higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

POWER MACHINES N5

26 NOVEMBER 2014

This marking guideline consists of 9 pages.

QUESTION 1

1.1 - The treated water can be re-used ✓ in the boiler and this reduces cost. ✓

- A hot water ✓ supply is available which requires less energy ✓ for transformation to steam.

- The pressure in the condenser is below atmospheric pressure which increases the thermal efficiency ✓ of the plant and the work done per ✓ kilogram of steam. (6)

1.2 Given:

M_s	=	$6500 kg / hour$	$Air\ Leakage$	=	$1{,}2 kg / 1000 kg\ steam$
t_c	=	$31^o C$	B_m	=	$760\, mmHg$
V_m	=	$662\, mmHg$	$t_2 - t_1$	=	$21^o C$
x	=	$0{,}83$	shc_w	=	$4{,}187\, kJ / kg.K$
R	=	$0{,}288\, kJ / kg.K$			

1.2.1

$$P_t = (B_m - V_m) \times \frac{101{,}325}{760} \checkmark$$

$$= (760 - 662) \times \frac{101{,}325}{760} \checkmark$$

$$= 13\, kPa \checkmark$$

$$Heat\ lost\ by\ steam = Heat\ gained\ by\ water$$

$$M_s\{(hf + xhfg) - hc\} \checkmark = M_w \times shc_w \times \Delta t \checkmark$$

$$\frac{6500}{60}\{[214 + (0{,}83 \times 2380)] - 130\} \checkmark = M_w \times 4{,}187 \times 21 \checkmark$$

$$223101{,}6667 = 87{,}927\, M_w$$

$$\therefore M_w = \boxed{2537{,}351\, kg / \min} \checkmark$$

(8)

1.2.2

$$P_a = P_t - P_s$$

$$= 13 - 4{,}5$$

$$= 8{,}5\, kPa \checkmark$$

$$T_a = 31 + 273$$

$$= 304\, K \checkmark$$

$$M_a = \frac{1{,}2}{1000} \times \frac{6500}{60}$$

$$= 0{,}13\, kg / \min \checkmark$$

$$P_aV_a = M_aRT_a \quad ✓$$
$$V_a = \frac{M_a \times R \times T_a}{P_a}$$
$$= \frac{0{,}13 \times 0{,}288 \times 304}{8{,}5} \quad ✓$$
$$= \boxed{1{,}339\, m^3/\min} \quad ✓$$

(6)
[20]

QUESTION 2

2.1 Given:

δ	=	$1{,}28\, kg/m^3$	m	=	$0{,}7\, kg$
P_1	=	$200\, kPa$	T_1	=	$540\, K$
n	=	$1{,}29$	V_2	=	$2{,}5V_1$

2.1.1

$$PV = MRT$$
$$R = \frac{PV}{MT} \quad ✓$$
$$= \frac{200 \times 1}{1{,}28 \times 540} \quad ✓$$
$$= \boxed{0{,}289\, kJ/kg.K} \quad ✓$$

(3)

2.1.2

$$P_1V_1 = MRT_1 \quad ✓$$
$$V_1 = \frac{MRT_1}{P_1}$$
$$= \frac{0{,}7 \times 0{,}289 \times 540}{200} \quad ✓$$
$$= 0{,}5462\, m^3 \quad ✓$$

$$V_2 = 2{,}5V_1 \quad ✓$$
$$= 2{,}5 \times 0{,}5462 \quad ✓$$
$$= \boxed{1{,}3655\, m^3} \quad ✓$$

(6)

2.1.3

$$P_1V_1^n = P_2V_2^n$$
$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^n \quad ✓$$
$$= 200\left(\frac{0{,}5462}{1{,}3655}\right)^{1{,}29} \quad ✓$$
$$= \boxed{61{,}332\, kPa} \quad ✓$$

(3)

2.1.4

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{n-1}$$

$$T_2 = \frac{P_2V_2T_1}{P_1V_1} \checkmark \qquad T_2 = T_1\left(\frac{V_1}{V_2}\right)^{n-1} \checkmark$$

$$= \frac{61{,}332 \times 1{,}3655 \times 540}{200 \times 0{,}5462} \checkmark \quad or \quad = 540\left(\frac{0{,}5462}{1{,}3655}\right)^{1{,}29-1} \checkmark$$

$$= \boxed{413{,}991\,K} \checkmark \qquad = \boxed{413{,}991\,K} \checkmark$$

(3)

