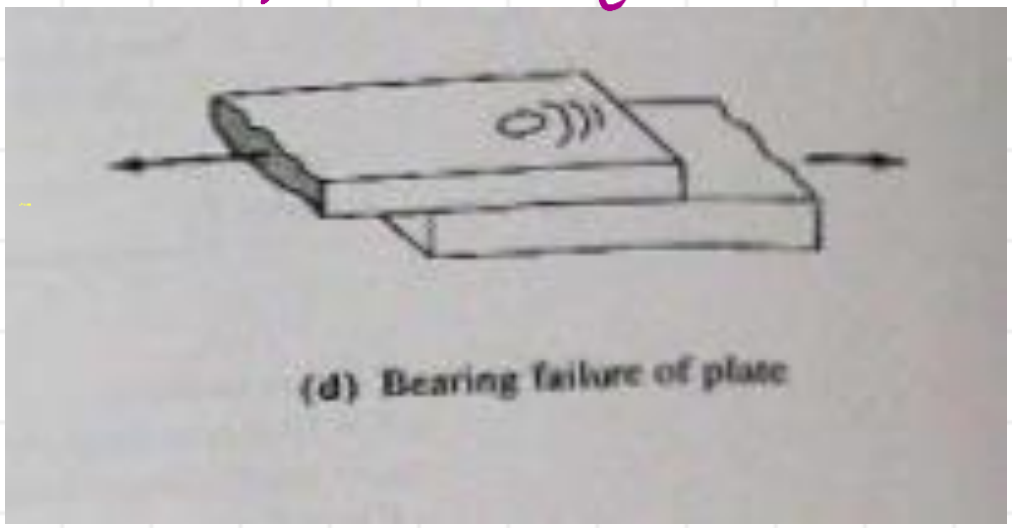
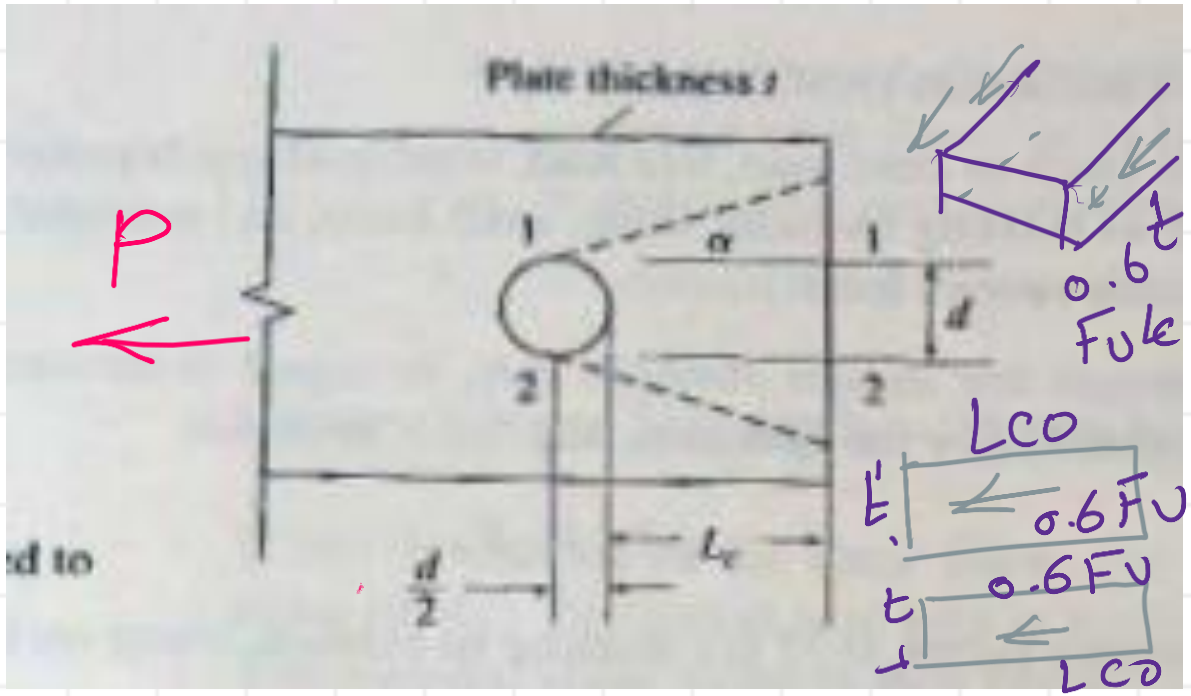
1. Lower Limit & upper Limit For Bearing against metal Based on deformations ≤ 0.25 inch.
2. Minimum edge distance For Bolts.
3. Minimum spacing between Bolts.
4. Short & Long-slotted Holes.
5. Edge distance increaments C_2.

