Tugra makina

CERTIFIED QUALITY MANAGEMENT SYSTEM ISO 9001:2000 SINCERT DNV

CALCULATIONS USED IN THE FASTENING OF THE TOROIDAL LPG TANKS

Manufacturer:

TUĞRA MAKİNA TAKIM TEZGAHLARI
VE MADENİ EŞYA SAN.TİC.LTD.ŞTİ.
Organize Sanayi Bölgesi 5. Cadde No:18
38030 KAYSERİ/TÜRKİYE

Calculated by:

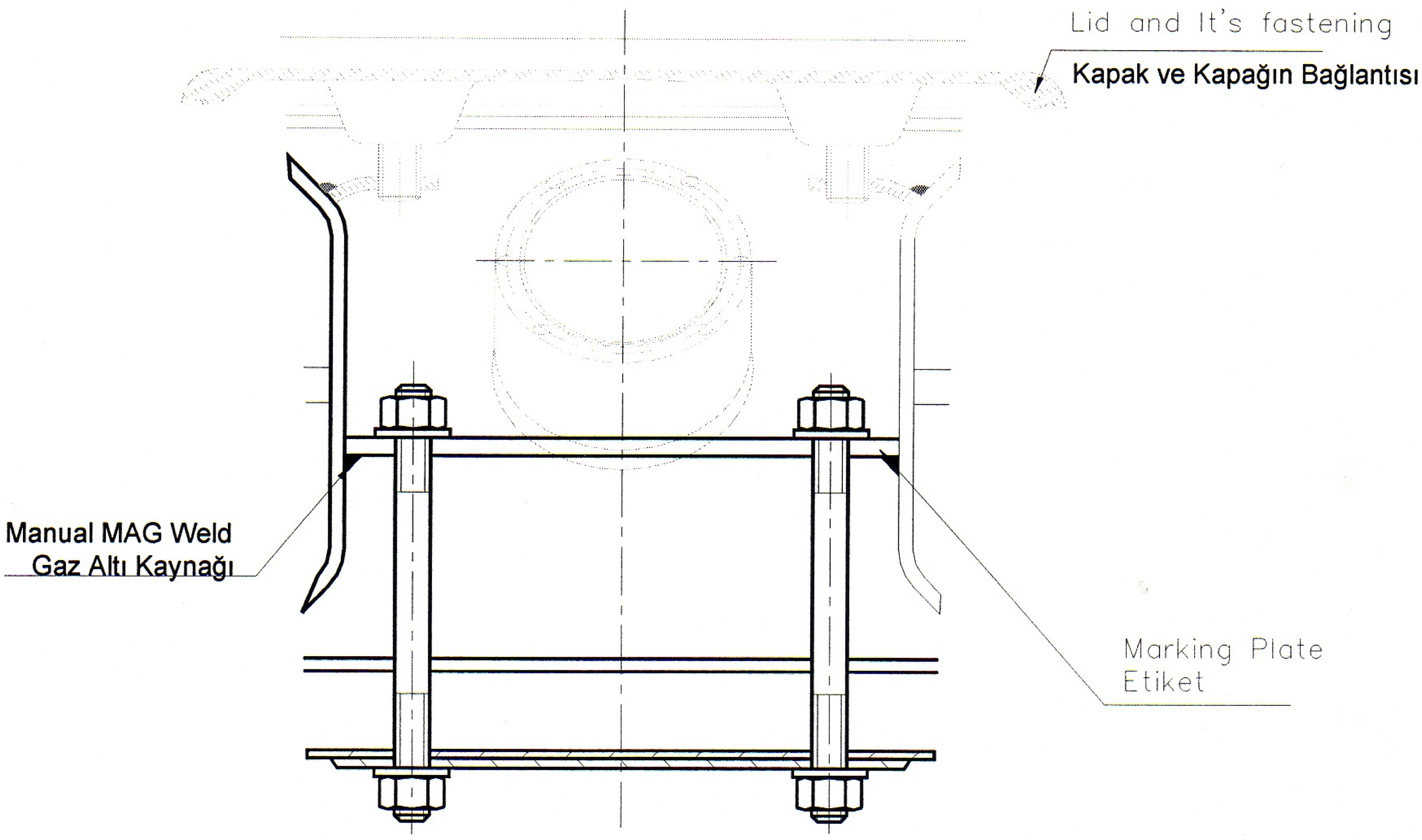
Öğr. Gör. İlhan BALOĞLU
ERCİYES ÜNİVERSİTESİ
KAYSERİ/TÜRKİYE

KAYSERİ 2003

1. GENERAL DESCRIPTION:

1.1 Scope:

This calculation is for the fastening elements used in the mounting of the Toroidal LPG Tank shown in Fig. 1.



