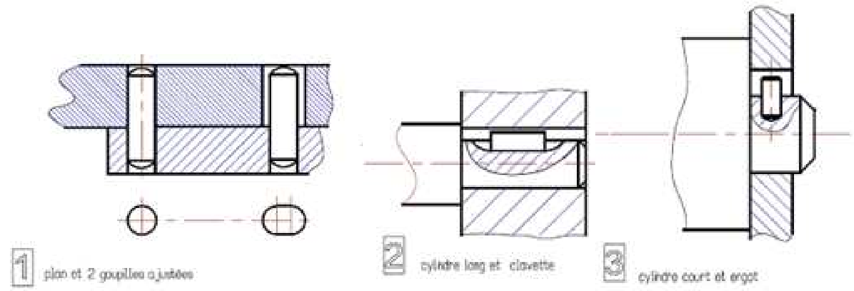
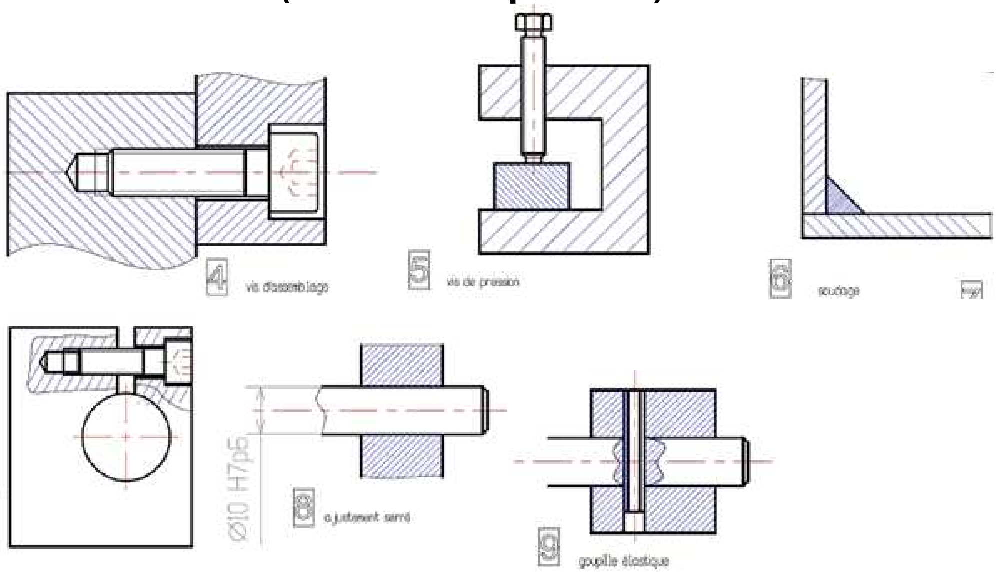
II.1 Solutions for the construction of the links:

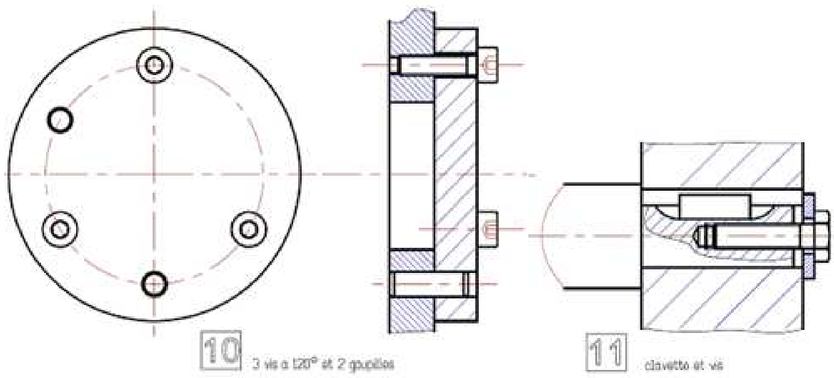
Relative position



Positional Hold (maintien en position)