2.1.5

$$W = \frac{P_1V_1 - P_2V_2}{n-1} \checkmark$$

$$= \frac{(200 \times 0{,}5462) - (61{,}332 \times 1{,}3655)}{1{,}29 - 1} \checkmark$$

$$= \boxed{87{,}9\,kJ} \checkmark$$

or

$$W = \frac{MR(T_1 - T_2)}{n-1} \checkmark$$

$$= \frac{0{,}7 \times 0{,}289(540 - 413{,}991)}{1{,}29 - 1} \checkmark$$

$$= \boxed{87{,}9\,kJ} \checkmark$$

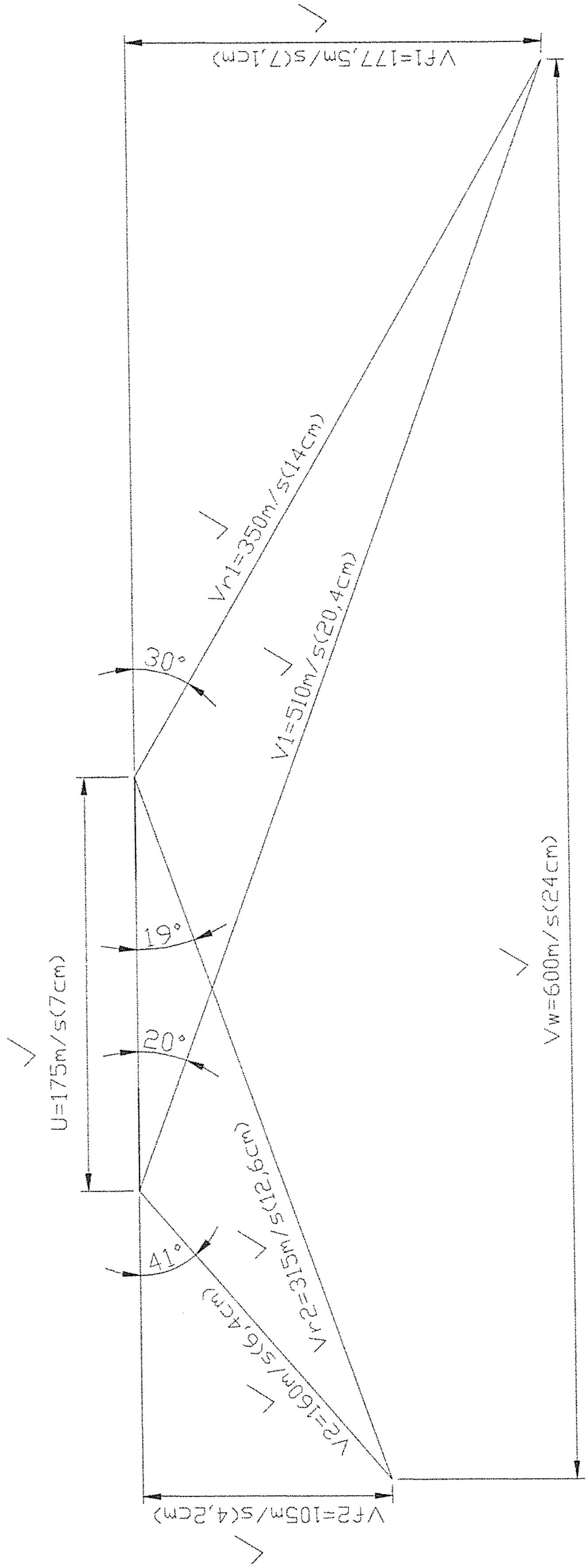
(3)

2.2 The function of a governor is to control ✓ the desired speed ✓ of an engine. (2)

[20]

QUESTION 3

3.1



$K = \frac{Vr_2}{Vr_1}$ ✓

$Vr_2 = K \times Vr_1$ ✓

$= 0{,}9 \times 350$

$= 315\, m/s$ ✓ (11)

3.2 3.2.1 $\alpha = 20^o$ ✓ (1)

3.2.2 $V_1 = 510\, m/s$ ✓ (1)

3.2.3 $\phi = 19^o$ ✓ (1)

3.2.4 $Fc = m(Vf_1 - Vf_2)$ ✓

$= 50(177{,}5 - 105)$ ✓

$= 3625\, N$

$= 3{,}625\, kN$ ✓ (3)

3.2.5 $P = MUC_w$ ✓

$= 50 \times 175 \times 600$ ✓

$= 5250000\, W$

$= 5250\, kW$ ✓

$= 5{,}25\, MW$ (3)

[20]

