higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N6

13 AUGUST 2019

This marking guideline consists of 8 pages.

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√ ½ mark ✓ 1 mark

QUESTION 1

1.1
$$BP = 2\pi NT \quad ✓$$
$$= \frac{2\pi \times 12 \times 88}{1\,000} \quad ✓$$
$$= 6,635kW \quad ✓$$
(3)

1.2
$$\eta_{b.t.} = \frac{BP}{m_{f/s} \times CV} \times 100\% \quad ✓$$
$$= \frac{6,635 \times 60 \times 60}{2,3 \times 38\,000} \times 100\% \quad ✓$$
$$= 27,33\% \quad ✓$$
(3)

1.3
$$Q_{gas} = m_w C_w \Delta t_w \quad ✓$$
$$= \frac{212}{60 \times 60} \times 4,2(63 - 15) \quad ✓$$
$$= 11,872kW \quad ✓$$
(3)

1.4
$$Q_{lost} = Q_{fuel} - Q_{BP} - Q_{gas} \quad ✓$$
$$= \frac{2.3 \times 38\,000}{60 \times 60} - 6,635 - 11,872 \quad ✓$$
$$= 5,771kW \quad ✓$$
(3)

1.5
$$\%_{\text{heat carried away}} = \frac{Q_{lost}}{Q_{fuel}} \times 100\% \quad ✓$$
$$= \frac{5,771}{24,278} \times 100\% \quad ✓$$
$$= 23,77\% \quad ✓$$
(3)

1.6
$$IP = \frac{BP}{\eta_{mech.}} \quad ✓$$
$$= \frac{6,635}{0,78} \quad ✓$$
$$= 8,506kW \quad ✓$$
(3)

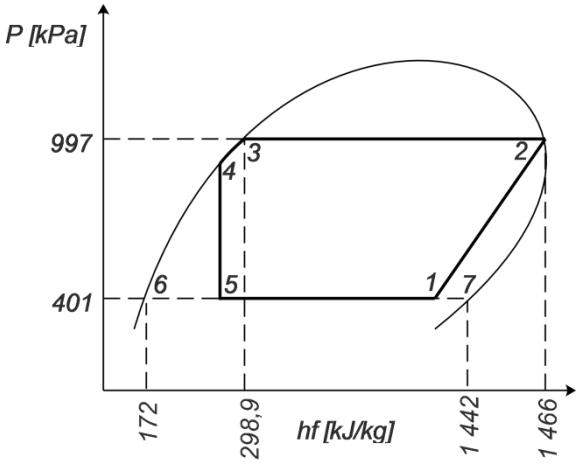
1.7
$$ISFC = \frac{m_{f/h}}{IP}$$
$$= \frac{2,3}{8,506} \quad ✓$$
$$= 0,27kg/kW.h \quad ✓$$
(2)
[20]

QUESTION 2

2.1 $h_1 = h_6 + x_1(h_7 - h_6)$ ✓

$= 172 + 0,91(1\,442 - 172)$ ✓

$= 1\,327,7 kJ / kg$ ✓



(3)

2.2 $h_5 = h_6 + x_5(h_7 - h_6)$ ✓

$= 172 + 0,07(1\,442 - 172)$ ✓

$= 260,9 kJ / kg$ ✓

(3)

2.3 $RE = h_1 - h_5$ ✓

$= 1\,327,7 - 260,9$ ✓

$= 1\,066,8 kJ / kg$ ✓

(3)

2.4 $WD = h_2 - h_1$ ✓

$= 1\,466 - 1\,327,7$ ✓

$= 138,3 kJ / kg$ ✓

(3)

2.5 $COP = \dfrac{RE}{WD}$ ✓

$= \dfrac{1\,066,8}{138,3}$ ✓

$= 7,714$ ✓

(3)

2.6 $Q_{ice} = m_r(h_1 - h_5)$

$= 0,75(1\,327,7 - 260,9)$ ✓

$= 800,0 kJ / \min$ ✓

(2)