Şekil 1

Figure 1

The calculation is done for the following tank which is the biggest tank produced by this company.

Outer Diameter	:650 mm.
Height	:270 mm.
Capacity	:72 dm^3

The materials used in the production of the tank has been chosen according to the EN 10120 and complies the provised characteristics of the regulation ECE-R 67.01.

1.2 The Basis of Calculation:

Regulation ECE-R 67.01 Part: 17 Item: 17.4

1.3 The Elements Calculated For:

a.- Bolt M10
b.- Nut M10
c.- Washer D30x2.4 mm

The Characteristics of the Materials Used:

Name	Material	Yield Strength σ_A[Mpa]	Tensile Strength σ_K[Mpa]
Fastening Hook	P265 NB	265	450
Bolt M10	C30	400	600
Nut M10	C30	400	600

1.3 Fastening of the Tank:

The fastening of the tank is shown in Fig. 1.

1.4 The Criteria Used in the Calculation:

The forces apply to the fastening of the tank and taken into the calculation are shown in Fig 2.

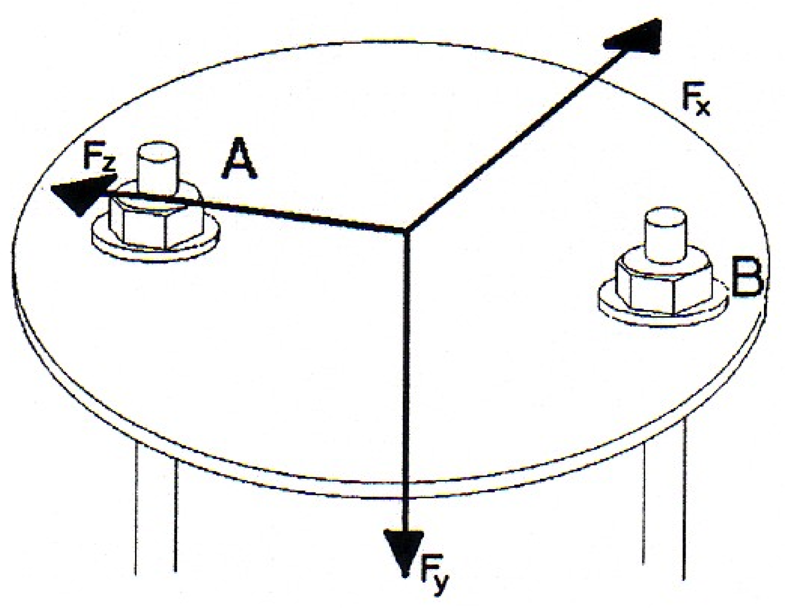


Figure 2

F_x, The inertia force in the direction of the movement of the vehicle
F_z, Inertia force perpendicular to F_x and at the same time in horizontal direction
F_y, Vertical force coming from the weight of the tank

1.5 Forces Apply to Tank:

a.- Multivalve mounted on the tank	0.8 Kg.
b.- Tank weight empty	37 Kg
c.- LPG 80% of the volume	0.509 kg/dm^3
d.- The gravity accelaration	~10 kgm/s^2

Possible dynamic forces applying to the tank mounted on a vehicle during movement:
F_x (Force of Inertia) according to the regulation ECE-R 67.01 17.4.6.(a)
F_x=20xG
Fz (Force of Inertia) according to the regulation ECE-R 67.01 17.4.6.(b)
F_z= 8xG taken

Reaction Forces:

R_A : Reaction forces at point A

R_B : Reaction forces at point B

2. CALCULATIONS:

2.1 Characteristics:

$V=72\ dm^3$	: Tank Capacity
$\gamma=0.509\ kg/dm^3$	: Density of LPG
$m=0.8\ kg$	: Weight of multivalve
$K=37\ kg$	: Weight of tank empty
$g=\sim 10\ kgm/s^2$	: Gravity accelaration
$F_y=G$	: Weight of 80% LPG filled tank