Tear out





Prof. SALmon

I_{shear}

$R_n = 2t \cdot L_c$ $I \rightarrow$ plate

$F_{ult} \approx 0.62 F_{ult}$

$2(0.60 F_u) L_c t = 1.2 F_u L_c t$

L_c: clear distance along the Line of Force

This is applied to for a single bolt hole

Tear out Limit state

$$P_n = 2(0.6) F_u \cdot L_e$$

$$= 1.2 F_u \left(L_o - \frac{d_h}{2}\right)$$

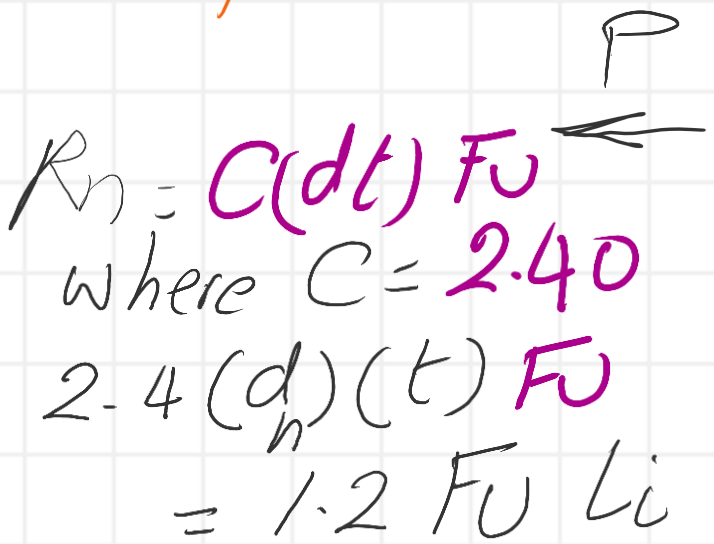
Lower Limit

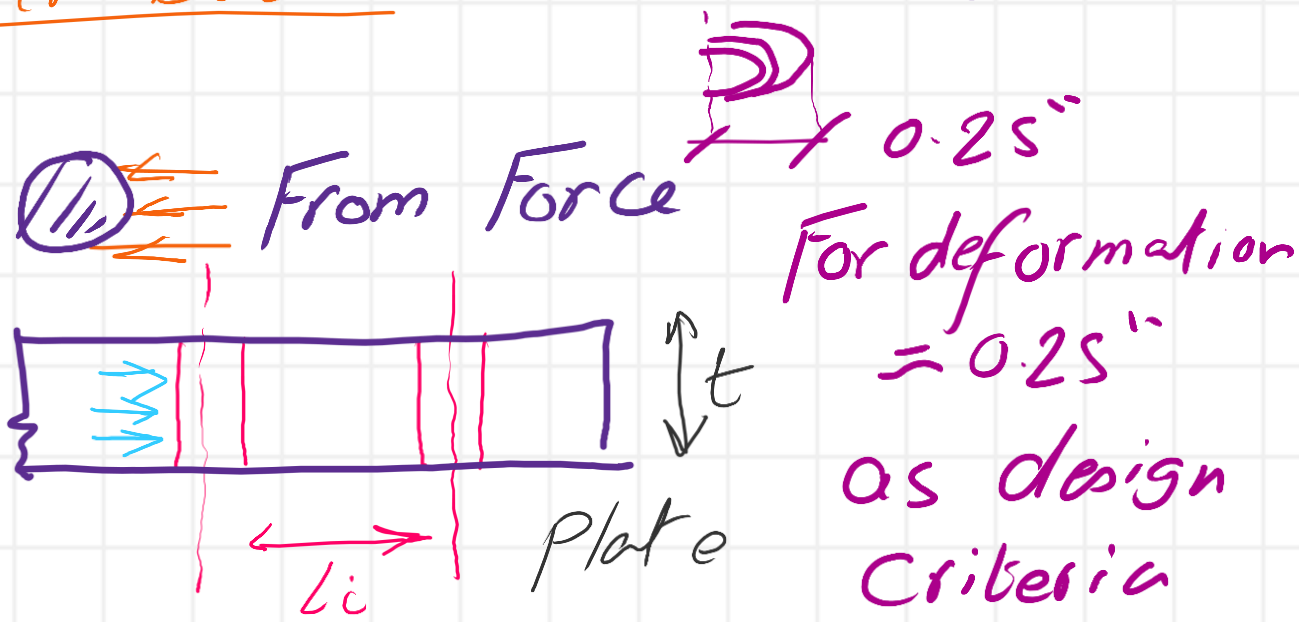
L_{co} : Clear out distance

$\Rightarrow$ edge $\left(L_e - \frac{d}{2}\right) < 2d$

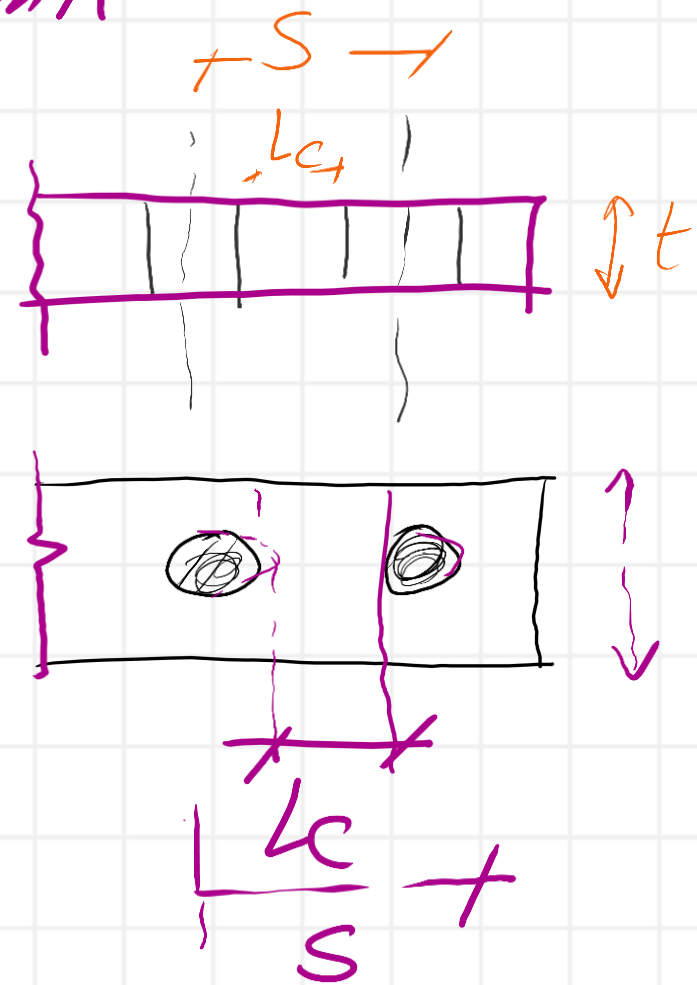
Upper Limit

inner bolts





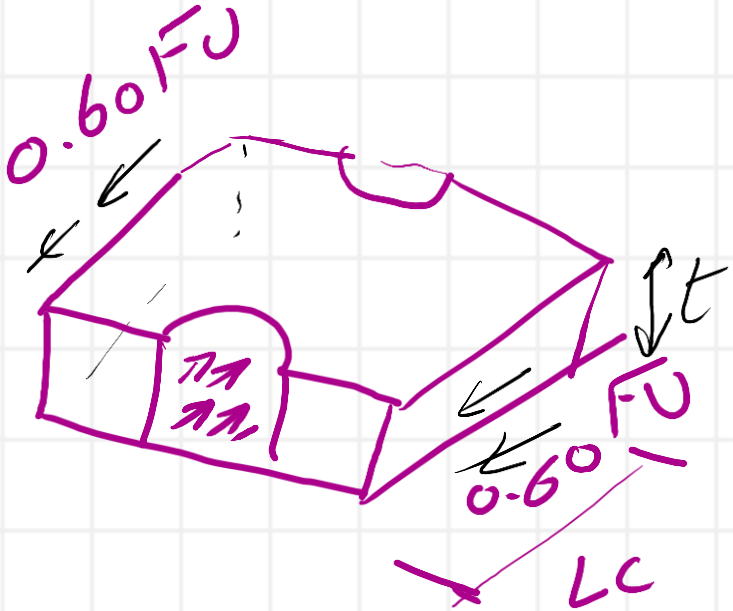
Continue upper Limit



$$2.4\, d_b t F_U = 2(0.60) F_U L_{c_i} t$$

$$2 d_b = L_{c_i}$$

inner clear distance $\leq 2 d_b$