2.7 $Q_{ice} = m_{ice}\left[h_{fg\ ice} + C_w \Delta t_w\right]$ ✓

$800,1 = m_{ice}\left[(341 \times 60) + 4,2(14 - 0)\right]$ ✓

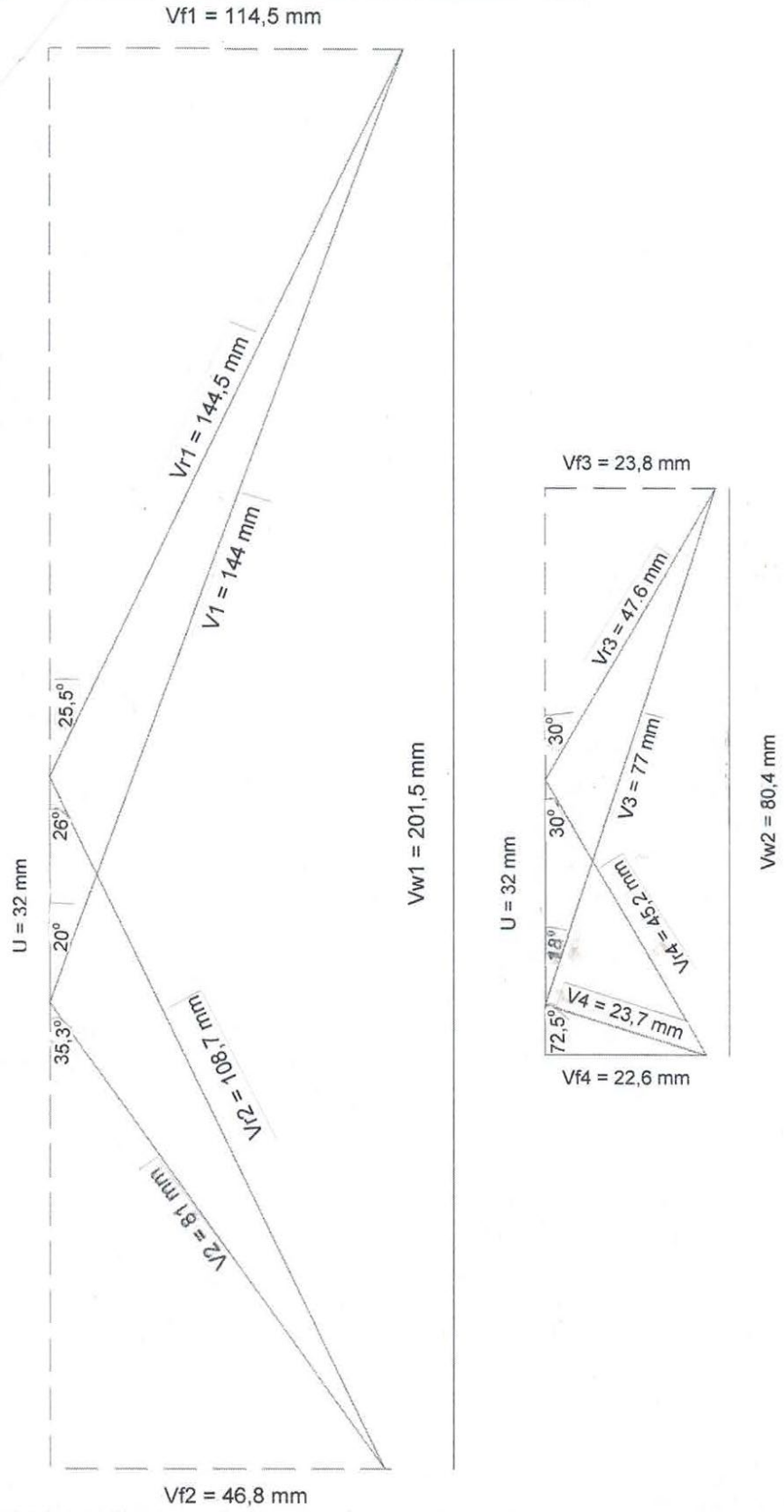
$m_{ice} = 134,17 kg\ ice / h$ ✓

(3)

[20]

QUESTION 3

3.1



Award ½ mark to each correct length and angle up to a maximum of 5 marks per diagram.
Allow a tolerance of up to ± 1° for angles and a tolerance of ± 2 mm for lengths of lines.
(2 × 5) (10)

3.2 3.2.1 $\beta_2 = 72,5°$ (1)

3.2.2 $V_2 = 81 \times 5 = 405m/s$ (1)

3.2.3 $V_3 = 77 \times 5 = 385m/s$ (1)

3.2.4 $V_4 = 23,7 \times 5 = 118,5m/s$ (1)

3.2.5 $V_{r1} = 114,5 \times 5 = 572,5m/s$ (1)

3.2.6 $V_{r4} = 42,5 \times 5 = 212,5m/s$ (1)

3.2.7 $\eta = \frac{2U.V_{WT}}{V_1^2} \times 100\%$ ✓

$= \frac{2 \times 160(201,5 + 80,4) \times 5}{720^2} \times 100\%$ ✓✓

$= 87,006\%$ ✓ (4)

[20]

QUESTION 4

4.1 $At\ 200kPa$ and $200°C : h_{su} = 2\ 871kJ/kg$

$Q_{moisture} = m_m(h_{su} - C_w.t_{atm.})$ ✓

$1\ 235,25 = 0,45(2\ 871 - 4,2.t_{atm.})$ ✓

$t_{atm.} = 30°C$ ✓ (3)