Relative position and positional hold



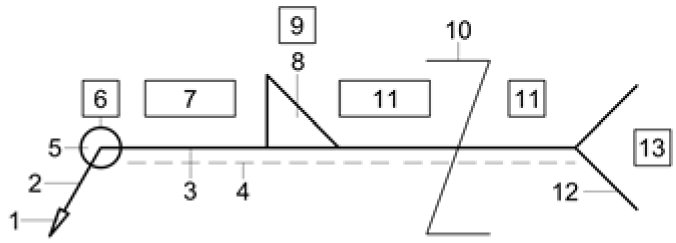
II.2 Complete bonding by welding:

Application domain:

1. Single part in series
2. Complex single parts
3. Prototypes

The Basic ISO Weld Symbol

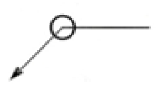
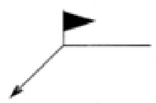
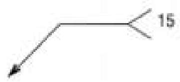
The diagram below illustrates the various elements making up the weld symbol

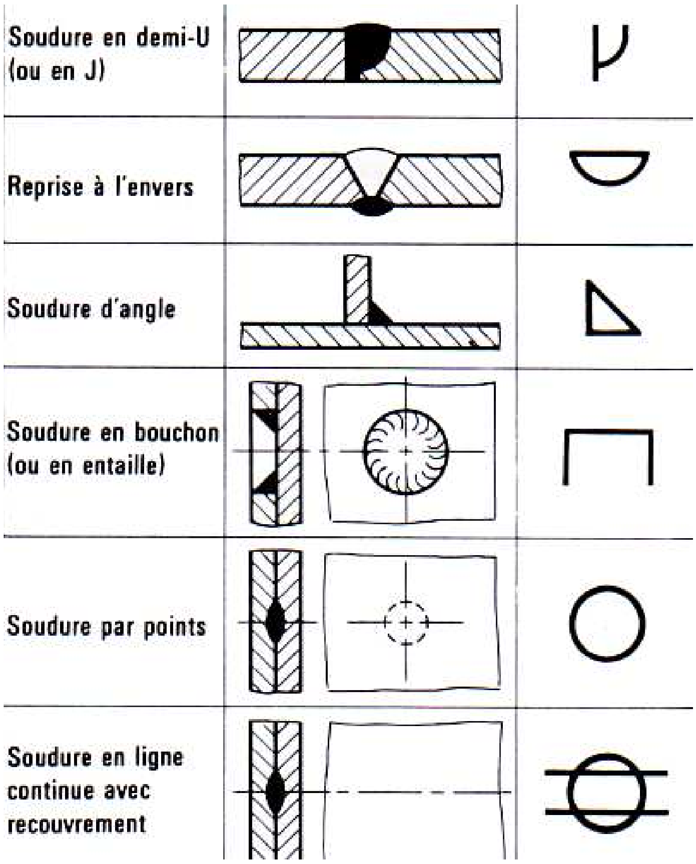


1. Arrow (Flèche)
2. Arrow ligne
3. Reference line
4. Dashed line (pointillé)
5. Weld type (type de soudure)
6. Shop or Field weld (soudure en atelier ou sur site)
7. Weld size * a / s / z (dimension de la soudure)
8. Weld symbol
9. Weld face contour
10. Intermittent staggered weld symbol ** (Symbole de soudure décalée intermittente)
11. Number, Length and Spacing of weld elements **
12. Tail (queue)
13. Welding process reference and Welding class (Référence du procédé de soudage et classe de soudage)

Note!
* = Fillet welds only
** = Intermittent welds only

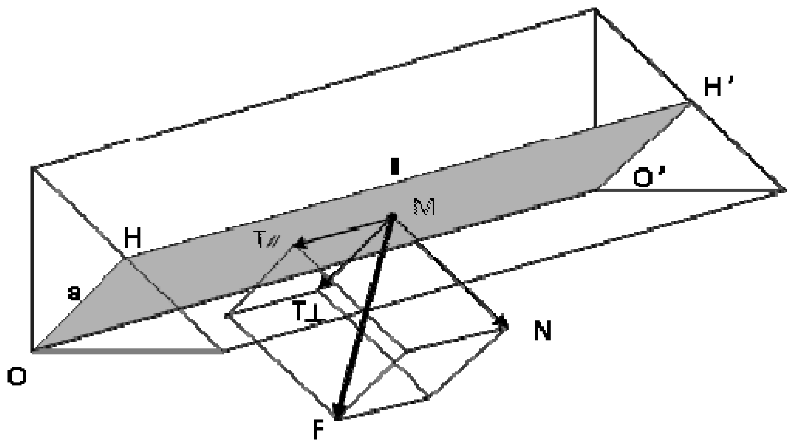
https://artizono.com/fr/types-de-cordons-de-soudure-symboles-codes-de-processus/