Bearing strength $R_n = 1.2 L_c F_U t \leq 2.40 d_b t F_U$ J-3.6a

Two Cases based on deformation

The expressions to follow are used to compute the nominal bearing strengths of bolts used in connections that have standard, oversized, or short-slotted holes, regardless of the direction of loading. They also are applicable to connections with long-slotted holes if the slots are parallel to the direction of the bearing forces.

a. If deformation around bolt holes is a design consideration (that is, if we want deformations to be ≤ 0.25 in), then

Deformation ≤ 0.25 $L_c < 2d$ $L_c = 2d$

$$R_n = 1.2 l_c t F_u \leq 2.4 d t F_u \qquad \text{(AISC Equation J3-6a)}$$

For the problems considered in this text, we will normally assume that deformations around the bolt holes are important. Thus, unless specifically stated otherwise, Equation J3-6a will be used for bearing calculations.

If deformation around bolt holes is not a design consideration (that is, if deformations > 0.25 in are acceptable), then

Not

Deformation > 0.25 $R_n = 1.5 l_c t F_u \leq 3.0 d t F_u$ (AISC Equation J3-6b)

$L_c < 2.5d$ $L_c = 2.5d$

b. For bolts used in connections with long-slotted holes, the slots being perpendicular to the forces,

Long slotted $R_n = 1.0 l_c t F_u \leq 2.0 d t F_u$ (AISC Equation J3-6c)

12.12 SPACING AND EDGE DISTANCES OF BOLTS

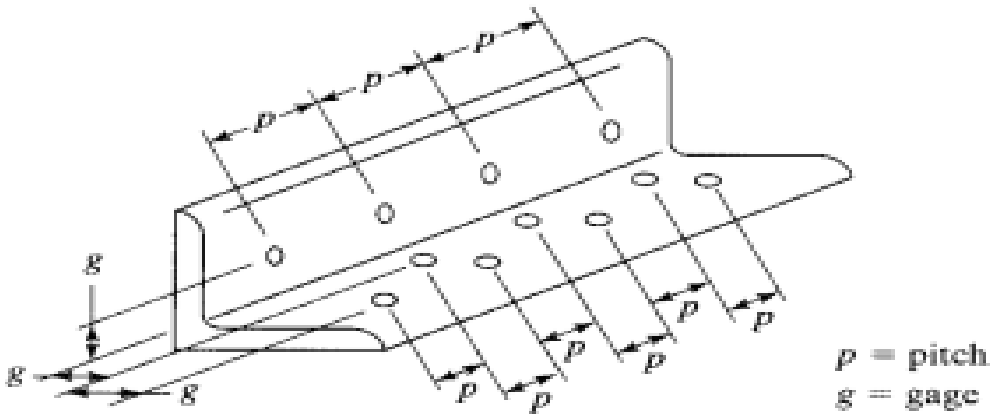
Before minimum spacings and edge distances can be discussed, it is necessary for a few terms to be explained. The following definitions are given for a group of bolts in a connection and are shown in Fig. 12.4:

