

## SYMBOLS AND UNIT OF MEASUREMENT

<b>cm</b>	= reeving ratio
<b>Q</b>	= rated load [kg]
<b>P3</b>	= sum of the masses of car, sling and reeving ropes if any [kg]
<b>Pr</b>	= mass of the ram = $\frac{L_p}{100} \cdot q + P_{gs} \cdot (N - 1)$ [kg]
<b>N</b>	= number of pieces for split jacks (1, 2, 3)
<b>Nr</b>	= number of jacks (1, 2)
<b>q</b>	= linear mass of the ram [kg/m]
<b>Pf</b>	= ropes weight [kg]
<b>Pgs</b>	= mass of one ram joint [kg]
<b>Pgc</b>	= mass of one cylinder joint [kg]
<b>Prh</b>	= mass of the devices connected to the ram top (pulley and pulley frame if any) [kg]
<b>F5</b>	= effective buckling force [daN]
<b>T</b>	= total force on ram top (for graphs reading) [daN]
<b>2</b>	= Eulero stability safety factor
<b>1,4</b>	= over pressure factor
<b>gE</b>	= total stability safety factor = $1,4 \cdot 2 = 2,8$ (for graphs reading)
<b>gn</b>	= standard gravity acceleration = $9,81 \text{ m/s}^2$ (in following formulas 0,981 is used for daN conversion)
<b>Lc</b>	= car travel [cm]
<b>Eic</b>	= bottom overtravel of the car [cm]
<b>Eip</b>	= bottom overtravel of the ram [cm] (to be calculated according EN 81-20 - § 5.8.1.4)
<b>Esc</b>	= top overtravel of the car = $E_{sp} \cdot cm$ [cm]
<b>Esp</b>	= top overtravel of the ram $\geq 5$ cm (suggested) (stroke of cushioned stop = 3,5 cm)
<b>Lo</b>	= buckling length [cm]
<b>Lp</b>	= total stroke of ram [cm]
<b>L1</b>	= distance between pulley axis and ram top (indirect acting jacks) [cm]
<b>d</b>	= outer diameter of ram [mm]
<b>di</b>	= inner diameter of cylinder [mm]
<b>es</b>	= ram wall thickness [mm]
<b>D</b>	= outer diameter of cylinder [mm]
<b>Di</b>	= inner diameter of cylinder [mm]
<b>ewall</b>	= cylinder wall thickness [mm]
<b>J</b>	= moment of inertia = $\frac{\pi \cdot (d^4 - di^4)}{640000}$ [cm <sup>4</sup> ]
<b>F</b>	= cross sectional area = $\frac{\pi \cdot (d^2 - di^2)}{400}$ [cm <sup>2</sup> ]
<b>i</b>	= radius of gyration = $\sqrt{\frac{J}{F}}$ [cm]
<b>λ</b>	= slenderness ratio = $\frac{L_0}{i}$

**A** = ram push area =  $\frac{\pi}{400} \cdot d^2$  [cm<sup>2</sup>]  
**Qc** = circulating oil per meter of stroke [dm<sup>3</sup>/m]  
**Qtc** = total circulating oil (complete extension of ram) [dm<sup>3</sup>]  
**Qr** = oil for filling per meter [dm<sup>3</sup>/m]  
**Qtr** = total oil for filling [dm<sup>3</sup>]  
**Qpo** = jack weight for stroke = 0 [kg]  
**Qp1** = additional jack weight per meter [kg/m]  
**Qtp** = total weight of jack (oil weight not included) [kg]  
**Qtcyl** = total weight of cylinder (oil weight not included) [kg]  
**Qtl** = oil weight for cylinder with complete extended ram [kg]  
**pstat** = full load static pressure [bar] (1bar = 0,1 MPa = 1 daN/cm<sup>2</sup>)  
**p<sub>v</sub>** = static pressure with empty car [bar]  
**E** = elasticity modulus = 2.100.000 daN/cm<sup>2</sup>  
**R<sub>m</sub>** = breacking limit load = 510 N/mm<sup>2</sup>  
**R<sub>p0,2</sub>** = proportional elongation conventional limit = 355 N/mm<sup>2</sup>

**NOTES:**

- The strength of a split jack is equal to or greater than that of a single piece jack with the same characteristics
- The upper limit of the ram stroke is given by contact of ram bottom on to the cylinder head (cushioned stop 35 mm)
- All the connections are designed and manufactured to a safety factor greater than 1,7 with respect to the proof stress (non-proportional elongation) calculated on a pressure = 2,3 x Maximum static pressure.