2.2 Calculation of the Forces Applying to Tank

$$Fy=G=g.[m+(\gamma.V.80\%)+K]$$

$$F_y=658.43\ N$$

$$Fx= 20.G$$

$$F_x=13168.6\ N$$

$$Fz= 8.G$$

$$F_z=5267.44\ N$$

2.3 Distribution of the Reaction Forces in the Screw Mounting:

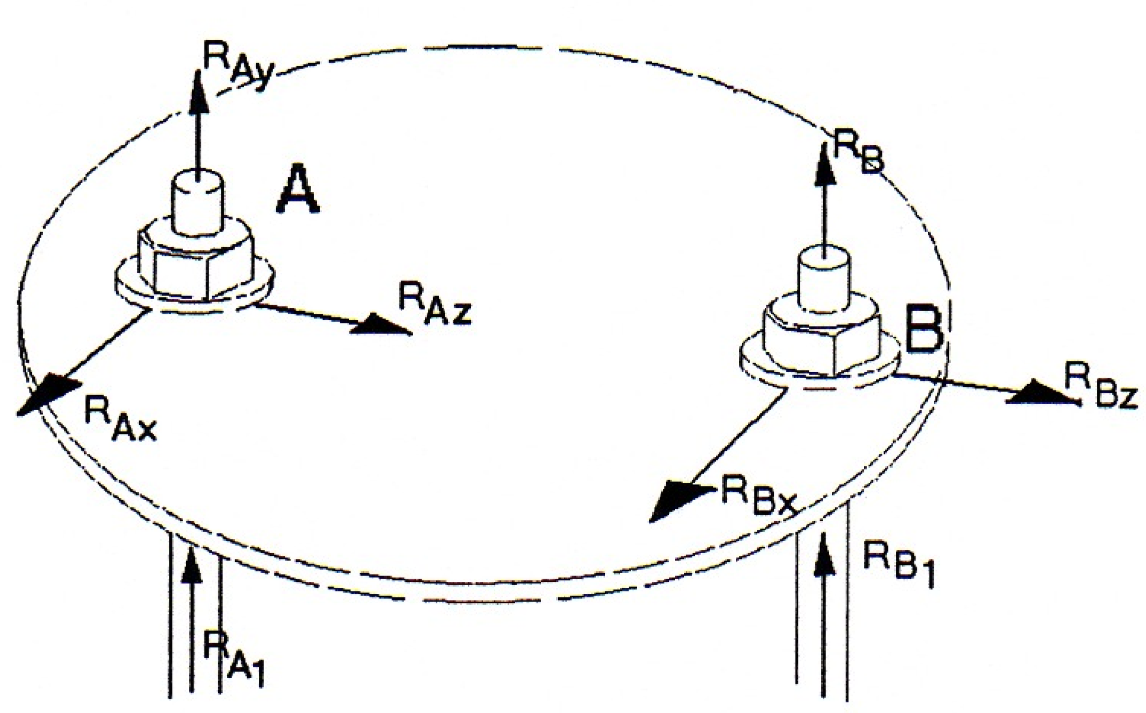


Figure 3

In direction x:

$$\mathbf{Fx = R_{Ax} + R_{Bx}}$$

In direction y:

$$\mathbf{Fy = R_{Ay} + R_{By} + R_{A1} + R_{B1}}$$

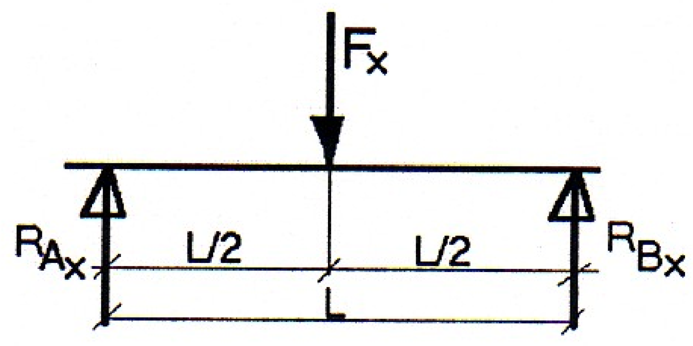
In direction z:

$$\mathbf{Fz = R_{Az} + R_{Bz}}$$

Calculation of Reaction Forces:

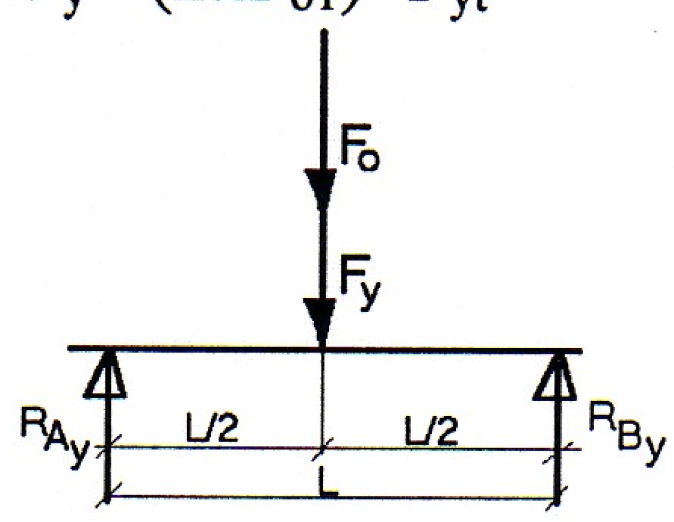
Reaction forces in X direction:

$$\mathbf{R_{Ax}} = \mathbf{R_{Bx}} = Fx/2 = 6534.3 \text{ N}$$



Reaction forces in Y direction:

$$\Sigma F_y = (2xF_{o1}) + F_{yt}$$



F_{o1}: Pretension
F_{yt}: Tank weight =G
A_1: The crosssection of M10

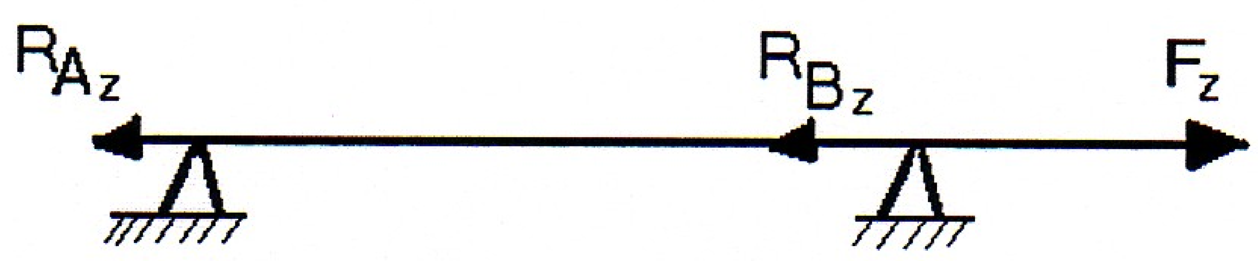
$$F_{01} = \sigma_0 \text{ x } A_1 = 10920 \text{ N}$$

$$\Sigma F_y = 22498.43 \text{ N}$$

$$\mathbf{R_{Ay}} = \mathbf{R_{By}} = 22498.43/2 = 11249 \text{ N}$$

Reaction forces in Z direction:

$$\mathbf{R_{Az} = R_{Bz} = 2633 \text{ N}}$$



Friction analysis:

$\mu = 0.25$
Fr=Friction Force

$$\mathbf{F_r} = \Sigma F_y \text{ x } \mu = 2812 \text{ N}$$

CONCLUSION:

Since $F_r > R_{Az} = R_{Bz}$; it is safe.

Organize Sanayi Bölgesi 5.Cad.No:18
Kayseri-TURKEY
Tel: + (90) (352) 321 28 17-18
Fax: +(90) (352)321 28 15

www.tugramakina.com
www.tugramak.com
e-mail: tugramak@tugramak.com

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3. ANALYSIS OF THE STRENGTH TO THE SURFACE PRESSURE

Calculation of the Contact Area of the Washer:

$A_r = \frac{pi}{4}(Dw^2 - Da^2) = \mathbf{6.115x10^{-4}\ m^2}$.

$P_{max} = \Sigma F_y\ /\ Ar = 1.8 \times 10^7$ Pa

For steel P_{em} :

$P_{em} \sim= \sigma_{Ak}/4 = 400/4 = 100$ Mpa= 10×10^7 Pa

For nut P_{em}:

$P_{em} = 265/4 = 66.25$ Mpa= 6.625×10^7 Pa

***** The Result: Since $P_{max} < P_{em}$; it is safe.**

4. ANALYSIS OF THE AUTOBLOCADE CONDITION

d_0 = Median diameter of M10 thread = 9.172 mm.
h = Pitch: 1.2 mm
α = Helix angle
ρ = Friction angle

tg α= h/(π x do) ➔ $\alpha = 2.38^0$

Since the friction coefficient between bolt and nut threads is $\mu = 0.15$:
tg $\rho = \mu$ ➔ $\rho = 8.5^0$

