

# Accessories – Stud bolts for diaphragm seals

## Description

Stud bolts are used to assemble a flanged construction. Flanged diaphragm seals types and some accessories such as flush and reducer flanges are to be mounted with stud bolts. Stud bolts are not part of Badotherm standard scope of supply, but our product dimensions do have an impact on the length and dimension of the stud bolts to be used. On request, with clear specifications provided, Badotherm can include stud bolts in their scope of supply.

Stud bolts selection needs to be done carefully, as there can be several specifications applicable, depending on pressure, temperature and process conditions. Many end users also have own guidelines to be used. Next to stud bolt selection, also applying the right torque, the right paste and related mounting method are important.

## Material of construction

Stud bolts are available in several materials. And the material quality is defined by different ASTM standards and are indicated by grades. The frequently used grades are covered in the ASTM A193 for thread rods and the ASTM A194 for the nuts.

The ASTM A193 covers the alloy and stainless-steel bolting material for pressure vessels, valves, flanges and fittings for high temperature or high-pressure service. The ASTM A194 covers the variety of carbon, alloy and martensitic and austenitic stainless-steel nuts.

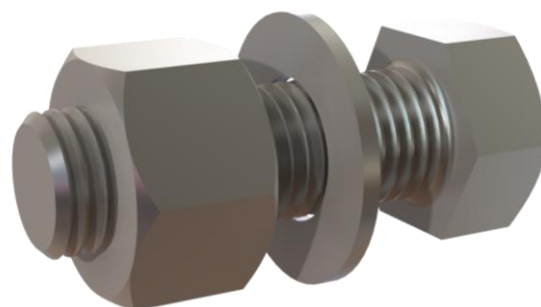
## Thread type

The thread of the stud bolt is up and including 1" are UNC. Over 1" diameter stud bolts are threaded 8UN. Both according to the ASME B1.1. The pitch for metric thread is ISO Coarse for all diameters.

## Service temperature

The service temperature is depending on the grade of the material. The service temperature for the Grade B7, B8 and B8M are mentioned in below table.

Grade	Service temperature
A193 Grade B7	-30°C to 400°C
A193 Grade B8	-30°C to 400°C
A193 Grade B8M Cl.2	-150°C to 575°C



## Marking

All stud bolts and nuts are marked as required by the ASTM A193/A194. This means the grade symbol is clearly visible on the bolt and the nut.

## Grades of stud bolts

Mounting flanges in instrumentation are mostly done with B7, B8 class 2 or B8M class 2 stud bolts in combination with grade 2H, Grade 8 or Grade 8M nuts. For Applications in NACE ISO 17945 (former NACE MR 0175) the materials B7M, L7M and B8MA cl. 1 are compliant due to the reduced hardness.

Stud Bolts	Compatible nuts	
ASTM material	ASTM material	Diameter range
A193 Grade B7	A194 Grade 2H	3/8" – 1 1/2" (M10 to M38)
A193 Grade B7M	A194 Grade 2HM	
A193 Grade L7M	A194 Grade 2H	
A193 Grade B8	A194 Grade 8	
A193 Grade B8MA Cl.1	A194 Grade 8MA	
A193 Grade B8M Cl.2	A194 Grade 8M	

Special materials such as Alloy 400/500, Duplex or Super Duplex ranges, Titanium, Hastelloy and Inconel ranges are available as well.

## Stud bolt length

Stud bolt length is depending on the type of assembly it is used. In combination with diaphragm seals there are 2 types of configurations. Mounting with holes through the flanges (in case of flush flanged seals such as BF, BRF or BC) or with threaded blind holes in case of the US/USL type of seals.

For the open hole length calculation, the knowledge of the flange thickness, tolerances, gasket thickness and the use of washers is needed. The simplified basic formula following non mandatory appendix C of the ASME B16.5 for calculating stud bolt length is:

For open hole flange with 2 sides nuts:

$$L_{CSB} = 2(b + t + N) + G + n$$

For one side tapped hole with one side open hole with 1 nut:

$$L_{CSB} = T + b + t + N + G + n$$

Where:

- $L_{CSB}$  = calculated stud bolt length (effective thread length, excluding end points)
- $b$  = minimum flange thickness (see applicable dimensional tables)
- $t$  = plus tolerance for flange thickness
- $N$  = heavy nut thickness (See tables in this datasheet)
- $G$  = 3.0 mm (0.12 in.) gasket thickness for raised face, male and female tongue-and-groove flanges; also, approximate distance between ring joint flanges
- $f$  = facing height according to standards (E for RJF)
- $n$  = negative tolerance on bolt length (1.5mm)
- $T$  = thread depth of tapped holes (1.5xD)

