

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° C	B_m	= 760 mmHg
V_m	= 662 mmHg	$t_2 - t_1$	= 21° C
x	= 0,83	shc_w	= 4,187 kJ / kg.K
R	= 0,288 kJ / kg.K		

1.2.1

$$\begin{aligned}
 P_t &= (B_m - V_m) \times \frac{101,325}{760} \quad \checkmark \\
 &= (760 - 662) \times \frac{101,325}{760} \quad \checkmark \\
 &= 13 \text{ kPa} \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Heat lost by steam} &= \text{Heat gained by water} \\
 M_s \{ (hf + xhfg) - hc \} \quad \checkmark &= M_w \times shc_w \times \Delta t \quad \checkmark \\
 \frac{6500}{60} \{ [214 + (0,83 \times 2380)] - 130 \} \quad \checkmark &= M_w \times 4,187 \times 21 \quad \checkmark \\
 223101,6667 &= 87,927 M_w \quad \checkmark \\
 \therefore M_w &= \boxed{2537,351 \text{ kg / min}} \quad \checkmark
 \end{aligned}$$

(8)

1.2.2

$$\begin{aligned}
 P_a &= P_t - P_s \\
 &= 13 - 4,5 \\
 &= 8,5 \text{ kPa} \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_a &= 31 + 273 \\
 &= 304 \text{ K} \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 M_a &= \frac{1,2}{1000} \times \frac{6500}{60} \\
 &= 0,13 \text{ kg / min} \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 P_a V_a &= M_a R T_a \quad \checkmark \\
 V_a &= \frac{M_a \times R \times T_a}{P_a} \\
 &= \frac{0,13 \times 0,288 \times 304}{8,5} \quad \checkmark \\
 &= \boxed{1,339 \text{ m}^3 / \text{min}} \quad \checkmark
 \end{aligned}$$

(6)
[20]**QUESTION 2****2.1 Given:**

$$\begin{aligned}
 \delta &= 1,28 \text{ kg / m}^3 & m &= 0,7 \text{ kg} \\
 P_1 &= 200 \text{ kPa} & T_1 &= 540 \text{ K} \\
 n &= 1,29 & V_2 &= 2,5 V_1
 \end{aligned}$$

$$\begin{aligned}
 2.1.1 \quad PV &= MRT \\
 R &= \frac{PV}{MT} \quad \checkmark \\
 &= \frac{200 \times 1}{1,28 \times 540} \quad \checkmark \\
 &= \boxed{0,289 \text{ kJ / kg.K}} \quad \checkmark
 \end{aligned}$$

(3)

$$\begin{aligned}
 2.1.2 \quad P_1 V_1 &= MRT_1 \quad \checkmark \\
 V_1 &= \frac{MRT_1}{P_1} \\
 &= \frac{0,7 \times 0,289 \times 540}{200} \quad \checkmark \\
 &= 0,5462 \text{ m}^3 \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 V_2 &= 2,5 V_1 \quad \checkmark \\
 &= 2,5 \times 0,5462 \quad \checkmark \\
 &= \boxed{1,3655 \text{ m}^3} \quad \checkmark
 \end{aligned}$$

(6)

$$\begin{aligned}
 2.1.3 \quad P_1 V_1^n &= P_2 V_2^n \\
 P_2 &= P_1 \left(\frac{V_1}{V_2} \right)^n \quad \checkmark \\
 &= 200 \left(\frac{0,5462}{1,3655} \right)^{1,29} \quad \checkmark \\
 &= \boxed{61,332 \text{ kPa}} \quad \checkmark
 \end{aligned}$$