4.2 $Q_g = (m_a + 1 - m_m)C_{pg}\Delta t_g$ ✓

$3\ 311,75 = (18 + 1 - 0,45)C_{pg}(200 - 30)$ ✓✓

$C_{pg} = 1,05kJ/kg.K$ ✓ (4)

4.3 $At\ 3\ 000kPa$ and $250°C : h_{su} = 2\ 858kJ/kg$

$At\ 32,9° : h_{fw1} = 138kJ/kg$

$EE = \frac{m_s(h_{su} - h_{fw1})}{m_f \times 2\ 257}$ ✓

$10,123 = \frac{m_s}{m_f} \times \frac{2\ 858 - 138}{2257}$ ✓

$\frac{m_s}{m_f} = 8,4:1$ ✓ (3)

4.4

$$\eta = \frac{m_s\left(h_{su} - h_{fw1}\right)}{m_f \times CV} \times 100\% \quad \checkmark$$

$$= \frac{8,4\left(2\,858 - 138\right)}{1 \times 28\,560} \times 100\% \quad \checkmark$$

$$= 80\% \quad \checkmark$$

OR

$$\eta = \frac{EE \times 2\,257}{CV} \times 100\%$$

$$= \frac{10,123 \times 2\,257}{28\,560} \times 100\%$$

$$= 80\%$$

(3)

4.5

$$Q_{econ.} = \frac{m_s}{m_f}\left(h_{fw2} - h_{fw1}\right)$$

$$2\,352 = \frac{8,4}{1}\left(h_{fw2} - 138\right) \quad \checkmark$$

$$h_{fw2} = 418kJ/kg \quad \checkmark$$

$$At\ h_{fw2} = 418kJ/kg; t_{fw2} = 99,6°C \quad \checkmark \left(\text{from steam tables}\right)$$

(3)

4.6

Q_{in}(kJ/kg)	Q_{out}(kJ/kg)	QUANTITY	%
28 560	Plant	8,4(2 858-138) = 22 848	✓ 80,000
	Moisture	1 235,25	✓½ 4,325
	Flue gases	3 311,175	✓½ 11,594
	Unaccounted	✓ 1 165,575	✓ 4,081
28 560		28 560	100,000

(4)
[20]

QUESTION 5

5.1 5.1.1

$$\eta_{overall} = \frac{T_1 - T_2}{T_1 - T_2'} \quad \checkmark$$

$$0,89 = \frac{T_1 - 494}{298} \quad \checkmark$$

$$T_1 = 759,22K \quad \checkmark$$

5.1.2

$$P_1 = P_c\left(\frac{\gamma + 1}{2}\right)^{\left(\frac{\gamma}{\gamma - 1}\right)} \quad \checkmark$$

$$= 1\,581\left(\frac{2,4}{2}\right)^{\left(\frac{1,4}{0,4}\right)} \quad \checkmark$$

$$= 2\,992,721kPa \quad \checkmark$$

(2 × 3) (6)

5.2 $\gamma = \frac{C_p}{C_v}$ and $C_v = \frac{C_p}{\gamma}$

$$R = C_p - C_v$$
$$= C_p - \frac{C_p}{\gamma}$$
$$= C_p\left(1 - \frac{1}{\gamma}\right)$$
$$= C_p\left(\frac{\gamma - 1}{\gamma}\right)$$

$$\therefore C_p = \frac{\gamma}{\gamma - 1} \times R \quad ✓$$
$$= \frac{1,4}{0,4} \times 0,288 \quad ✓$$
$$= 1,008 kJ/kg.K \quad ✓$$ (3)

5.3 5.3.1
$$T_c = T_1\left(\frac{2}{\gamma + 1}\right)$$
$$= 759,22\left(\frac{2}{2,4}\right) \quad ✓$$
$$= 632,683K \quad ✓$$ (2)

5.3.2
$$C_c = \sqrt{2\,000 C_p\left(T_1 - T_c\right)}$$
$$= \sqrt{2\,000 \times 1,008\left(759,22 - 632,683\right)} \quad ✓$$
$$= 505,073 m/s \quad ✓$$ (2)

5.3.3
$$V_c = \frac{RT_c}{P_c} \quad ✓$$
$$= \frac{0,288 \times 632,683}{1\,581} \quad ✓$$
$$= 0,115 m^3/kg \quad ✓$$ (3)

5.4 5.4.1 $T_1 - T_2' = 298$

$759,22 - T_2' = 298$ ✓

$T_2' = 461,22K$ ✓

5.4.2 $C_2 = \sqrt{2\ 000 C_p \left(T_1 - T_2\right)}$

$= \sqrt{2\ 000 \times 1,008\left(759,22 - 494\right)}$ ✓

$= 731,221 m/s$ ✓

(2 × 2) (4)
[20]

TOTAL: 100

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