higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# MARKING GUIDELINE

## NATIONAL CERTIFICATE

## MECHANICAL DRAWING AND DESIGN N5

**30 March 2020**

**This marking guideline consists of 9 pages.**

Copyright reserved

## QUESTION 1: WELDING

1.1 Throat thickness: $t_t = 0{,}707t = 0{,}707 \times 6 = 4{,}242$ mm✓

$L_e = 2(L - 2t_t) = 2\big(60 - (2 \times 4{,}242)\big) = 103{,}03$ mm
$P = t_t \times L_e \times \sigma_c$
$P = 4{,}242 \times 10^{-3} \times 103{,}03 \times 10^{-3} \times 85 \times 10^6$✓
$P = 37{,}15$ kN✓✓ (4)

1.2 $\sigma_t = \dfrac{P}{t_t} \times L_e$

$P = \dfrac{\sigma_t \times t_t}{L_e}$✓

$L_e = L - W = 150 - 8 = 142$ mm✓

$t_t = W = 8$ mm✓

$P = \dfrac{138 \times 10^6 \times 0{,}008}{0{,}142}$✓

$P = 7{,}77$ MN✓✓ (6)
**[10]**

## QUESTION 2: LAP AND BUTT JOINTS

2.1 Shearing load on one rivet = Crushing load on one rivet

$\tau \times 1{,}75 \times \frac{\pi d^2}{4} = \sigma_c \times d \times t$

$62 \times 10^6\ \text{N/m}^2 \times 1{,}75 \times \dfrac{\pi \times d^2}{4} = 170 \times 10^6\ \text{N/m}^2 \times d \times 0{,}010$ m

$\dfrac{d^2}{d} = \dfrac{170 \times 10^6\ \text{N/m}^2 \times 0{,}010\ \text{m} \times 4}{62 \times 10^6\ \text{N/m}^2 \times 1{,}75 \times \pi}$✓

$d = 0{,}0199$✓

Use 20 mm diameter standard-sized rivets.✓✓

OR

$d = 6\sqrt{t}$
$= 6\sqrt{10}$✓
$= 18{,}97$ mm✓

Say 20 mm rivets.✓✓ (4)

2.2 $\sigma_t \times (w - d) \times t$
$= 108 \times 10^6\ N/m^2 \times (0{,}178\ m - 0{,}02) \times 0{,}010\ m$
$= 170{,}64\ kN$✓✓ (2)

2.3 $62 \times 10^6\ N/m^2 \times 1{,}75 \times \frac{\pi \times (0{,}02\ m)^2}{4}$
$= 34{,}09\ kN$✓✓ (2)

2.4 $\sigma_c \times d \times t$
$= 170 \times 10^6\ N/m^2 \times 0{,}02\ m \times 0{,}01\ m$
$= 34\ kN$✓✓ (2)

2.5 $\frac{\text{Maximum safe load}}{\text{Minimum safe load}}$

$= \frac{170{,}64 \times 10^3}{34 \times 10^3}$

$= 5{,}02$✓✓ (2)
**[12]**

## QUESTION 3: BELT DRIVES

3.1 $\sin\beta = \frac{(D + d)}{2C}$

$\therefore \beta = \sin^{-1}\left[\frac{(D + d)}{2C}\right] = \sin^{-1}\left[\frac{(0{,}36 + 0{,}28)}{2(1{,}2)}\right] = 15{,}466°$✓✓

$\theta = 180° + 2\beta = 180° + 2(15{,}466°) = 210{,}932°$ ✓✓ (4)

3.2 $T_1 = wt\sigma$

$\therefore w = \frac{T_2}{t\sigma_t} = \frac{(105 \times 10^2)}{(0{,}015)(26 \times 10^6)} = 0{,}26923\ m$✓ $= 270\ mm$✓✓ (3)

3.3 $L = \frac{\pi}{2}(D + d + 2t) + \frac{(D + d + 2t)^2}{4C} + 2C$

$L = \frac{\pi}{2}[0{,}36 + 0{,}28 + 2(0{,}015)] + \frac{[0{,}36 + 0{,}28 + 2(0{,}015)]^2}{4(1{,}2)} + 2(1{,}2)$✓

$L = 1{,}052433539 + 0{,}093521 + 2{,}4$✓

$\therefore L = 3{,}546\ m$✓✓ (4)

3.4 $\frac{T_1}{T_2} = e^{x\theta} = e^{0,4}\left(210,932° \times \frac{\pi}{150°}\right) = 4,36$✓✓

$T_1 = 4,36T_2$

$T_2 = \frac{T_1}{4,36} = \frac{(105 \times 10^3)}{4,36}$

$= 24\ 082,5688$ N
$= 24,083$ kN✓✓ (4)