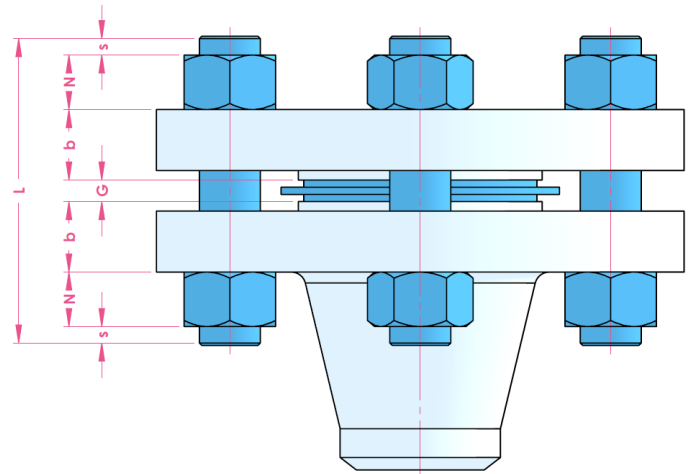
For reference the tables in this datasheet are based on the ASME B16.5 and EN 1092-1 tables based on above calculations.

### Tolerance table

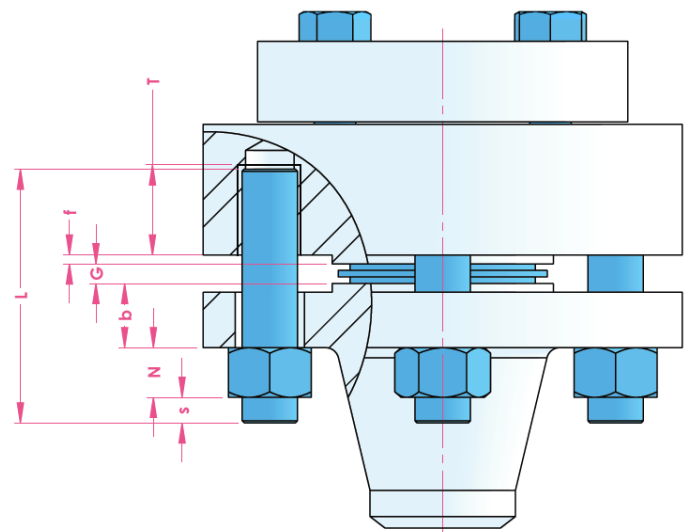
Tolerances of the flanges used to calculate the length sizes are:

Standard	Size	Tolerance (t)
ASME B16.5	Flange size <18"	+3.0/-0.0 mm
EN 1092-1	≤18mm thickness	+1.0/-1.3mm
	>18mm ≤50mm thickness	+/- 1.5mm
	>50mm thickness	+/- 2.0mm

Dimensions for open hole flange construction.



Dimensions for blind hole flange construction.



### Facing height table

Below tables represent facing height of type RF and B1/B2 face flanges and a separate table for RJF facing and other facings refer to the specific product datasheet.

Standard	Size / class_PN	Size f
ASME B16.5	All sizes / cl. 150 - cl. 300	2 mm
	All sizes / cl. 600 - cl. 2500	7 mm
EN 1092-1	DN10-DN32 / all PN	2 mm
	DN40-DN100 / all PN	3 mm

## Nut dimensions

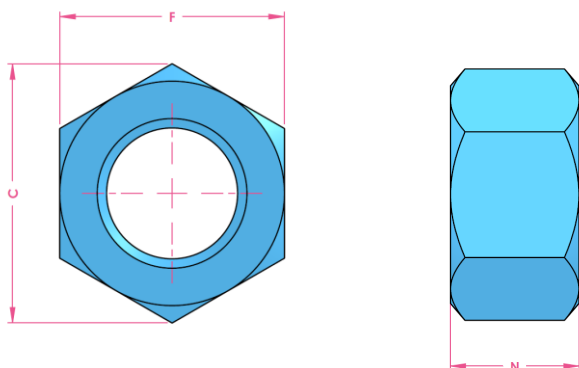
Nuts for imperial stud bolts are Unified Heavy Hexagon series to dimensions in the following table. These conform to AS 2528 and are equivalent to ANSI B18.2.2 for Heavy Hexagon Nuts. Metric nuts in 2H material is manufactured to DIN 934 H = D dimensions. Nominal dimensions are set out in the table below.