(3)

$$\begin{aligned}
 2.1.4 \quad \frac{P_1 V_1}{T_1} &= \frac{P_2 V_2}{T_2} \quad \checkmark & \frac{T_2}{T_1} &= \left(\frac{V_1}{V_2} \right)^{n-1} \quad \checkmark \\
 T_2 &= \frac{P_2 V_2 T_1}{P_1 V_1} \quad \checkmark & T_2 &= T_1 \left(\frac{V_1}{V_2} \right)^{n-1} \quad \checkmark \\
 &= \frac{61,332 \times 1,3655 \times 540}{200 \times 0,5462} \quad \checkmark \text{ or } & &= 540 \left(\frac{0,5462}{1,3655} \right)^{1,29-1} \quad \checkmark \\
 &= \boxed{413,991 K} \quad \checkmark & &= \boxed{413,991 K} \quad \checkmark \quad (3)
 \end{aligned}$$

$$\begin{aligned}
 2.1.5 \quad W &= \frac{P_1 V_1 - P_2 V_2}{n-1} \quad \checkmark \\
 &= \frac{(200 \times 0,5462) - (61,332 \times 1,3655)}{1,29-1} \quad \checkmark \\
 &= \boxed{87,9 kJ} \quad \checkmark
 \end{aligned}$$

or

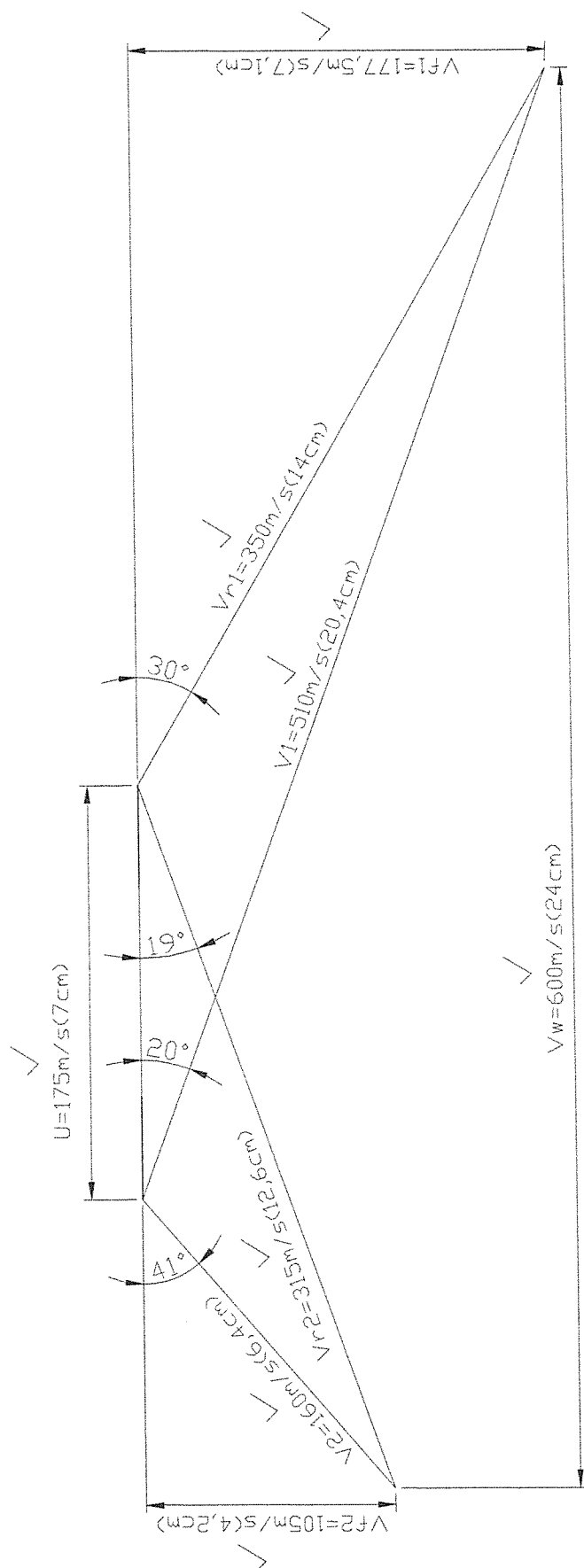
$$\begin{aligned}
 W &= \frac{MR(T_1 - T_2)}{n-1} \quad \checkmark \\
 &= \frac{0,7 \times 0,289(540 - 413,991)}{1,29-1} \quad \checkmark \\
 &= \boxed{87,9 kJ} \quad \checkmark \quad (3)
 \end{aligned}$$

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

[20]

