at } 300\text{ kPa and } 150^\circ\text{C} \checkmark$$

$$h_f + x h_{fg} = h_{su} \checkmark$$

$$849,2 + x(1\,941,4) = 2\,762 \checkmark$$

$$x = 0,985 \checkmark$$

(6)
[20]

QUESTION 4

4.1 $P_s = 8,5 \text{ kPa} \checkmark$

$$P = P_a + P_s$$

$$12 = P_a + 8,5$$

$$P_a = 3,5 \text{ kPa} \checkmark$$

$$T_a = 312 \text{ K} \checkmark$$

$$m_a = \frac{0,3}{1\,000} \times 4\,800$$

$$m_a = 1,44 \frac{\text{kg}}{\text{h}} \checkmark$$

$$P_a V_a = m R T_a$$

$$V = \frac{(1,44)(0,289)(312)}{(3,5)}$$

$$V = 37,097 \frac{\text{m}^3}{\text{hr}} \times \frac{1 \text{ h}}{3\,600 \text{ s}} \checkmark$$

$$V = 0,01 \frac{\text{m}^3}{\text{s}} \checkmark$$

(6)

4.2 4.2.1 $V_{a(\text{theoretical})} = \frac{100}{23} [V(O_2)]$

$$V_a = \frac{100}{21} (3) \checkmark$$

$$V_a = 14,286 \frac{\text{cubic metre air}}{\text{cubic metre fuel}} \checkmark$$

(2)

4.2.2 $V_{\text{actual}} = \frac{100 + x}{100} [V_{\text{theoretical}}]$

$$17,858 = \frac{100 + x}{100} (14,286) \checkmark$$

$$x = 25\% \checkmark$$

(3)

4.2.3 $N_2 = \frac{79}{100} \times 17,858 \checkmark$

$$N_2 = 14,108 \checkmark$$

$$O_2 = 0,25 \times 3 \checkmark$$

$$O_2 = 0,75 \checkmark$$

(4)

QUESTION 5

5.1

5.1.1

$$S_V = V_1 - V_3$$

$$V_3 = V_c = 0,05S_V$$

$$S_V = V_1 - 0,05S_V \checkmark$$

$$1,05S_V = V_1 \checkmark$$

$$V_4 = V_3 \left(\frac{P_3}{P_4} \right)^{\frac{1}{n}}$$

$$V_4 = 0,05S_V \left(\frac{790}{105} \right)^{\frac{1}{1,3}} \checkmark$$

$$V_4 = 0,236S_V$$

$$V_e = V_1 - V_4 \checkmark$$

$$V_e = 1,05S_V - 0,236S_V \checkmark$$

$$V_e = 0,814S_V$$

$$\frac{12 \text{ m}^3}{\text{min}} \times \frac{\text{min}}{350r} \checkmark = 0,814S_V$$

$$S_V = \frac{0,034}{0,814} \checkmark$$

$$S_V = 0,0418 \text{ m}^3 \checkmark$$

(8)

5.1.2

$$P = \frac{n}{n-1} P_1 V_e \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right] \checkmark$$

$$P = \frac{1,2}{1,2-1} (105) \left(\frac{1,2}{60} \right) \left[\left(\frac{790}{105} \right)^{\frac{1,3-1}{1,3}} - 1 \right] \checkmark$$

$$P = 7,474 \text{ kW} \checkmark$$

(4)

$$5.2 \quad m\omega^2 h = (m + M)g$$
$$\omega^2 h = \frac{(1,2 + 5,5)9,8}{1,2} \quad \checkmark$$