3.5 $v = \frac{\pi(D + c)N}{60} = \frac{\pi(0,36 + 0,015)(281)}{60} = 5,517$ m/s✓✓ (2)

3.6 $P = (T_1 - T_2)v = [(105 \times 10^3) - (24,083 \times 10^3)](5,517) = 446\ 419,089$ W✓

$\therefore P = 446,419$ kW✓✓ (3)
**[20]**

## QUESTION 4: COTTER AND KNUCKLE JOINTS

4.1 $F_t = \frac{\pi}{4}d^2\sigma_t = \frac{\pi}{4}(0,018^2)(104,5 \times 10^6)$✓ $= 26,592$ kN✓✓ (3)

4.2 $F_t = (d_2 - d_1)t\sigma_t$

where $d_2 = 2d_2 2(18)$✓ $= 36$ mm✓

$\therefore t = \frac{F}{(d_2 - d_1)\sigma_t}$

$= \frac{(26,592 \times 10^2)}{[(0,036) - (0,018)](104,5 \times 10^6)}$

$= 0,0141376$
$= 14$ or 15 mm✓✓ (4)

4.3 $F_t = 2(d_2 - d_1)t_1\sigma_t$

$\therefore t_1 = \frac{F_t}{2(d_2 - d_1)\sigma_t}$

$= \frac{(26,592 \times 10^2)}{2[(0,036) - (0,018)](104,5 \times 10^6)}$

$= 7,06858 \times 10^{-3}$ m✓
$= 7$ mm✓✓ (3)
**[10]**

## QUESTION 5: BEARINGS

5.1 $$\text{Power} = \frac{2\pi T_{mean} N}{60}$$

$$T_{mean} = \frac{\text{power} \times 60}{2\pi N}$$

$$= \frac{53 \times 10^3 \times 60}{2 \times \pi \times 140}$$

$= 3\,615$ Nm✓
$= 3{,}615$ kNm✓✓ (3)

5.2 $$T_{mean} = T_{max}$$

$$T = \frac{\pi d_s{}^3}{16}\tau$$

$$\therefore d_s = \sqrt[3]{\frac{T \times 16}{\pi \times \tau}}$$

$$= \sqrt[3]{\frac{3\,615 \text{ Nm} \times 16}{\pi \times 65 \times 10^6 \text{ N/m}^2}}$$

$d = 0{,}06566$ m
$d = 66$ mm✓

$l = 2 \times d_s$
$l = 2 \times 66$
$l = 132$ mm✓✓ (3)

5.3 $$\text{Pressure} = \frac{\text{Force}}{\text{Projected area}}$$

$$\therefore P_b = \frac{Q}{l \times d}$$

$$\text{but } l = 2d_s$$

$$\therefore P_b = \frac{Q}{2d_s \times d_s}$$

$$P_b = \frac{Q}{2d_s^2}$$

$$\therefore d_s^2 = \frac{18 \times 10^3 \text{ N}}{2 \times 1 \times 10^6 \text{ N/m}^2}$$

$$= \sqrt{0{,}009 \text{ m}^2}$$
$$= 0{,}09486 \text{ m}$$
$$d = 95 \text{ mm} ✓✓$$

$$l = 2d_s$$
$$l = 2 \times 95$$
$$l = 190 \text{ mm} ✓✓$$ (4)

**[10]**

## QUESTION 6: COUPLINGS

6.1 $$T = \frac{\text{Power} \times 60}{2\pi N}$$

$$= \frac{373 \times 10^3 \times w \times 60}{2 \times \pi \times 300 \text{ r/min}}$$

$$T = 11\,873 \text{ Nm} ✓✓$$

Also

$$T = \frac{\pi {d_s}^3}{16} \times \tau$$

$$11\,873 \text{ Nm} = \frac{\pi \times {d_s}^3 \times 69 \times 10^6 \text{ Nm}}{16}$$

$$\therefore d_s = \sqrt[3]{\frac{11\,873 \text{ Nm} \times 16}{\pi \times 69 \times 10^6 \text{ Nm}}}$$

$$= 0{,}09568 \text{ m}$$
$$= 95{,}68 \text{ mm} ✓✓$$ (4)

6.2 Torque on shaft = torque on key

$$T = W \times l \times T_{key} \times \frac{d_s}{2}$$

$$11\,873\ \text{Nm} = 0{,}028\ \text{m} \times l \times 83 \times 10^6\ \text{N/m}^2 \times \frac{0{,}01\ \text{m}}{2}$$

$$l = \frac{11\,873\ \text{Nm} \times 2}{0{,}28 \times 83 \times 10^6\ \text{N/m}^2 \times 0{,}1\ \text{m}}\ ✓$$