**** Conclusion: Since the Friction Angle > Helix angle, there is autoblocade.**

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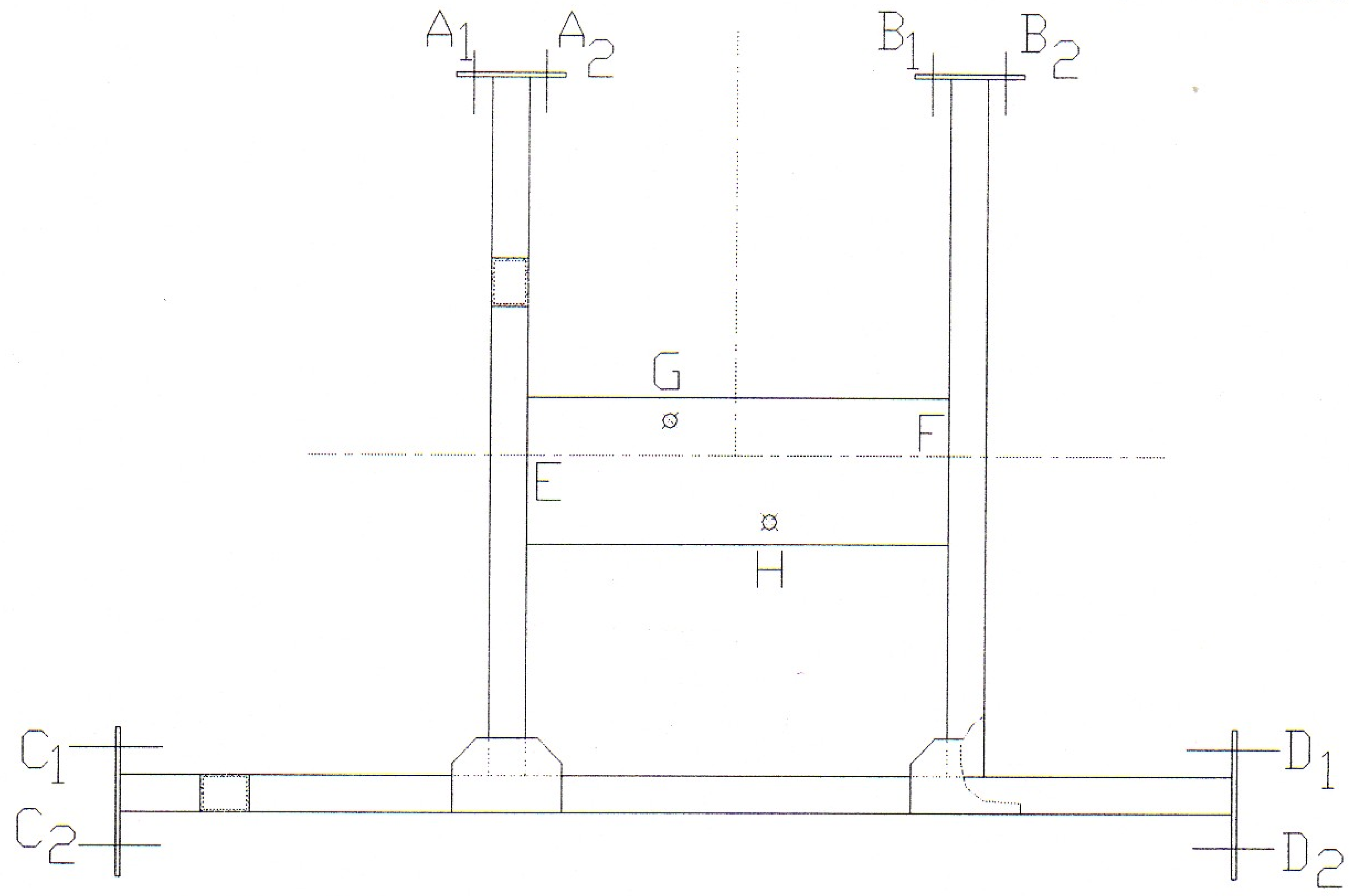
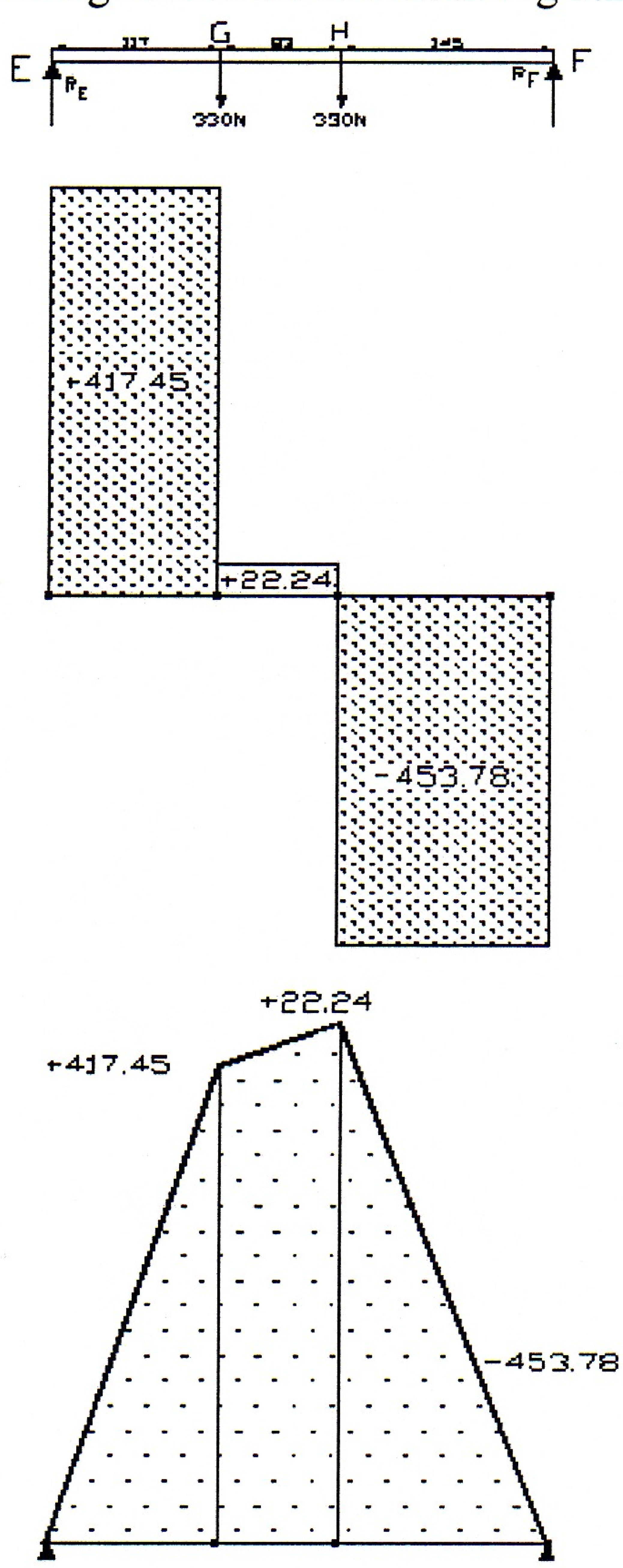
5. CALCULATIONS FOR THE TOROIDAL TANK FASTENING