## **INSTRUCTION FOR JACK SELECTION**

For a quick selection of the jack use the graphs in this section. They have been calculated with a safety factor  $g_E = 2,8$  (see EN 81-50 : "Eulero stability safety factor" = 2 and "over pressure factor" = 1,4 ) . For different values of  $g_E$ , please contact **GMV** or specify them on the order.

The total forces (T) on ram top (for direct acting jacks) or on pulley shaft (for indirect acting jacks) are drawn on horizontal axis; the buckling lengths ( $L_o$ ) are drawn on vertical axis. Trace two perpendicular lines from the total force and from the buckling length. If the intersection of the two lines is below the graph of the selected jack, it is verified against buckling. If the intersection is close to the graph we suggest carrying out the analytical calculation to verify the jack.

Use the following formulas to calculate T,  $L_o$  and  $L_p$ .

### **ONE DIRECT ACTING JACK**

$$T = \left[ (Q + P_3) \cdot \frac{gn}{10} \right] \text{ [daN]}$$

$$L_p = L_c + E_{sp} + E_{ip} \text{ [cm]; } L_o = L_p + 4 \text{ [cm]}$$

### **ONE INDIRECT ACTING JACK 2:1 (cm = 2)**

$$T = [(Q + P_3 + P_f) \cdot 2 + P_{rh}] \cdot \frac{gn}{10} \text{ [daN]}$$

$$L_p = \left( \frac{L_c}{2} + E_{sp} + E_{ip} \right) \text{ [cm]; } L_o = L_1 + 4 \text{ [cm]}$$

### **TWO DIRECT ACTING JACKS**

$$T = \frac{(Q + P_3)}{2} \cdot \frac{gn}{10} \text{ [daN]}$$

$$L_p = L_c + E_{sp} + E_{ip} \text{ [cm]; } L_o = L_p + 4 \text{ [cm]}$$

### **TWO INDIRECT ACTING JACKS 2:1 (cm = 2)**

$$T = \left[ \frac{(Q + P_3 + P_f) \cdot 2}{2} + P_{rh} \right] \cdot \frac{gn}{10} \text{ [daN]}$$

$$L_p = \left( \frac{L_c}{2} + E_{sp} + E_{ip} \right) \text{ [cm]; } L_o = L_p + L_1 + 4 \text{ [cm]}$$

### **NOTA:**

- The bottom overtravel of the car with the full load is given by the deflection of the car buffer. The bottom overtravel of the jack shall be calculated in order to ensure that, with the completely compressed buffer, the ram bottom does not touch the cylinder base (ref. to EN 81-20 § 5.8.1.4).
- The top overtravel of the jack is given by contact of ram bottom on to the cylinder head. In case of lift with indirect acting jacks the top overtravel of the car will be the top overtravel of the jack by multiplied the reeving ratio.

## VERIFYING CALCULATIONS FOR JACKS

These calculations have to be carried out when the point related to the selected jack is close to the graphs:

### CALCULATION OF EFFECTIVE BUCKLING FORCE:

$$F5 = 1,4 \cdot 0,981 \cdot \left[ cm \cdot \left( \frac{Q + P3 + Pf}{Nr} \right) + 0,64 \cdot Pr + Prh \right] \text{ [daN]}$$

Verifica della stabilità per  $\lambda \geq 100$ :

$$F5 \leq \frac{\pi^2 \cdot E \cdot J}{2 \cdot Lo^2}$$

Verifica della stabilità per  $\lambda < 100$ :

$$F5 \leq \frac{F}{2} \cdot \left[ Rm - (Rm - 2100) \cdot \left( \frac{\lambda}{100} \right)^2 \right] \text{ [daN]}$$