$$\omega = \sqrt{\frac{54,717}{h}} \quad \checkmark$$

$$h_1 = 0,25$$

$$\omega_1 = \sqrt{\frac{54,717}{0,25}} \quad \checkmark$$

$$\omega_1 = 14,794 \frac{\text{rad}}{\text{s}} \quad \checkmark$$

$$\omega_1 = 2\pi N$$

$$N = \frac{(14,794)}{2\pi}$$

$$N = 2,355 \frac{\text{rev}}{\text{s}} \quad \checkmark$$

$$h_2 = 0,3 \text{ m}$$

$$\omega_2 = \sqrt{\frac{54,717}{0,3}} \quad \checkmark$$

$$\omega_2 = 13,505 \frac{\text{rad}}{\text{s}} \quad \checkmark$$

$$\omega_2 = 2\pi N$$

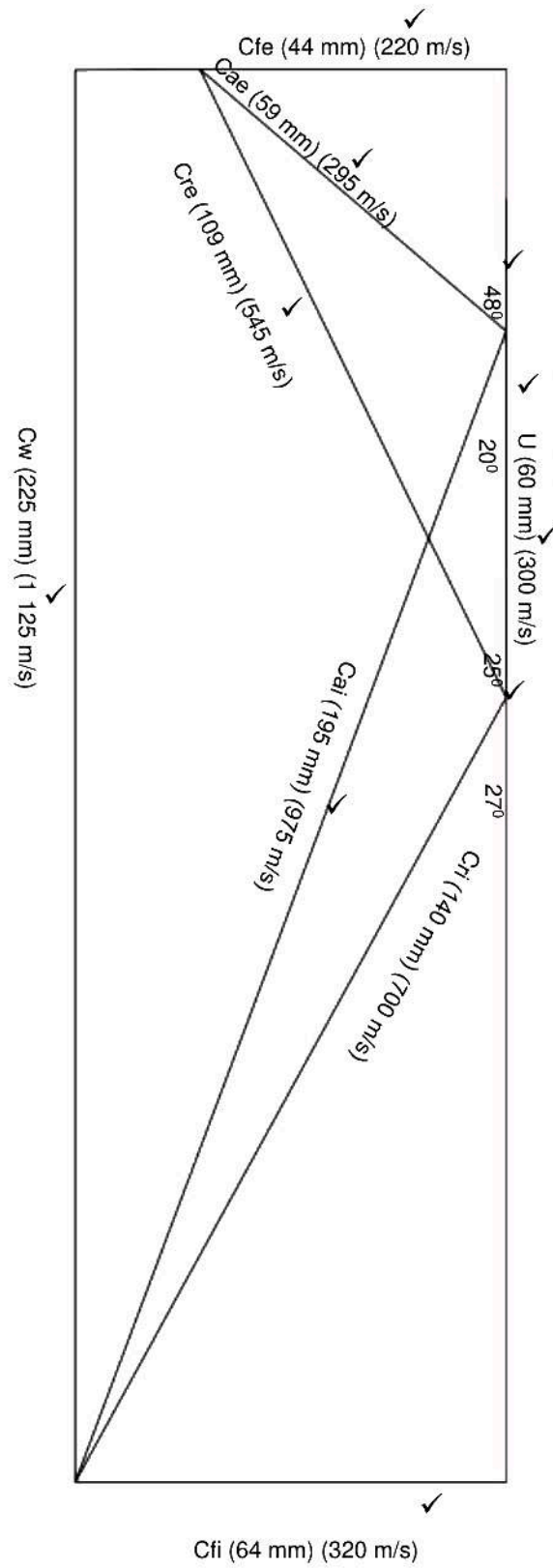
$$N = \frac{13,505}{2\pi}$$

$$N = 2,149 \frac{\text{rev}}{\text{s}} \quad \checkmark$$

(8)
[20]

QUESTION 6

6.1



(10)

6.2	6.2.1	$\alpha = 20^\circ \checkmark$ $\phi = 25^\circ \checkmark$	(2)
	6.2.2	$C_{ae} = 59 \times 5 = 295 \text{ m/s} \checkmark \checkmark$	(2)
	6.2.3	$C_{re} = 109 \times 5 = 545 \text{ m/s} \checkmark \checkmark$	(2)
	6.2.4	$\eta = \frac{2UC_w}{C_{ai}^2} \checkmark$ $\eta = \frac{2(300)(1\,125)}{(975)^2} \times 100\% \checkmark$ $\eta = 71,444\% \checkmark$	(4) [20]
TOTAL:			100