Load magnitudes are shown in Fig 2.2.



5.1 Calculation of the forces in "Y" axis:

$\sigma = \dfrac{Mxc}{I}$ $\quad \sigma_{sac}$ =265 Mpa

σ_{kaynak} =265 Mpa

$\tau = kx\dfrac{V}{A}$

τ_{kaynak} =0.65xσ_{kaynak} =172.25 Mpa

$\sum M_E=0$

330x117+330x200-RFx345=0

R_F=303.2N

$\sum F_X$=~660N

R_E+R_F=660 ➔ R_E=660-303.2=356.8N

$$\tau_E = \frac{1.5x303.2}{0.43x12} = 95.9MPa$$

$$\sigma_F = \frac{1.5x417.45}{0.43x12} = 121.35MPa < \sigma_{kaynak}$$

$$\sigma_{H\max} = \frac{453.78x6}{0.43x12^3/12} = 43.97MPa < \sigma_{sac}$$

$\tau_E < \tau_{Kaynak} \quad \sigma_F < \sigma_{kaynak} \quad \sigma_{H\max} < \sigma_{Sac}$

Conclusion: It is safe in "Y" axis.

Organize Sanayi Bölgesi 5.Cad.No:18
Kayseri-TURKEY
Tel: + (90) (352) 321 28 17-18
Fax: +(90) (352)321 28 15