QUESTION 4

4.1

$$\text{Theoritical mass of air reqd.} = \frac{100}{23}\left[\frac{8}{3}C + 8H_2 + S - O_2\right] \checkmark$$

$$= \frac{100}{23}\left[\left(\frac{8}{3}\times 0{,}87\right) + (8\times 0{,}025) + 0{,}01\right] \checkmark$$

$$= \frac{100}{23}\times 2{,}53 \checkmark$$

$$= 11\,kg\ air\,/\,kg\ fuel \checkmark$$

$$\text{Mass of excess air} = \text{Actual air} - \text{Theoritical air}$$

$$= 18{,}04 - 11 \checkmark$$

$$= 7{,}04\,kg \checkmark$$

$$\text{Percentage of excess air} = \frac{7{,}04}{11}\times\frac{100}{1} \checkmark$$

$$= 64\,\% \checkmark$$

Mass of Products of Combustion:

CO_2	=	$3{,}667\times 0{,}87$	=	$3{,}19\,kg$	✓
H_2O	=	$9\times 0{,}025$	=	$0{,}225\,kg$	✓
$Excess\ O_2$	=	$2{,}53\times\frac{64}{100}$	=	$1{,}619\,kg$	✓
SO_2	=	$2\times 0{,}01$	=	$0{,}02\,kg$	✓
N_2	=	$18{,}04\times\frac{77}{100}$	=	$13{,}89\,kg$	✓
				18,944 kg	

Percentages of Products of Combustion:

CO_2	=	$\frac{3{,}19}{18{,}944}\times\frac{100}{1}$	=	$16{,}839\,\%$	✓
H_2O	=	$\frac{0{,}225}{18{,}944}\times\frac{100}{1}$	=	$1{,}188\,\%$	✓
$Excess\ O_2$	=	$\frac{1{,}619}{18{,}944}\times\frac{100}{1}$	=	$8{,}546\,\%$	✓
SO_2	=	$\frac{0{,}02}{18{,}944}\times\frac{100}{1}$	=	$0{,}106\,\%$	✓
N_2	=	$\frac{13{,}89}{18{,}944}\times\frac{100}{1}$	=	$73{,}321\,\%$	✓
				100 %	

(18)

4.2 To provide suitable openings to clean and inspect all internal surfaces, longitudinal seams and circumferential seams. ✓

To provide at least one manhole to permit entry into the boiler. ✓ (2)
[20]

QUESTION 5

5.1 <u>Given:</u>

$Double-Acting$			M	=	$16\,m^3/\min$
P_1	=	$101{,}3\,kPa$	T_1	=	$293\,K$
V_e	=	$0{,}94V_s = 16\,m^3$	P_2	=	$900\,kPa$
N	=	$375\,r/\min$	n	=	$1{,}3$
η_{mech}	=	$79\,\%$			

5.1.1

$$\eta_{vol} = 1+\alpha-\alpha\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} \times \frac{100}{1} \quad ✓$$

$$= 1+0{,}06-0{,}06\left(\frac{900}{101{,}3}\right)^{\frac{1}{1{,}3}} \times \frac{100}{1} \quad ✓$$

$$= \boxed{73{,}8\,\%} \quad ✓$$

(3)

5.1.2

$$V_e = V_\eta \times V_s \times N \times 2 \quad ✓$$

$$V_s = \frac{V_e}{V_\eta \times N \times 2}$$

$$= \frac{16}{0{,}738 \times 375 \times 2} \quad ✓ ✓$$

$$= \boxed{0{,}0289\,m^3} \quad ✓$$

(4)

5.1.3

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} \quad ✓$$

$$= 293\left(\frac{900}{101{,}3}\right)^{\frac{1{,}3-1}{1{,}3}} \quad ✓$$

$$= \boxed{485{,}05\,K} \quad ✓$$

(3)

5.1.4

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

$$= \frac{1,3}{1,3-1} \times 101,3 \times \frac{16}{60} \left[\left(\frac{900}{101,3} \right)^{\frac{1,3-1}{1,3}} - 1 \right] \checkmark$$

$$= 76,725\, kW \checkmark$$

$$P_{comp} = P_{indicated} \times \eta \checkmark$$

$$= 76,725 \times \frac{100}{79} \checkmark$$

$$= \boxed{97,12\, kW} \checkmark$$

(6)

5.2

5.2.1 For gauge pressures which do not exceed 500 kPa, the hydraulic test pressure shall be double ✓ the authorised working gauge pressure. ✓ (2)

5.2.2 For gauge pressures which exceed 500 kPa, the hydraulic test pressure shall be 1,2 ✓ times the authorised working gauge pressure plus 400 kPa. ✓ (2)

[20]

TOTAL: 100