Additional indication			
Signification	Peripheral welding (soudure périphérique)	Welding done on site (soudure faite au site)	Welding process (Procédé de soudage)


Soudure en demi-U (ou en J)
Reprise à l'envers
Soudure d'angle
Soudure en bouchon (ou en entaille)
Soudure par points
Soudure en ligne continue avec recouvrement

Principaux procédés de soudage NF EN 4063, ISO 4063 (« 1998 ») – Détails NF EN 14610	
1 – Électrique à l'arc	**4 – Par pression**
101 – Avec électrode fusible 11 – Électrode fusible sans protection gazeuse 111 – Électrodes enrobées 114 – Avec fil fourré protecteur 12 – Sous flux solide 13 – Protection gazeuse et électrode fusible 131 – Protection gazeuse MIG 135 – Protection gazeuse MAG 136 – MAG avec fil fourré 137 – MIG avec fil fourré 14 – Protection gazeuse et électrode réfractaire 141 – TIG 142 – TAG 15 – Soudage au plasma 151 – Plasma-MIG 152 – Plasma avec poudre	41 – Par ultrasons 42 – Par friction 43 – Par forgeage 44 – Par haute énergie mécanique 441 – Par explosion 45 – Par diffusion 47 – Aux gaz par pression 48 – À froid avec pression **5 – Par faisceau** 51 – Par faisceau d'électrons 511 – Sous vide 512 – Atmosphère 52 – Par laser 521 – Avec laser solide 522 – Avec laser à gaz
2 – Par résistance	**7 – Procédés divers**
21 – Par points 22 – À la molette 23 – Par bossages 24 – Par étincelage 25 – En bout par résistance pure 29 – Autre procédés 291 – Soudage par résistance HF	71 – Aluminothermique 72 – Sous laitier 73 – Électrogaz 74 – Par induction 75 – Par rayonnement lumineux 753 – Par infrarouge 77 – Avec percussion 78 – Soudage des goujons
3 – Aux gaz	**9 – Brasage**
31 – Soudage oxygaz 311– Oxyacétylène 312 – Oxypropane 313 – Oxydrique 32 – Soudage aérogaz (ancienne norme)	91 – Brasage fort 94 – Brasage tendre 97 – Soudobrasage 971 – Soudobrasage aux gaz 972 – Soudobrasage à l'arc

Calculations of the strength (resistance) of a fillet weld seam (cordon de soudure) with oriented loading:



The force F exerted by the assembled parts is considered to be reduced at the center of the Bead (cordon) modeled by a triangular cross-section prism. The solicitation is then in the OHH'O' plane and we make an assumption of uniform distribution of Stress in the surface l * a

L'équilibre statique donne : $\vec{F} = \vec{N} + \vec{T}_{//} + \vec{T}_{\perp}$

$$\sigma = \frac{N}{l.a} \; ; \quad \tau_{//} = \frac{T_{//}}{l.a} \; ; \quad \tau_{\perp} = \frac{T_{\perp}}{l.a}$$

Weld Design Standards

The standards take up the approach used previously. The general test is

$$k \sqrt{\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{//}^2)} \leqslant \sigma_e$$

$$\sigma_{\perp} \leqslant \sigma_e$$

k = 1/α is the factor of safety; α is a quality coefficient

With, regardless of the thickness of the product.

- k 0.7 for grades E 24, E 24w. TS E 24, TU E 24.
- k 0.8 for grades E 26. TS E 26, TU E 26.
- k 0.85 for grades E 30. E 375 D. E 335 D. TS E 30. TU E 30. TS E 30B,
- k 1.0 for grades E 36. E 36W. E 355.E 355 D. E 375,E 390 D. E 420.E 430 0, E 445 D. E 460,E 490 D.

In the case of the joint being made up of steels of different grades, the yield strength to be used for the application of the formula is that of the lowest grade.