www.tugramakina.com
www.tugramak.com
e-mail: tugramak@tugramak.com

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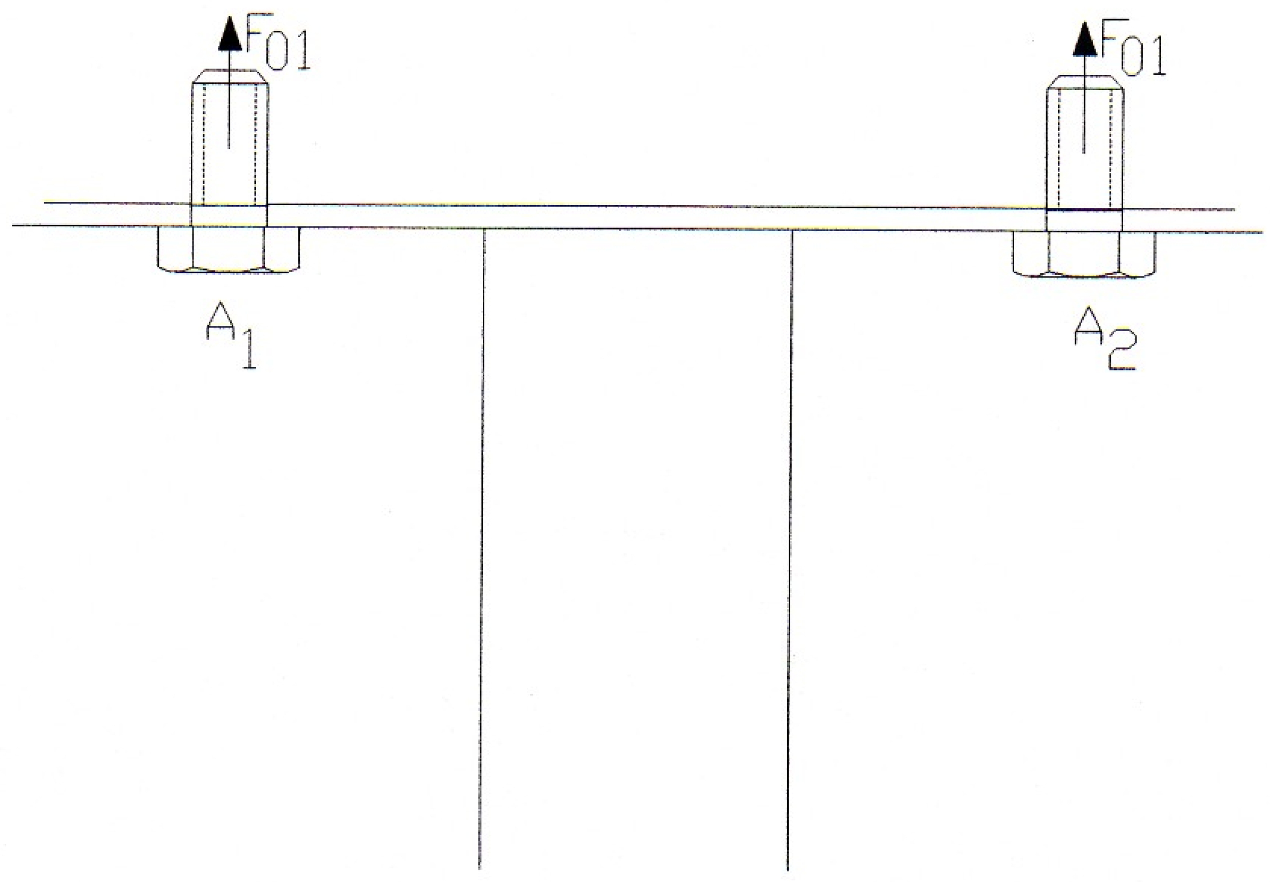
5.2 Calculation of the forces in "Z" axis:

F_{Z}=5267.44 N (Sec. 2.2)



Picture: Example of fixing points A,B,C,D

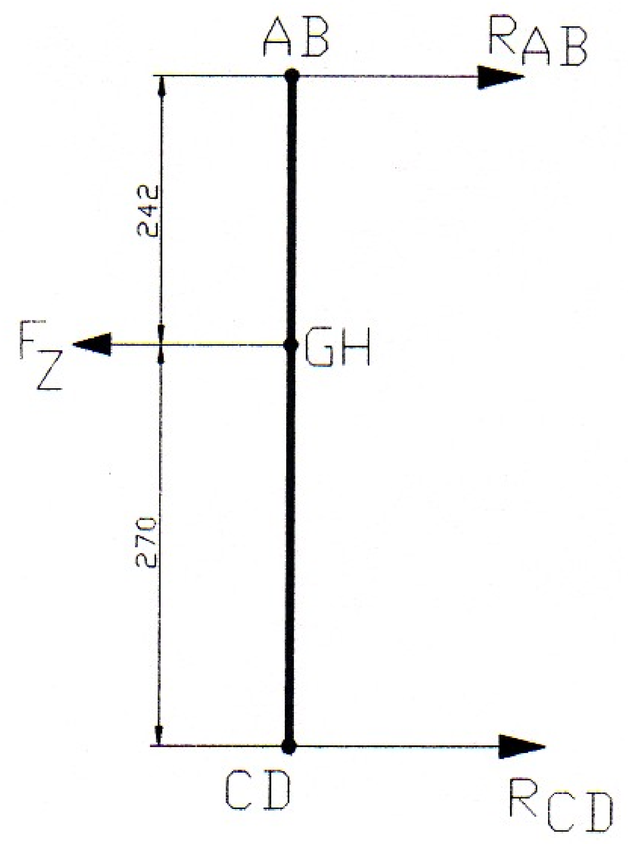
Calculation is made for toroidal tank fastening mounted by 4 bolts at points A and B. (A_1, A_2, B_1, B_2) and M10 is assumed for the bolts as the minimum diameter.

$\mathbf{F_{01}}$: Pretension= **10920 N** (Page 4 Sec. 2.3)

For Four pcs nuts
F_{T01}= 4x10920= **43680 N**

Friction force created by the pretension (μ=0.25)

F_{RZ}= F_{T01} x μ = 43680 x 0.25 =**10920 N.**



$\Sigma M_{AB} = 0 \rightarrow = 242 \times F_Z - R_{CD} \times 512 = 0 \rightarrow R_{CD} =$ **2490 N.**

$R_{AB} = F_Z - 2490 =$ **2778 N**

$R_{AB}, R_{CD} < F_{RZ}$=**10920 N.**

Conclusion: It is safe to "Z" axis.

