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Inspection - Certification

VALIDATION DOCUMENT

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Manufacturer	**ITALIAN TOP GEARS S.R.L.** **Via Giovanni Falcone 8/a** **42020 Borzano di Albinea(RE) - Italy**
Subject of Verification	**Calculation for main shaft of Gearless Lift Machine ITG 160**
Year of fabrication	**2013**
Place of Verification	**Korai 35 Kalamaria 55132 Thessaloniki Greece**
Documentation / Attachments	**DRAWINGS: - Assembly drawing of the gearless Lift Machine ITG 160** **-Detailed drawing of the main shaft.** **CALCULATIONS -Static verification of the main shaft.** **-Technical characteristics of bearings SKF 22214 E & SKF 22218 E** **-F.M.E. for the shell (main body).**

This Validation Document has been carried out to the best knowledge and ability and our responsibility is limited to the exercise of due care and the results concern only the item verified.

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Verified by

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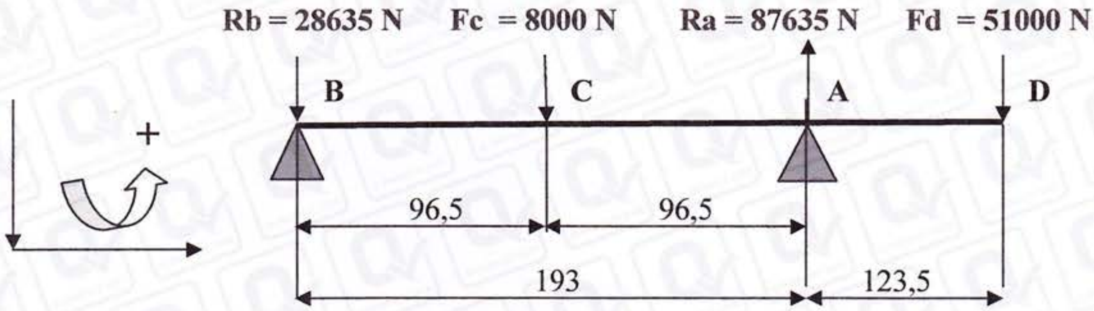
1. VERIFICATION OF MAIN SHAFT FOR GEARLESS LIFT MACHINE ITG 160

According to the shaft drawing 02.160.002.00100 the most stressed diameter is 90 mm nearest to the bearing SKF 22218 E (90x160x40) of support beam A.



The shaft is bound to the bearings SKF 22218 E (90x160x40 at point (A) & SKF 22214 E (70x125x31) at point (B),and is stressed with the loads (according to the designer)

- 8000 N at the point C
- 51000 N at the point D

A. Equation of equilibrium to vertical translation

- Ra+Rb+Fc+Fd = 0 (1)

1. Equation of equilibrium of moments at point A
   - Ra+ Rb+8000 + 51000 = 0 $\Longrightarrow$
   59000 N+ Rb = Ra **(2)**
   Rb x 193mm + Fc x 96,5mm - Fd x 90mm = 0 $\Longrightarrow$
   Rb x 193mm + 8000 N x 96,5mm - 51000 N x 123,5 mm = 0 $\Longrightarrow$
   Rb x 193mm – 5526500 Nmm = 0 $\Longrightarrow$ Rb = 5526500 / 193 = 28635 N

From (1) & (2) Ra = 59000N + 28635 N = 87635 N

Results: Ra = 87635 N
Rb = 28635 N
Fd = 51000 N
Fc = 8000 N

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2. STATIC VERIFICATION OF MAIN SHAFT

a. Solicitation of Bending (bending stress)

The maximum bending moment resulted from:
Mf = Fd x 123,5 mm = 51000N x 123,5 mm = 6298500 Nmm $\Longrightarrow$ **Mf = 6298500 N mm**

The most stressed diameter of shaft is D = 90 mm

The solicitation of bending resulted from: $\sigma_f = \dfrac{Mf}{Wf}$

$$\sigma_f = \frac{Mf}{Wf} = \frac{6298500Nmm}{\frac{\Pi D^3}{32}} = \frac{6298500}{71569,4} = 88 \text{ Mpa} \Longrightarrow \sigma_f = 88 \text{ Mpa}$$

b. Solicitation of torsion. (torsion strength)

The maximum torsion moment offered by gearless lift machine according to the designer is:

Mt = 2700000Nmm

The solicitation of torsion resulted from: $\tau = \dfrac{Mt}{Wt}$

$$\tau = \frac{Mt}{Wt} = \frac{2700000}{\Pi D^3/16} = \frac{2700000}{143139} = 18,86 \text{ Mpa} \Longrightarrow \tau = 18,86 \text{ Mpa}$$

c. Equivalent static solicitation.