Pitch is the center-to-center distance of bolts in a direction parallel to the axis of the member.

Gage is the center-to-center distance of bolt lines perpendicular to the axis of the member.

The *edge distance* is the distance from the center of a bolt to the adjacent edge of a member.

The *distance between bolts* is the shortest distance between fasteners on the same or different gage lines.



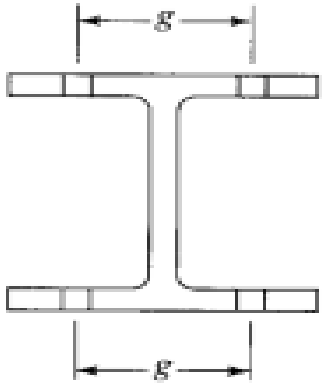
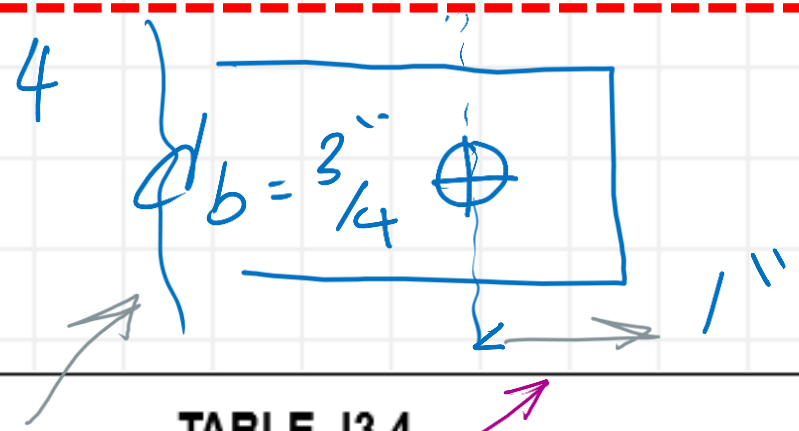
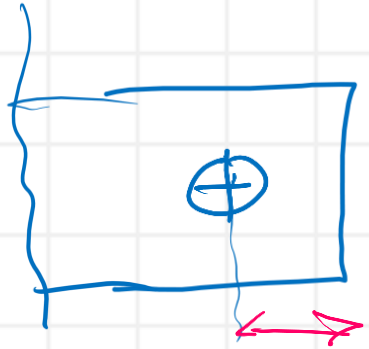


FIGURE 12.4





J3.4M Metric

$d_b = 20$ mm

26 mm

Minimum Edge

TABLE J3.4
Minimum Edge Distance[a] from Center of Standard Hole[b] to Edge of Connected Part, in.

Bolt Diameter, in.	Minimum Edge Distance
1/2	3/4
5/8	7/8
3/4	1
7/8	1 1/8
1	1 1/4
1 1/8	1 1/2
1 1/4	1 5/8
Over 1 1/4	1.25d

[a] If necessary, lesser edge distances are permitted provided the applicable provisions from Sections J3.10 and J4 are satisfied, but edge distances less than one bolt diameter are not permitted without approval from the engineer of record.
[b] For oversized or slotted holes, see Table J3.5.