In recent standards, these include:

Eurocode 3 (1993)

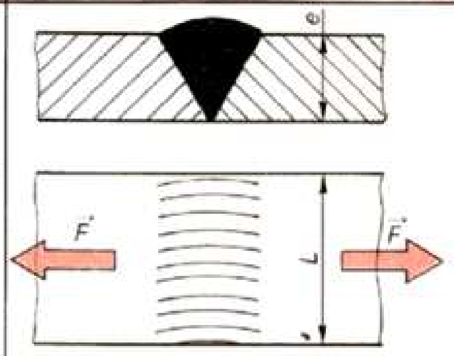
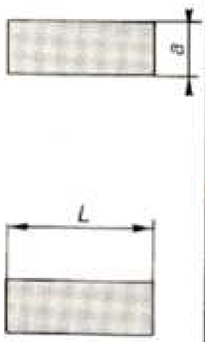
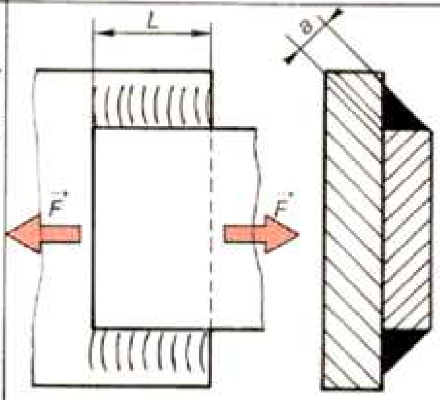
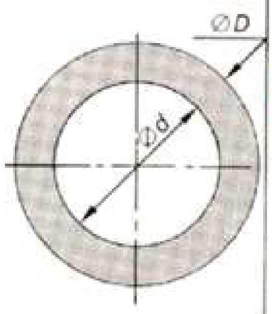
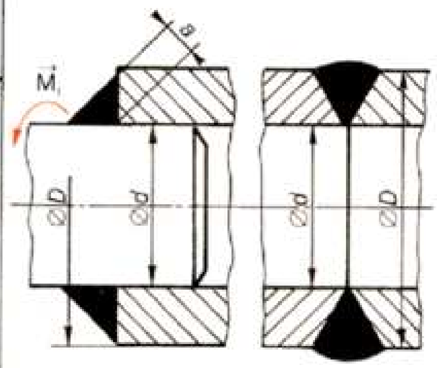
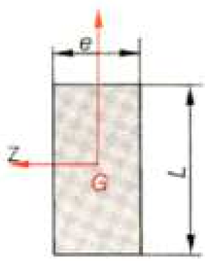
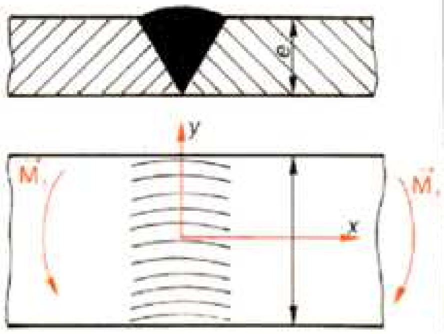
$$\begin{cases} \beta_w \times \sqrt{\sigma_\perp^2 + 3 \times (\tau_\perp^2 + \tau_{//}^2)} \leqslant \frac{f_u}{\gamma_{M2}} \\ \text{et } \sigma_\perp \leqslant 0,9 \frac{f_u}{\gamma_{M2}} \end{cases}$$

with

1- β_w: correlation factor ranging from 0.7 to 1.8;
2- f_u: ultimate strength R_m of steel;
3- γ_{M2}: Partial safety factor for tensile (rupture) cross-sections (transversal), 1.25 [EN 1993-1-1:2005]

Coefficients by steel grade			
Nuance	**f_u (R_m) (MPa)**	**β_w**	**γ_{M2}**
S235 (E24)	360	0,8	1,25
S275 (E28)	430	0,85	1,30
S355 (E36)	510	0.9	1,35

Calculation for simple loads:

Sollicitation	Exemple	Calcul de la contrainte
Traction compression 		$\sigma = \frac{F}{e.L}$ σ = contrainte en N/mm², F = force appliquée en N, e = hauteur du cordon en mm, L = longueur du cordon en mm.
Cisaillement 		$\tau = \frac{F}{a.L}$ τ = contrainte en N/mm², F = force appliquée en N, a = épaisseur du cordon en mm, L = longueur du cordon en mm.
Torsion 		$\tau = \frac{M_t}{W_t}$ τ = contrainte en N/mm², M_t = moment de torsion en mm.N, W_t = module de torsion en mm³. $W_t = \frac{I_0}{v}$ $\quad I_0 = \frac{\pi}{32}(D^4 - d^4)$ $\quad v = D/2$
Flexion 		$\sigma_f = \frac{M_f}{W_f}$ σ_f = contrainte en N/mm², M_f = moment de la flexion en mm.N, W_f = module de flexion en mm³. $W_f = \frac{I_{Gz}}{v}$ $\quad I_{Gz} = \frac{e.L^3}{12}$ $\quad v = \frac{L}{2}$

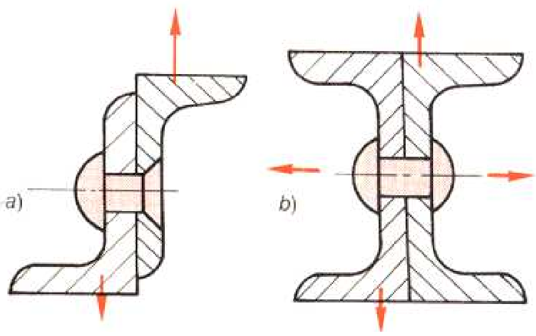
II.3 Complete rivet connection:

The diameter of a rivet depends on the thickness e of the thickest sheet to be assembled. It is given by the following expression:

$$d = \frac{45.e}{15+e}$$

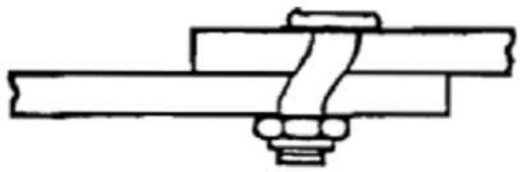
Assembly:

Cold laying: they work with shear (a)
Hot-laid: they work on shear and tensile work (b)



Rivet shear failure:

$$\tau = \frac{F}{n\frac{\pi d^2}{4}} \leq \frac{\tau_{lim}}{k}$$



N: number of rivets
K: safety factor

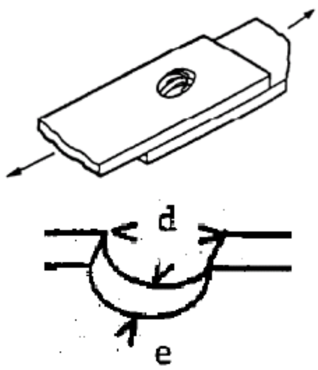
$$\tau_{lim} = 0,8\,R_m$$

Sheet metal matting

Resistance Criterion: Matting Pressure < Permissible Pressure

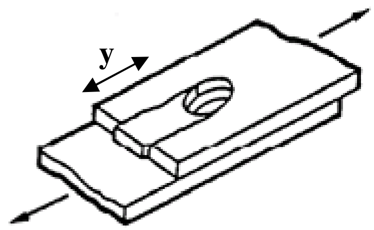
$$\frac{F}{d.e} \leq \sigma_{mat\_adm}$$

En l'absence de σ_{mat_adm} on peut utiliser $\sigma_{mat\_adm} = 1,5R_m$



Tensile strength of the sheet:

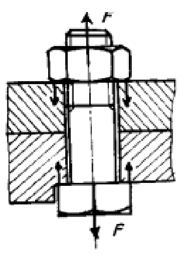
$$\frac{F}{2.y.e} \leq \tau_{adm\_tôle} = 0,6R_{m\_tôle}$$



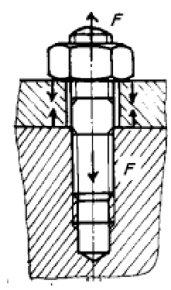
y: distance to edge

II.4 Complete connection that can be dismantled by threaded elements:

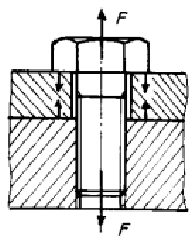
Carried out either by:



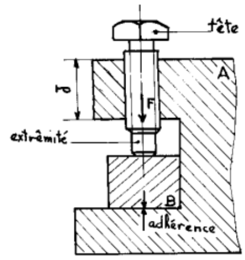
Bolts



Studs



Screws

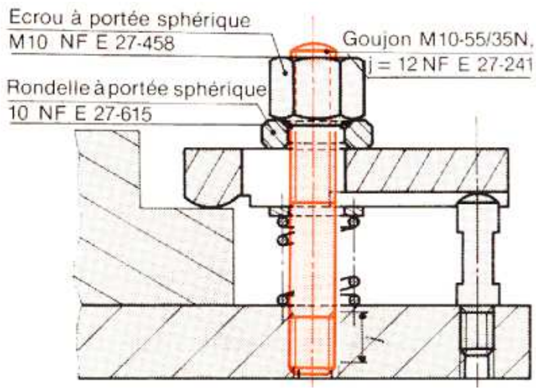


Pressure screws

These include:

1. One end penetrating the support piece (screw or stud) or a nut (bolt) without reaching the end of the thread,
2. A cylindrical part (which can also be threaded) forming the passing body. With diametrical play, through the piece bind,
3. A head (screws, bolts) or nut (stud) for manoeuvring (tightening) under which it is essential to place a washer (force distribution or braking).

Stud (goujon) mounting: Locking flange (Bride de blockage)

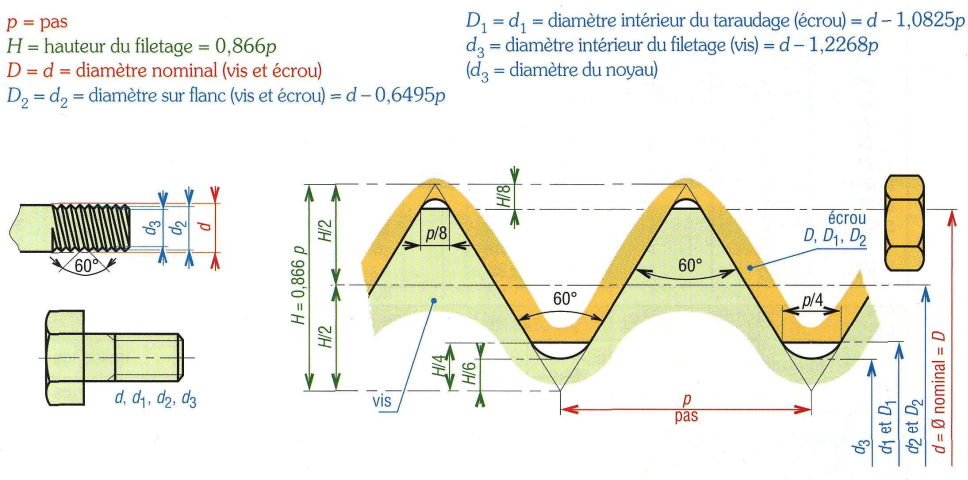


Threaded at both ends: j implantation and nut (écrou) mounting. The stud must be forced into the bracket.

Designation of a stud:

- The term stud
- the M thread symbol
- The nominal diameter d of the thread 10
- rod free length l 55
- Threaded Length x 35
- the finish symbol of the stud N
- the length of implantation j= 12
- the reference to the NF E 27.241 standard

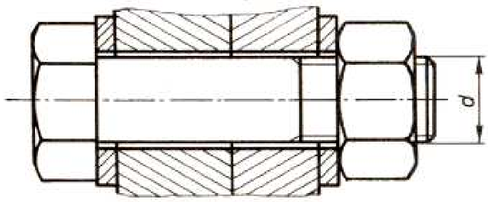
II.4.2 Filetage métrique ISO à filet triangulaire