### CALCULATION OF FULL LOAD STATIC PRESSURE (20 ≤ pstat ≤ 45):

The full load static pressure is the one measured into the cylinder. According to different working conditions of the lift we suggest limiting this pressure to the following values:

- Residential lift (houses, hospitals, shopping centres, hotels): pstat ≤ 35 bar
- Industrial lifts (good lifts, car lifts): pstat ≤ 45 bar

$$pstat = \frac{0,981 \cdot \left[ \left( \frac{Q + P3 + Pf}{Nr} \right) \cdot cm + Pr + Prh \right]}{A} \text{ [bar]}$$

Thicknesses of ram and cylinder base are calculated for a static pressure according to the EN 81-50 regulations up to 45 bar max.

### CALCULATION OF EMPTY CAR PRESSURE:

$$pv = \frac{0,981 \cdot \left[ \left( \frac{P3 + Pf}{Nr} \right) \cdot cm + Pr + Prh \right]}{A} \text{ [bar]}$$

To achieve the rated down speed this pressure has to be higher than the ones shown below:

- for power unit with valve block type 3010: pv ≥ 12 bar

## CALCULATION OF OTHER DATA OF JACK

### CALCULATION OF OIL VOLUMES:

The following formulas are used to calculate the oil volumes to enable complete extension of the ram and to fill up the cylinder..

#### Circulating oil:

The useful capacity of the tank is calculated according the oil needed for the complete extension of the ram. A margin of 10% more is suggested.

$$Q_{tc} = Q_c \cdot \frac{L_p}{100} \text{ [dm}^3\text{]}$$

#### Oil for filling

During the normal use of the lift, this oil volume remains into the cylinder. **In case it should be necessary to empty the cylinder, please verify the remaining capacity of the tank or use auxiliary containers for oil collection.**

$$Q_{tr} = Q_r \cdot \frac{L_p}{100} \text{ [dm}^3\text{]}$$

### CALCULATION OF WEIGHTS:

#### Ram weight:

$$P_r = \frac{L_P}{100} \cdot q + P_{sg} \cdot (N - 1) \text{ [kg]}$$

#### Total weight of jack:

Section 3 of this catalogue reports the weight of the jack with stroke  $L_p = 0$  ( $Q_{p0}$ ) and the additional weigh for each meter of stroke ( $Q_{p1}$ ). Total weight of jack is :

$$Q_{tp} = Q_{p0} + P_{sg} + P_{gc} + Q_{p1} \cdot \frac{L_p}{100} \text{ [kg]}$$

#### Total weight of cylinder:

This data might be necessary to calculate the strength of the pillar. The weight of the empty cylinder is:

$$Q_{tcyl} = Q_{tp} - P_r \text{ [kg]}$$

When the ram is fully extended, The weight of the oil into the cylinder is :

$$Q_{tl} = (Q_r + Q_c) \cdot \frac{L_p}{100} \cdot \gamma \text{ [kg]}$$

### OIL INLET POSITION:

The position of the oil inlet is normally based on the inspectionability of the rupture valve. For side acting jacks (direct or indirect acting) the oil inlet position has to be specified on the order. It could be placed at the top (close to the cylinder head) or at the bottom (close to the cylinder base). For borehole cylinders the oil inlet is always at the top (above the support plate).

## EXAMPLE

Selection of jack for a lift with 2:1 driving (cm=2) having the following characteristics: :

- Q = rated load = 630 kg
- P3 = mass of the car, sling and travelling cables = 750 kg
- Pf = mass of the suspension ropes = 20 kg
- Prh = mass of the pulley and pulley frame = 60 kg
- L1 = distance between ram top and pulley axis = 25 cm
- Lc = car travel = 1050 cm
- Eip = bottom over travel of the ram = 13 cm
- Esp = top over travel of the ram = 7 cm
- gE = safety factor  $\geq 2,8$
- pstat = full load static pressure = circa 35 bar