TABLE J3.4M
Minimum Edge Distance[a] from Center of Standard Hole[b] to Edge of Connected Part, mm

Bolt Diameter, mm	Minimum Edge Distance
16	22
20	26
22	28
24	30
27	34
30	38
36	46
Over 36	1.25d

[a] If necessary, lesser edge distances are permitted provided the applicable provisions from Sections J3.10 and J4 are satisfied, but edge distances less than one bolt diameter are not permitted without approval from the engineer of record.
[b] For oversized or slotted holes, see Table J3.5M.

4. Minimum Edge Distance

The distance from the center of a standard hole to an edge of a connected part in any direction shall not be less than either the applicable value from Table J3.4 or Table J3.4M, or as required in Section J3.10. The distance from the center of an oversized or slotted hole to an edge of a connected part shall be not less than that required for a standard hole to an edge of a connected part plus the applicable increment, C_2, from Table J3.5 or Table J3.5M.

User Note: The edge distances in Tables J3.4 and J3.4M are minimum edge distances based on standard fabrication practices and workmanship tolerances. The appropriate provisions of Sections J3.10 and J4 must be satisfied.

Oversized or slotted hole

$Le = Le + C_2$ Refer to table J3.5

S.T

12.12.1 Minimum Spacings

Minimum Spacing (S)

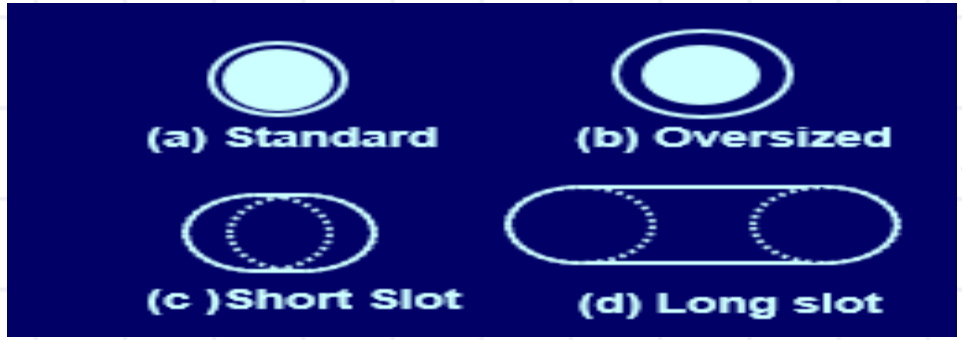
Bolts should be placed a sufficient distance apart to permit efficient installation and to prevent bearing failures of the members between fasteners. The AISC Specification (J3.3) provides a minimum center-to-center distance for standard, oversized, or slotted fastener holes. For standard, oversized, or slotted holes, the minimum center-to-center distance should not be less than 2 2/3 diameters (with three diameters being preferred). Test results have clearly shown that bearing strengths are directly proportional to the center-to-center spacing up to a maximum of 3d. No additional bearing strength is obtained when spacings greater than 3d are used.

Standard Hole

3. Minimum Spacing

The distance between centers of standard, oversized or slotted holes shall not be less than $2^2/_3$ times the nominal diameter, d, of the fastener. However, the clear distance between bolt holes or slots shall not be less than d.

User Note: A distance between centers of standard, oversize or slotted holes of $3d$ is preferred.



Oversized – Used in Slip-critical

Short-slotted – SC / ST

Long-slotted

→ ST or SC →

(d) Oversized holes are permitted in any or all plies of slip-critical connections, but they shall not be used in bearing-type connections.

(e) Short-slotted holes are permitted in any or all plies of slip-critical or bearing-type connections. The slots are permitted without regard to direction of loading in slip-critical connections, but the length shall be normal to the direction of the loading in bearing-type connections.

(f) Long-slotted holes are permitted in only one of the connected parts of either a slip-critical or bearing-type connection at an individual faying surface. Long-slotted holes are permitted without regard to direction of loading in slip-critical connections, but shall be normal to the direction of loading in bearing-type connections.

ST: snug-tight

SC: slip critical

PT: pre tension

standard   over size   S.S   LS

TABLE J3.3
Nominal Hole Dimensions, in.