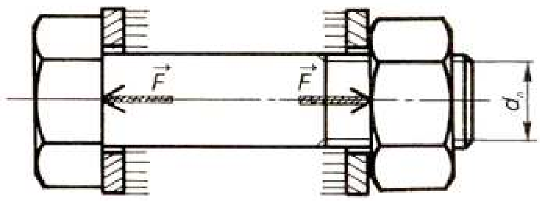
Filetage métrique à pas fin (extrait)					
d mm	pas fins	S_{eq} en mm^2 section résistante	D_1 mm	$D_2 = d_2$ mm	d_3 mm
8	1	39,2	6,917	7,350	6,773
10	1	64,5	8,917	9,350	8,773
10	1,25	61,2	8,647	9,188	8,466
12	1,25	92,1	10,647	11,188	10,466
12	1,5	88,1	10,376	11,026	10,160
(14)	1,5	125	12,376	13,026	12,376
16	1,5	167	14,376	15,026	14,160
(18)	1,5	216	16,376	17,026	16,160
20	1,5	272	18,376	19,026	18,160
20	2	258	17,835	18,701	17,546
(22)	1,5	333	20,376	21,026	20,160
24	1,5	401	22,376	23,026	22,160
24	2	384	21,835	22,701	21,546
(27)	2	496	24,835	25,701	24,546
30	2	621	27,835	28,701	27,546
(33)	2	761	30,835	31,701	30,546
36	3	865	32,752	34,051	32,319
(39)	3	1 028	35,752	37,051	35,319

II.4.3 Calculation of screws and bolts:

Let us consider a bolt clamping fixture (Fig.). Through the washers (rondelles) , screws (vis) and nuts (écrous) are in contact with the parts to be tightened. From this position, the nut is acted upon with the help of a wrench (clé), and the force *F to* be made at the end of the wrench increases until the final desired phase of tightening.



Screw, nut, insulated washer assembly
The forces applied are the contact actions of the clamped parts, on the head of the screw and on the nut (via the washers), parallel to the axis of the screw. Their resultants, of common value *F,* show:



Ensemble vis, d'écrou, rondelles isole
Les forces appliquées sont les actions de contact des pièces serrées, sur la tète de la vis et sur l'écrou (par l'intermédiaire des rondelles), parallèles a ['axe de la vis. Leurs résultantes, de valeur commune *F,* font apparaitre :

$$\sigma = \frac{F}{S_n} \leq Rp$$

F: effort de traction axial
Sn: Screw core section
σ: constraint. traction
k: coef. Stress concentration.
Re: elastic limit of the screw
S : coef. Security (2 to 5)

Rg: shear stress.
P: Screw/Nut Pressure
ds: surface element
f *:* coef. Frottement / filets
p: distance from *ds* to axis
RM1 : *R* Contact Medium

δ: constrained. Shear
DN: Diameter Core Screw
pH: Helical pitch
n: number of threads
RM2: Fillet Medium
A: Screw Helix Angle

$$R_p = \frac{R_e}{s} = \text{résistance pratique de la vis à l'extension}$$

A shear load at the level of the recess of the screw threads on the stress hub cylinder:

$$\tau = \frac{F}{\pi d_n \cdot P_h \cdot n} \leq Rp_g$$

Non-Thread Pull-Out Condition (daN/mm2)

Tightening torque:

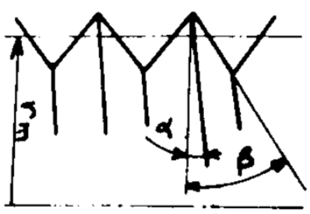
Pre-tightening has the following advantages:

1. It prevents the bolt from loosening (desserrage)
2. it prevents the chords (membrures) from separating:
3. it reduces the fatigue load.

Tightening torque is often expressed as the sum of the torque C1 due to the frictional forces between the threads and C2 due to the frictional forces between the assembled parts.

We can therefore write:

$$C_S = C_1 + C_2$$



β: demi-angle de sommet des filets,
α: angle d'inclinaison de l'hélice,
r_m: rayon moyen du filetage.