$l = 0{,}102$ m
$l = 102$ mm✓✓

Also
Torque on shaft = torque on key

$$T = \frac{T}{2} \times l \times \sigma_c \times \frac{d_s}{2}$$

$$11\,873\ \text{Nm} = \frac{0{,}016}{2}\ \text{m} \times l \times 207 \times 10^6\ \text{N/m}^2 \times \frac{0{,}1}{2}\ \text{m}$$

$$l = \frac{11\,873\ \text{Nm} \times 2 \times 2}{0{,}016\ \text{m} \times 207 \times 10^6\ \text{N/m}^2 \times 0{,}1\ \text{m}}\ ✓$$

$l = 143$ mm✓✓ (6)

6.3 $D_2 = 3d_s$ standard proportion
$= 3 \times 100$
$= 300$ mm✓

Torque on bolts = Torque on shaft

$$\therefore \frac{\pi {d_b}^2}{4} \times n \times \tau_b \times \frac{D_2}{2} = 11\,873\ \text{Nm}✓✓$$

$$\therefore {d_b}^2 = \frac{11\,873\ \text{Nm} \times 4 \times 2}{\pi \times 4 \times 55 \times 10^6\ \text{N/m}^2 \times 0{,}300\ \text{m}}$$

$$d_b = \sqrt{0{,}000458\ \text{m}^2}$$
$d_b = 0{,}0214$ m
$d_b = 21{,}4$ mm✓✓ (5)

Copyright reserved 

6.4 $\text{Torque} = \text{force} \times \text{radius} \times \text{number of bolts}$

$$\therefore \text{Force} = \frac{\text{Torque}}{\text{Radius} \times \text{n}}$$

$$= \frac{11\,873 \text{ Nm} \times 2}{0{,}3 \text{ m} \times 4}$$

$\text{p} = 19\,788 \text{ N}$
$\text{p} = 19{,}788 \text{ kN}$✓✓

$$\text{But stress} = \frac{\text{Force}}{\text{Area}}$$

$$27{,}6 \times 10^6 \text{ N/m}^2 = \frac{19\,788 \text{ N}}{t_1 \times d_b}$$

$$\therefore t_1 = \frac{19\,788 \text{ N}}{27{,}6 \times 10^6 \text{ N/m}^2 \times 0{,}024 \text{ m}}$$

$= 0{,}02987 \text{ m}$✓
$= 29{,}87 \text{ mm}$✓✓ (5)

**[20]**

## QUESTION 7: STEAM COVERS

7.1 $$F = \frac{\pi}{4} D^2 \delta = \frac{\pi}{4}(0{,}32)^2(1\,425 \times 10^3) = 114\,605{,}3 \text{ N} = 114{,}605 \text{ kN}$$✓✓ (3)

7.2 $$F = F_6 = 0{,}7n\left(\frac{\pi}{4} d^2\right)\sigma_t$$

$$\therefore d = \sqrt[2]{\frac{4F}{0{,}7n\pi c_t}} = \sqrt[2]{\frac{4(114{,}605 \times 10^3)}{(0{,}7)(15\pi)(25 \times 10^6)}} = 0{,}023577\text{m} = 24 \text{ mm}$$✓✓ (3)

7.3 $\text{PCD} = D + 2t + d = 320 + 2(20) + 24 = 384 \text{ mm}$✓✓ (3)

7.4 $$\text{CP} = \frac{\pi \text{PCD}}{n} = \frac{\pi(384)}{(15)} = 80{,}425 \text{ mm}$$✓✓

$\delta = 1\,425 \text{ kPa}$ falls above $1\,215 \text{ kPa}$ $\therefore 3d < CP < 5d$

$3d = 3(24) = 72 \text{ mm}$✓
$5d = 5(24) = 120 \text{ mm}$✓

$\therefore$ Cp falls between 3d and 5d. Yes, steam tight.✓ (5)

**[14]**

## QUESTION 8: KEYS AND KEYWAYS

$$T = \delta AR_{mean} = p(nLh)\frac{1}{2}(D - h)$$

$$T = (6 \times 10^6)(10)(0{,}07)(0{,}005)\frac{1}{2}(0{,}06 - 0{,}005)$$

$\therefore T = 5{,}775 \text{ Nm}$✓✓

$$P = \frac{2\pi NT}{60}$$

$$P = \frac{2\pi(2\,750)(577{,}5)}{60}$$

$P = 166\,308{,}06 \text{ W}$

$P = 166{,}308 \text{ kW}$✓✓ **[4]**

**TOTAL: 100**

Copyright reserved