Bolt Diameter, in.	Hole Dimensions: Standard (Dia.)	Oversize (Dia.)	Short-Slot (Width × Length)	Long-Slot (Width × Length)
1/2	9/16	5/8	9/16 × 11/16	9/16 × 1 1/4
5/8	11/16	13/16	11/16 × 7/8	11/16 × 1 9/16
3/4	13/16	15/16	13/16 × 1	13/16 × 1 7/8
7/8	15/16	1 1/16	15/16 × 1 1/8	15/16 × 2 3/16
1	1 1/8	1 1/4	1 1/8 × 1 5/16	1 1/8 × 2½
≥ 1 1/8	$d + 1/8$	$d + 5/16$	$(d + 1/8) \times (d + 3/8)$	$(d + 1/8) \times 2.5d$

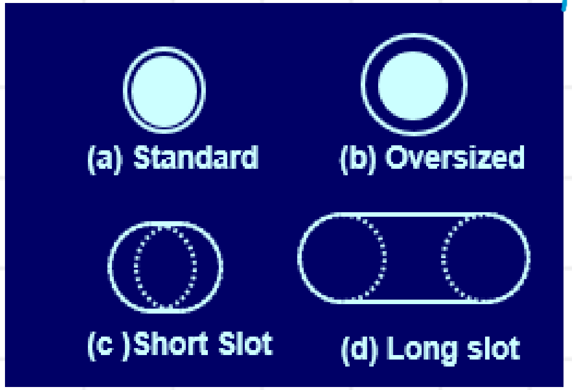
$\frac{1}{2}$" Dia → Hole $= 1/2 + \frac{1}{16}$"

$D_H = \frac{9}{16}$"

For $\frac{3}{4}$" bolt → $\frac{3}{4}$" + $\frac{1}{16}$" = $\frac{13}{16}$"

oversize from table

S. slot ↕ $d + \frac{1}{16}$"



↔ From table

Tensile Strength - Shear Strength of Fastners

TABLE J3.2
Nominal Strength of Fasteners and Threaded Parts, ksi (MPa)

Description of Fasteners	Nominal Tensile Strength, F_{nt}, ksi (MPa)[a]	Nominal Shear Strength in Bearing-Type Connections, F_{nv}, ksi (MPa)[b]
A307 bolts	45 (310)[c]	27 (186)[c][d]
Group A (e.g., A325) bolts, when threads are not excluded from shear planes	90 (620)	54 (372)
Group A (e.g., A325) bolts, when threads are excluded from shear planes	90 (620)	68 (469)
Group B (e.g., A490) bolts, when threads are not excluded from shear planes	113 (780)	68 (469)
Group B (e.g., A490) bolts, when threads are excluded from shear planes	113 (780)	84 (579)
Group C (e.g., F3043) bolt assemblies, when threads and transition area of shank are not excluded from the shear plane	150 (1040)	90 (620)
Group C (e.g., F3043) bolt assemblies, when threads and transition area of shank are excluded from the shear plane	150 (1040)	113 (779)
Threaded parts meeting the requirements of Section A3.4, when threads are not excluded from shear planes	$0.75F_u$	$0.450F_u$
Threaded parts meeting the requirements of Section A3.4, when threads are excluded from shear planes	$0.75F_u$	$0.563F_u$

[a] For high-strength bolts subject to tensile fatigue loading, see Appendix 3.
[b] For end loaded connections with a fastener pattern length greater than 38 in. (950 mm), F_{nv} shall be reduced to 83.3% of the tabulated values. Fastener pattern length is the maximum distance parallel to the line of force between the centerline of the bolts connecting two parts with one faying surface.
[c] For A307 bolts, the tabulated values shall be reduced by 1% for each 1/16 in. (2 mm) over five diameters of length in the grip.
[d] Threads permitted in shear planes.

TABLE J3.5
Values of Edge Distance Increment C_2, in.

