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HYPERBARIC RECIPIENTS

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Abstract: There are two types of recipients that work in hyperbarism:
1. Recipients under inner pressure
2. Recipients under outer pressure
- General presentation
- Calculation example

1. INTRODUCTION

1.1 RECIPIENTS UNDER INNER PRESSURE

In hyperbarism these recipients may be:
- recipients pressurized with breathing mixtures;
- recipients pressurized with water.

The making of the Communication Apparatus and the Wireless Phone imposed the designing of the Container for testing the electric cables (Fig. 1).

This container may be used for testing the strength and tightness of the special electric cables and other apparatus used in diving activities.

The main characteristics of the container are:
- work pressure : 38 bars
- pressure for hydraulic check-up : 47 bars
- ringing fluids : water
- dimensions: ø 312*6 mm, H 1660 mm.

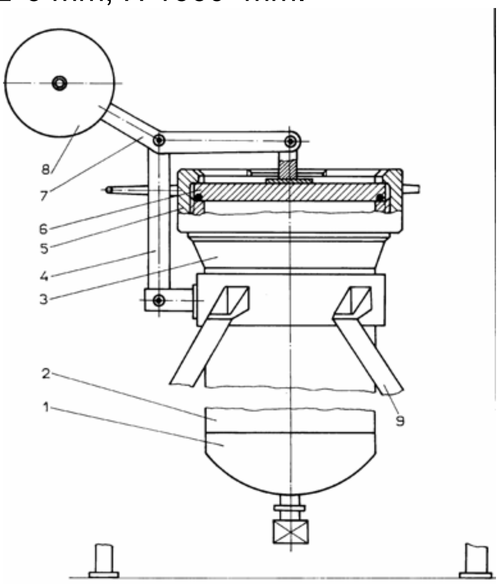


Fig. 1 Container for testing the electric cables
1. Recipient bottom 2. Body 3. Flange 4. Arm A 5. Coupling Flange 6. Cover 7. Arm B 8. Equilibrium weight 9. Pylon

1.2 RECIPIENTS UNDER OUTER PRESSURE

The container for stuff materials transfer was designed because there was necessary to make the transfer of materials from a submarine of intervention to a drift submersible during the rescue operation.

The main characteristics of the container are:

- the major outer pressure : 30 bars
- the work environment : sea water
- dimensions : ø 400*13 mm, H 1600 mm
- weight in air :85 kg
- components are shown in fig. 2.

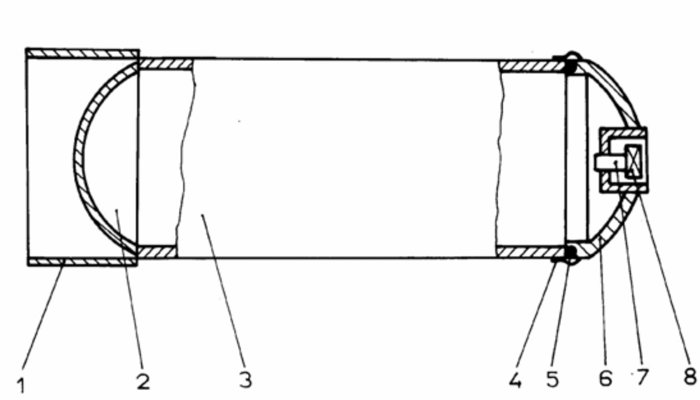


Fig. 2 container for stuff materials transfer
1. Support 2. Bottom 3. Body 4. Latch 5. O-ring 6. Cover 7. Nozzle 8. Cock

2. ELEMENTS OF CALCULATION

2.1 RECIPIENTS UNDER INNER PRESSURE

The Container for testing the electric cables are made of a special steel an isotropic material De = external diameter

D_i = internal diameter

δ = theoretical thickness

β = defining body index

$\beta = D_e/D_i$

For the cylindrical body,

$$\beta < 1.2 \quad (1)$$, in conclusion these is a cover.

p = internal pressure witch activate in static charge conditions.

δ = thickness of cover element

r = cylinder radium

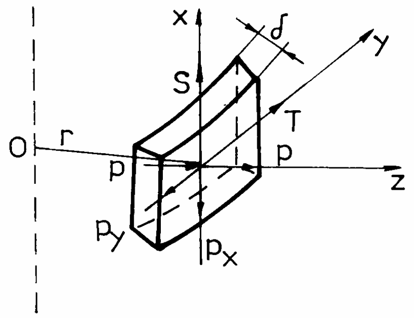
In this case is available the Maximum tangent tension efforts theory for the extreme status:

$$\sigma_e = \sigma_{max} - \sigma_{min} \quad .(2)$$

Regarding a cover element (fig. 3), with the thickness δ, the forces witch acct into cover are:

- S on the x axis
- T on the y axis

FIG. 3



For the cylindrical cover:

$$R_1 = r = \frac{D_i}{2} \quad (3)$$

$R_2 = \infty \Rightarrow$ on the z axis the force is null.

The resulted tensions are:

$$\sigma_1 = \frac{S}{\delta} \quad (4)$$

$$\sigma_2 = \frac{T}{\delta} \quad (5)$$

It is applying the Maximum tangent tension efforts theory

$$\sigma_e = \sigma_{max} - \sigma_{min} = \sigma_a \quad (6)$$

$$S = \frac{p \times r}{2} \quad (7)$$

$$T = p \times r \quad (8)$$

$$\sigma_{max} = \frac{T}{\delta} = \frac{p \times r}{\delta} \quad (9)$$

$$\sigma_{min} = -\frac{p}{2} \quad (10)$$

$$\sigma_{ech} = \sigma_{max} - \sigma_{min} = z \times \sigma_a \quad (11)$$

$$\frac{p \times r}{\delta} + \frac{p}{2} = z \times \sigma_a \quad (12)$$

$$\delta = \frac{p \times D_i}{2 \times z \times \sigma_a - p} \quad (13)$$

Because the cylindrical body welded here appear weaknesses in the strength of the material, that are compensated by the coefficient z<1.