The equivalent static solicitation is given by the formulate:

$$\sigma_{EQ} = \sqrt{(\sigma f)^2 + 3(\tau^2)}$$

$$\sigma_{EQ} = \sqrt{(\sigma f)^2 + 3(\tau^2)} = \sqrt{(88)^2 + 3(18,86)^2} \Longrightarrow$$

$$\sigma_{EQ} = \sqrt{7744 + 1067} = \sqrt{8811} = 93,87 \text{ Mpa} \Longrightarrow \sigma_{EQ} = 93,87 \text{ Mpa}$$

d. Safety factor

Technical characteristics of shaft material.(EN 10083 -3)

- Steel: 42CrMo4
- Re min: 650Mpa
- R m: 900Mpa
- A min: 12%
- Z min: 50%
- KV(min): 35J

The safety factor for rupture according to the Rm is:

$$\eta = \frac{R}{\sigma_{EQ}} \Longrightarrow \eta = \frac{900}{93{,}87} = 9{,}6 \Longrightarrow \boldsymbol{\eta = 9{,}6}$$

Alternative verification:

$$\boldsymbol{\sigma_{AMM}} = \frac{Re}{1{,}5} \Longrightarrow \sigma_{AMM} = \frac{650}{1{,}5} = 433{,}3\text{Mpa} \Longrightarrow \boldsymbol{\sigma_{AMM} = 433{,}3\text{Mpa}}$$

where σ_{AMM} is the allowable stress

According to formulate:

$\boldsymbol{\sigma_{EQ} < \sigma_{AMM}} \Longrightarrow$ 93,87 Mpa < 433,3 Mpa

e. Fatigue verification (Gough – Pollard principle)

1. Calculation of deflection limit effort σ_{LIM}

$\boldsymbol{\sigma_{LIM} = \sigma_{FAF} \cdot b_1 \cdot b_2 / Kf}$

$\boldsymbol{\sigma_{FAF}}$ = Solicitation of deflection limit = $Rm/2$ = 450Mpa

b_1 = Coefficient referring to surface quality = 0,89
b_2 = Coefficient referring to size = 0,78
Kf = Fatigue strength reduction factor (Peterson equation)
Kf = 1 + q (Kt-1) where **q = 0,85** (Neuber), **Kt = 1,15**
Kf = 1,13
$\boldsymbol{\sigma_{LIM}}$ = 450 · 0,78 · 0,89 / 1,13 = 276,5 Mpa $\Longrightarrow$ **σ_{LIM} = 276,5 Mpa**

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2. **Calculation of torsion limit effort τ_{LIM}**

$\tau_{LIM} = 0{,}6 \text{ x Re min}$
Re min = 650 Mpa
$\tau_{LIM} = 0{,}6 \text{ x Re min} = 0{,}6 \cdot 650 = 390 \text{ Mpa} \Longrightarrow \boldsymbol{\tau_{LIM} = 390}$ **Mpa**

3. **Gough – Pollard principle σ_{GP}**

$$\boldsymbol{\sigma_{GP}} = \sqrt{\sigma f^2 + \left(\frac{\sigma_{LIM}}{\tau_{LIM}}\right)^2 \cdot \tau^2 \max} \leq \frac{\sigma_{LIM}}{n} \Longrightarrow \boldsymbol{\sigma_{GP}} \leq \frac{\sigma_{LIM}}{n}$$

Where $\eta = 1{,}5$
$\sigma f = 88$ Mpa
$\sigma_{LIM} = 276{,}5$ Mpa
$\tau_{LIM} = 390$ Mpa
$\tau_{MAX} = 18{,}86$ Mpa

$$\boldsymbol{\sigma_{GP}} = \sqrt{(88)^2 + \left(\frac{276{,}5}{390}\right)^2 \cdot 18{,}86^2} \leq \frac{276{,}5}{1{,}5}$$

$$\boldsymbol{\sigma_{GP}} = \sqrt{3778{,}5 + (0{,}5x355{,}6)} = 74{,}54 \leq 184{,}3 \Longrightarrow \textbf{Acceptable}$$

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