Nominal Diameter of Fastener	Oversized Holes	Slotted Holes		
		Long Axis Perpendicular to Edge		Long Axis Parallel to Edge
		Short Slots	Long Slots[a]	
≤ 7/8	1/16	1/8	3/4d	0
1	1/8	1/8		
≥ 1 1/8	1/8	3/16		

[a] When the length of the slot is less than the maximum allowable (see Table J3.3), C_2 is permitted to be reduced by one-half the difference between the maximum and actual slot lengths.

C_2 value

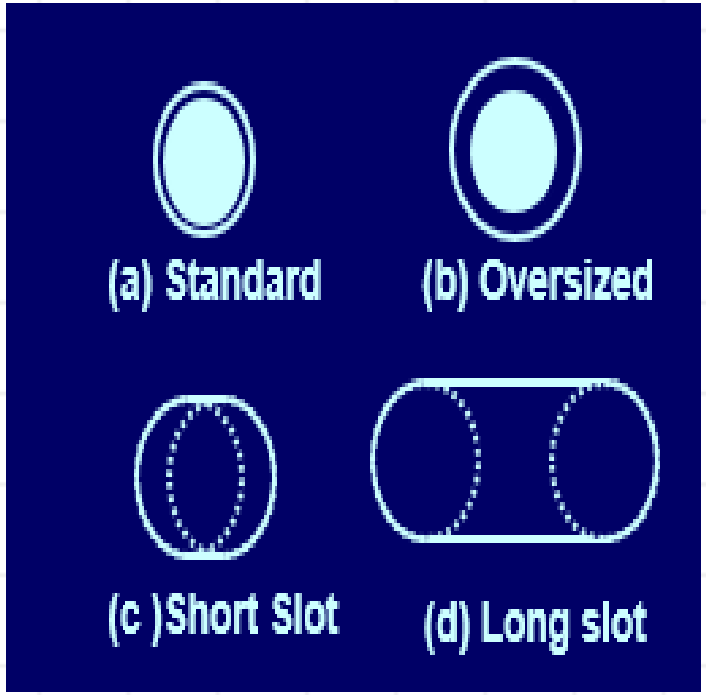
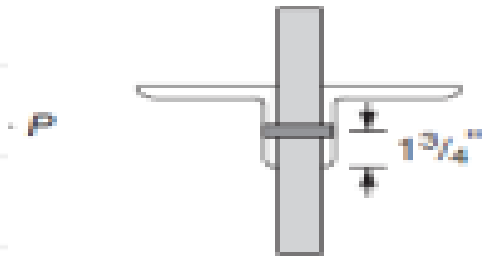


TABLE J3.5M
Values of Edge Distance Increment C_2, mm

Nominal Diameter of Fastener	Oversized Holes	Slotted Holes		
		Long Axis Perpendicular to Edge		Long Axis Parallel to Edge
		Short Slots	Long Slots[a]	
≤ 22	2	3	0.75d	0
24	3	3		
≥ 27	3	5		

[a] When the length of the slot is less than the maximum allowable (see Table J3.3M), C_2 is permitted to be reduced by one-half the difference between the maximum and actual slot lengths.



Long slotted

d = 1"

1 3/4"

$L_e = L_{e_s} + \frac{3}{4}d$

J3.4 $\frac{5}{4} + \frac{3}{4}(1) = 2"$

OK >

Maximum Spacing and Edge Spacing

5. Maximum Spacing and Edge Distance

The maximum distance from the center of any bolt to the nearest edge of parts in contact shall be 12 times the thickness of the connected part under consideration, but shall not exceed 6 in. (150 mm). The longitudinal spacing of fasteners between elements consisting of a plate and a shape, or two plates, in continuous contact shall be as follows:

(a) For painted members or unpainted members not subject to corrosion, the spacing shall not exceed 24 times the thickness of the thinner part or 12 in. (300 mm).

(b) For unpainted members of weathering steel subject to atmospheric corrosion, the spacing shall not exceed 14 times the thickness of the thinner part or 7 in. (180 mm).