The designed thickness is :

$$s_p = \delta + c_1 + c_r \quad (14),$$

where c1 = corrosion addition

c_r = round up addition

This formula is adopted by the ISCIR prescriptions (C4-83).

2.2 RECIPIENT UNDER OUTER PRESSURE

It may be started from the same hypothesis as in point 2.1.

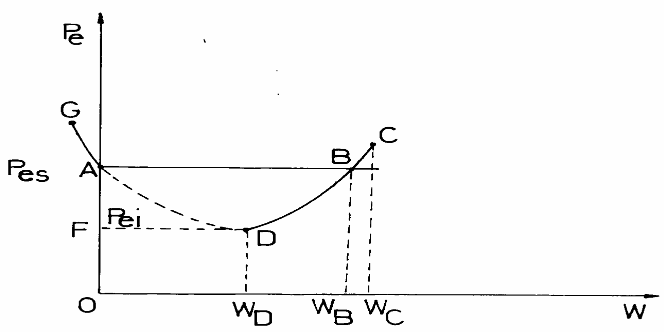
The container for stuff materials transfer has a cylindrical body, which is the cover ($\beta \leq 1.2$).

Because it has to be easily manipulated by the divers, the material chosen is aluminum alloy resistant to the sea corrosion, an isotropic material.

The calculation of the strength to the outer pressure refers to the stability of the covert and it is based on experimental methods.

The cylindrical diaphragm is considered a mechanic system with an only degree of freedom. It is studied the radial movement w function of p_e, resulting the characteristic curve from fig.4.

FIG. 4



p_{es} = the major outer pressure

p_{ei} = the inferior outer pressure

Up to the achievement of the value p_{es}, there is no movement occurring, the rising of the pressure is dove after OA.

At the achievement of p_{es} value there is a first rise of equilibrium by the radial movement from A to B.

The rising of p_e, the radial movement is very little, after BC.

At the lowering of the pressure to p_{ei} it occurs the radial distortion, after CD.

In point D there is a rising of the cylindrical cover from the point it was situated to the initial position of equilibrium. This rise of equilibrium at the discharge dislodging is produced at a value of pressure $p_{ei} < p_{es}$ from the loading.

On AG there are no equilibrium positions.

There is a probability in the phenomenon of loosing the stability similar to that of entering into a resonance of the critical revolution.

The cover is considered long, if the critical pressure $L > L_{cr}$.

$$L_{cr} = k \times D \times \sqrt{\frac{D}{\delta}} \text{ (15), for } \frac{\delta}{D} \in (0.0146 \div 0.097) \text{ (16)}$$

$$p_{ext.cr.} = \frac{E}{4 \times (1 - \nu)} \times \left(\frac{\delta}{R}\right)^3 \leq \sigma_p \text{ (17)}$$

where : L = the cylindrical body , R=Di/2

L_{cr} = the critical value

ν = Poisson s constant

E = the elasticity modulus
k = constant of the material

If ,

$$\sigma_{2cr} = \frac{p_{ecr} \times R}{\delta} \le \sigma_p \quad (18),$$

the change is produced in the elastic field.

By first approximation it interschimbabil determined δ^*= the theoretical thickness with calculus at the interior pressure, where $p_{icr} = p_{ecr}$

$$\sigma_a = \frac{\sigma_r}{3.5} \quad (19) \text{ for aluminum}$$

p_{icr} = critical inner pressure
p_{ecr} = critical outer pressure

$$\delta^* = \frac{p_{ecr} \times D_i}{2 \times \sigma_a - p_{ecr}} \quad (20)$$

Then it is established the field of loading stress:

- plastic if $$\frac{\delta^*}{D_i} > 1.1 \times \left(\frac{L}{D_i} \times \frac{\sigma_{cr}}{E}\right)^{2/3} \quad (21)$$
- elastic if $$\frac{\delta^*}{D_i} < 1.1 \times \left(\frac{L}{D_i} \times \frac{\sigma_{cr}}{E}\right)^{2/3} \quad (22)$$

The container for stuff materials transfer is a long cover that changes in the elastic field. It is checked up:

$$1.644 \times \left(\frac{p_{ecr}}{E}\right) \le \frac{L}{D_i} \le 0.764 \times \left(\frac{E}{p_{ecr}}\right)^{1/6} \quad (23),$$

then it is calculated theoretical thickness δ :

$$\delta = 1.178 \times D_i \times \left(\frac{p_{ecr}}{E} \times \frac{L}{D_i}\right)^{0.4} + c_1 + c_r \quad (24)$$

Thus it was obtained a container of reasonable dimensions easy to be handled (85 kgs) , that can resist to p_{ecr}=300 bars (depth 300m).

3. CONCLUSIONS

Because the calculus of resistance of the recipients, especially to the outer pressure is based on experimental methods, there are very important the pressure tests that are dove during the experiments of the prototypes.

At any change of the initial conditions of the cover element (the variation of thickness, the joining with another body, holes in cylindrical body, etc.), there appear changes in the tensions and the moments that induce it. This asked for the calculus of the resistance to be dove on computer.

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