### DATA FOR GRAPHS INTERPRETATION:

For the selection of jack when using graphs, the total load on ram top or pulley axis and the buckling length are necessary:

$$T = [(Q + P3 + Pf) \cdot cm + Prh] \cdot \frac{gn}{10} = [(630 + 750 + 20) \cdot 2 + 60] \cdot 0,981 = 2860 \text{ daN}$$

$$Lp = \left( \frac{Lc}{2} + Esp + Eip \right) = \left( \frac{1050}{2} + 7 + 13 \right) = 545 \text{ cm}$$

$$Lo = Lp + L1 + 4 = 545 + 25 + 4 = 574 \text{ cm}$$

The values of Lp and Lo are the minimum ones. If they have to be changed for any reason the buckling calculations have to be made once again.

From the graphs we can choose between two suitable jacks:

- $\varnothing 110 \times 5$  (full load static pressure = about 31 bar)
- $\varnothing 100 \times 5$  (full load static pressure = about 37 bar)

The full load static pressure given by jack  $\varnothing 100 \times 5$  is higher than the requested one. The jack  $\varnothing 110 \times 5$  will be selected. The ram weight is:

$$Pr = \frac{Lp}{100} \cdot q + Pgs \cdot (N - 1) = \frac{545}{100} \cdot 12,94 = 71 \text{ kg}$$

### CALCULATION OF THE EFFECTIVE BUCKLING FORCE:

$$F5 = 1,4 \cdot 0,981 \cdot \left[ cm \cdot \left( \frac{Q + P3 + Pf}{Nr} \right) + 0,64Pr + Prh \right] =$$

$$= 1,4 \cdot 0,981 \cdot [2 \cdot (630 + 750 + 20) + 0,64 \cdot 71 + 60] = 3990,3 \Rightarrow 3991 \text{ daN}$$

### BUCKLING CALCULATION:

$$F5 \leq \frac{\pi^2 \cdot E \cdot J}{2 \cdot Lo^2} = \frac{\pi^2 \cdot 2,1 \cdot 10^6 \cdot 227,81}{2 \cdot 574^2} = 7165 \text{ daN. Stability is verified.}$$

### **CALCULATION OF STATIC PRESSURES:**

$$p_{stat} = \frac{0,981 \cdot [(Q + P_3 + P_f) \cdot cm + Pr + Prh]}{A} = \frac{0,981 \cdot [(630 + 750 + 20) \cdot 2 + 71 + 60]}{95,03} = 30,28 \text{ bar}$$

$$p_v = \frac{0,981 \cdot [(P_3 + P_f) \cdot cm + Pr + Prh]}{A} = \frac{0,981 \cdot [(750 + 20) \cdot 2 + 71 + 60]}{95,03} = 17,28 \text{ bar}$$

### **OIL VOLUMES:**

Circulating oil (for the full extension of the ram)

$$Q_{tc} = Q_c \cdot \frac{L_p}{100} = 9,5 \cdot \frac{545}{100} = 51,78 \text{ dm}^3$$

The useful capacity of the tank shall be at least  $57 \text{ dm}^3$  ( $51,78 \times 1,1 = 56,96$ )

Oil for filling:

$$Q_{tr} = Q_r \cdot \frac{L_p}{100} = 7,9 \cdot \frac{545}{100} = 43,1 \text{ dm}^3$$

### **CALCULATION OF THE WEIGHTS:**

From the data sheet of jacks type 1008 (see section 3), read the values of  $Q_{po}$  and  $Q_{p1}$  and calculate the total weight of the jack:

$$Q_{tp} = Q_{po} + P_{gs} + P_{gc} + Q_{p1} \cdot \frac{L_p}{100} = 43 + 33 \cdot \frac{545}{100} = 222,85 \Rightarrow 223 \text{ kg}$$

The total weight of the empty cylinder is:

$$Q_{tcyl} = Q_{tp} - Pr = 223 - 71 = 152 \text{ kg}$$

The oil weight (with fully extended ram) is:

$$Q_{tl} = (Q_r + Q_c) \cdot \frac{L_p}{100} \cdot \gamma = (9,5 + 7,9) \cdot \frac{545}{100} \cdot 0,88 = 83,45 \Rightarrow 84 \text{ kg}$$