5.3 Calculation of the forces in "X" axis:

Fx= 13168N (Sec: 2.2)

Calculation for CD points:
It is assumed that 4 bolts of M10 is used at points CD:

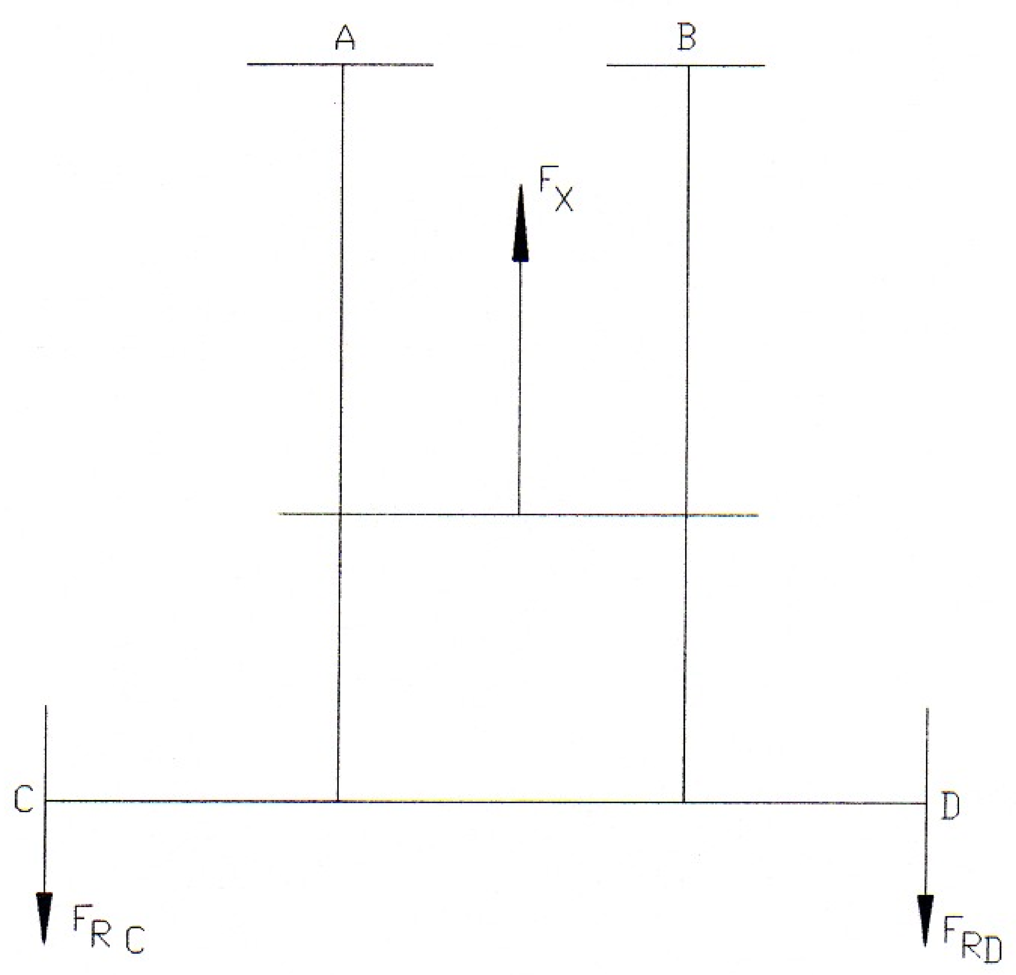
F_{01}: Pretention=**10920 N** (Page 4 Sec. 2.3)

Total bolt pretension:

F_{T01}= 4x10920= **43680 N**

Friction force created by the pretension (μ=0.25)

$F_{Rx} = F_{T01} \times \mu = 43680 \times 0.25 =$ **10920 N.**



$\Sigma M_{RD}=0 \rightarrow F_{RC}=$**5530 N**

$F_{RD} = F_X - F_{RC} = 13168-5530=$**7638 N.**

Since $F_{RC} < F_{Rx}$ and $F_{RD} < F_{Rx}$, it is safe in "X" axis.

GENERAL CONCLUSION:

***** According to the calculations, the method used in fastening of the toroidal LPG tank is safe.**

Organize Sanayi Bölgesi 5.Cad.No:18
Kayseri-TURKEY
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Fax: +(90) (352)321 28 15
www.tugramakina.com
www.tugramak.com
e-mail: tugramak@tugramak.com
MİMARSİNAN V.D. 0710061205