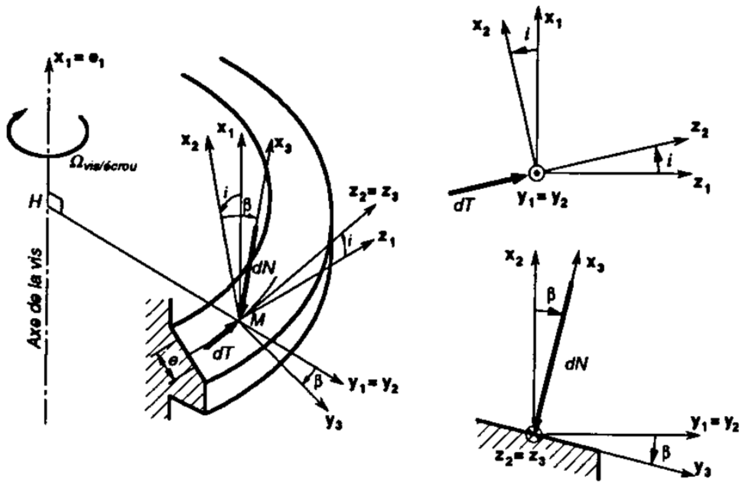


Figure 8.8 – *Actions de contact écrou-vis (liaison avec frottement)*

Specification for a metric net

$$C_1 = Fr_m \tan(\alpha + \varphi_1)$$

Where φ1 is the angle of friction between threads, given by:

$$\tan \varphi_1 = \mu_1 / \cos \beta = \mu'_1.$$

μ1 is the slip coefficient (coefficient de glissement) between the screw and the nut

Since α and φ1 are small angles, we can write:

$$\tan(\alpha + \varphi_1) = \alpha + \varphi_1.$$

We also have:

$$\tan \alpha = \alpha = P/\pi d \text{ et } r_m = d/2.$$

Where from:

$$C_1 = F(\frac{P}{2\pi} + \frac{d}{2}\mu'_1)$$

The pair C2 can be expressed by the relationship:

$$C_2 = FR_m \tan \varphi_2$$

Where φ2 is the friction angle,

$$\tan \varphi_2 = \mu_2$$

D'où

$$C_2 = FR_m \mu_2$$

Rm is the average radius of the friction surface. The value of this parameter from one case to another. Figure 2.17 shows the possible mounting cases with the value of Rm

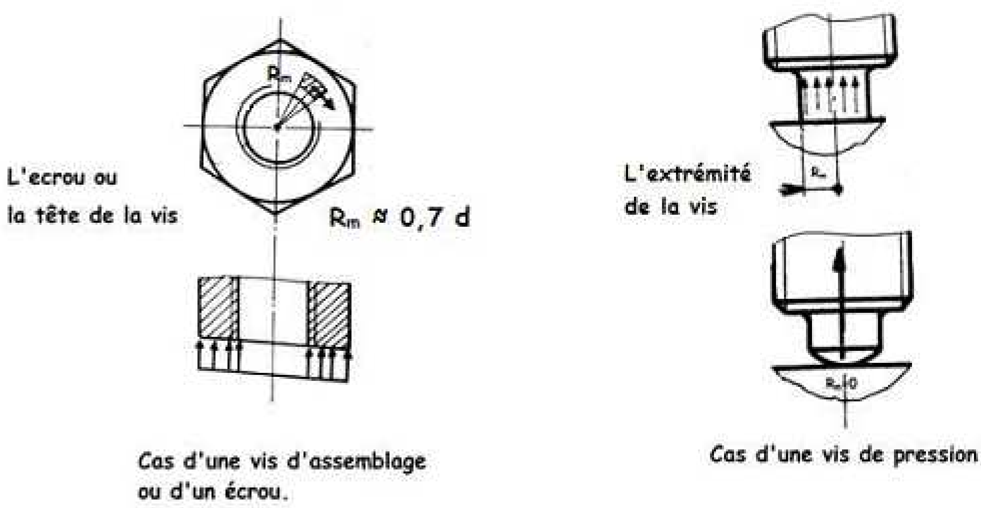


Figure 2.17: Average radius of friction in threaded joints.

$$C_s = F(\frac{P}{2\pi} + \frac{d}{2}\mu_1' + R_m\mu_2)$$

We thus find that this expression is the sum of three pairs:

1. $F(p/2\pi)$: torque required to tension the clamping element,
2. $F(d/2)\ \mu'_1$: torque required to overcome friction between threads,
3. $FR_m\ \mu_2$ *:* torque required friction between the clamping elements and the assembled parts.