QUESTION 3

3.1



$$\begin{aligned}
 K &= \frac{V_{r_2}}{V_{r_1}} \quad \checkmark \\
 V_{r_2} &= K \times V_{r_1} \quad \checkmark \\
 &= 0,9 \times 350 \\
 &= 315 \text{ m/s} \quad \checkmark
 \end{aligned}
 \tag{11}$$

$$3.2 \quad 3.2.1 \quad \alpha = 20^\circ \quad \checkmark \tag{1}$$

$$3.2.2 \quad V_1 = 510 \text{ m/s} \quad \checkmark \tag{1}$$

$$3.2.3 \quad \phi = 19^\circ \quad \checkmark \tag{1}$$

$$\begin{aligned}
 3.2.4 \quad F_c &= m(V_{f_1} - V_{f_2}) \quad \checkmark \\
 &= 50(177,5 - 105) \quad \checkmark \\
 &= 3625 \text{ N} \\
 &= 3,625 \text{ kN} \quad \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 3.2.5 \quad P &= MUC_w \quad \checkmark \\
 &= 50 \times 175 \times 600 \quad \checkmark \\
 &= 5250000 \text{ W} \\
 &= 5250 \text{ kW} \quad \checkmark \\
 &= 5,25 \text{ MW}
 \end{aligned}$$

(3)
[20]

QUESTION 4

$$\begin{aligned}
 4.1 \quad \text{Theoretical mass of air reqd.} &= \frac{100}{23} \left[\frac{8}{3} C + 8H_2 + S - O_2 \right] & \checkmark \\
 &= \frac{100}{23} \left[\left(\frac{8}{3} \times 0,87 \right) + (8 \times 0,025) + 0,01 \right] & \checkmark \\
 &= \frac{100}{23} \times 2,53 & \checkmark \\
 &= 11 \text{ kg air / kg fuel} & \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Mass of excess air} &= \text{Actual air} - \text{Theoretical air} \\
 &= 18,04 - 11 & \checkmark \\
 &= 7,04 \text{ kg} & \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Percentage of excess air} &= \frac{7,04}{11} \times \frac{100}{1} & \checkmark \\
 &= 64 \% & \checkmark
 \end{aligned}$$

Mass of Products of Combustion :

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

Percentages of Products of Combustion :

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

(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 Given:

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

5.1.1

$$\begin{aligned} \eta_{\text{vol}} &= 1 + \alpha - \alpha \left(\frac{P_2}{P_1} \right)^{\frac{1}{n}} \times \frac{100}{1} \quad \checkmark \\ &= 1 + 0,06 - 0,06 \left(\frac{900}{101,3} \right)^{\frac{1}{1,3}} \times \frac{100}{1} \quad \checkmark \\ &= \boxed{73,8 \%} \quad \checkmark \end{aligned} \quad (3)$$

5.1.2

$$\begin{aligned} V_e &= V_\eta \times V_s \times N \times 2 \quad \checkmark \\ V_s &= \frac{V_e}{V_\eta \times N \times 2} \\ &= \frac{16}{0,738 \times 375 \times 2} \quad \checkmark \\ &= \boxed{0,0289 \text{ m}^3} \quad \checkmark \end{aligned} \quad (4)$$

5.1.3

$$\begin{aligned} \frac{T_2}{T_1} &= \left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} \\ T_2 &= T_1 \left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} \quad \checkmark \\ &= 293 \left(\frac{900}{101,3} \right)^{\frac{1,3-1}{1,3}} \quad \checkmark \\ &= \boxed{485,05 \text{ K}} \quad \checkmark \end{aligned} \quad (3)$$

5.1.4

$$\begin{aligned}
 P_{\text{indicated}} &= \frac{n}{n-1} P_1 V_e \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right] && \checkmark \\
 &= \frac{1,3}{1,3-1} \times 101,3 \times \frac{16}{60} \left[\left(\frac{900}{101,3} \right)^{\frac{1,3-1}{1,3}} - 1 \right] && \checkmark \\
 &= 76,725 \text{ kW} && \checkmark
 \end{aligned}$$

$$\begin{aligned}
 P_{\text{comp}} &= P_{\text{indicated}} \times \eta && \checkmark \\
 &= 76,725 \times \frac{100}{79} && \checkmark \\
 &= \boxed{97,12 \text{ kW}} && \checkmark
 \end{aligned}$$

(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**