### Inch units

Size (inch)	Pitch (TPI)	Across flats (F)		Across corners (C)	Nut Height (T)	
		Max	Min	nominal	Max	Min
3/8	16	0.688	0.669	0.779	0.377	0.341
1/2	13	0.875	0.850	0.989	0.504	0.464
5/8	11	1.062	1.031	1.201	0.631	0.587
3/4	10	1.250	1.2112	1.143	0.758	0.710
7/8	9	1.43	1.394	1.625	0.885	0.833
1	8	1.625	1.575	1.836	1.012	0.956
1 1/8		1.812	1.756	2.047	1.139	1.079
1 1/4		2.00	1.938	2.259	1.251	1.187
1 3/8		2.188	2.119	2.471	1.378	1.310
1 1/2		2.375	2.300	2.682	1.505	1.433

### Metric units

Dia mm	Pitch (TPI)	Across flats (F) Nominal	Across corners (C) Nominal	Nut Height (N) Nominal
M10	1.5	17.0	19.60	10.0
M12	1.75	19.0	21.90	12.0
M14	2.00	22.0	25.40	14.0
M16		24.0	27.70	16.0
M18	2.5	27.0	31.20	18.0
M20		30.0	34.60	20.0
M22		32.0	37.00	22.0
M24	3.00	36.0	41.60	24.0
M27		41.0	47.30	27.0
M30	3.50	46.0	53.10	30.0
M33		50.0	57.70	33.0
M36	4.00	55.0	62.50	36.0
M39		60.0	69.30	39.0



## Selection support

All flanged diaphragm seals are mounted with stud bolts to the process flange. The most common materials of the stud bolts are mentioned in the ASTM A193 for bolts, and ASTM A194 for nuts. All materials can be supplied by Badotherm, however the materials B8M c12 and B7 are most common.

The length of the stud bolts can be calculated according to the formula mentioned earlier or taken from the tables below. All calculations and tables are based on standards and experience but must be considered a guidance for further engineering. The local regulations and factory standards must be followed at all time.

There are two different variants on mounting, the threaded holes of the smaller sizes US/USL/USM, and the open holes of the flanged items and the larger US/USM/USL types. In the two figures on the right the two different mounting versions are represented. The letters refer to the tables in this datasheet and the formula's on length. The letter "s" represents a guidance of the free threads above the nut after reaching the maximum torque. A rule of thumb is that  $s = 1/3$  of the bolt diameter. This extra length is already encountered in the standard-length calculation formula.

## Use of Washers

The PCC-1 states that the use of washers is optional. However, it is generally recognized that the use of through-hardened steel washers will improve the translation of torque input into consistent bolt stretch. Washers protect the contact surface of the flange from damage caused by a turning nut. The use of through hardened washers is advised as the surface hardened will flow plastically causing cupping and thinning with associated reduction in preload.

There are 4 types of washer materials. The table below represent the 4 types of materials. The material application in combination with the ASTM A194 Grades are with brackets behind the type.

### Service temperature limits

Type	Material Type washer	Service temperature - single use (reuse)
Type 1 (2H)	Carbon steel	425°C (205°C)
Type 4 (2H)	Low alloy steel	540°C (400°C)
Type 5 (8)	Martensitic steel	650°C (425°C)
Type 6 (8)	Precipitation hardening steel	815°C (550°C)

Washers should be marked with the type. During the assembly it is advised to have the marking face towards the flange to avoid effect of the washer marking on the performance of the washer.

## Dimensions of Washers

### Dimensions imperial washers

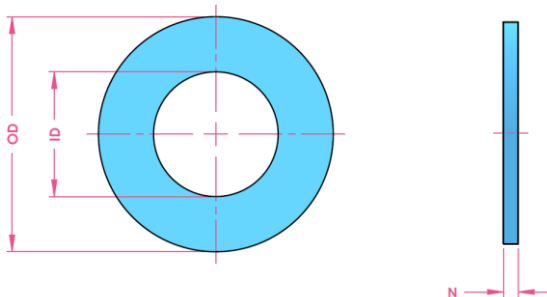
Nominal Size	Outside diameter		Inside diameter		Thickness	
	mm	Inch	mm	Inch	mm	Inch
1/2	27.0	1.063	14.3	0.563	3.2	0.125
5/8	33.4	1.313	17.5	0.688	4.0	0.156
3/4	38.1	1.500	20.7	0.813	4.8	1.188
7/8	43.6	1.718	23.8	0.938	5.6	0.219
1	50.0	1.968	27.0	1.063	6.4	0.250
1 1/8	54.8	2.156	30.2	1.188		
1 1/4	60.3	2.375	33.4	1.313		
1 3/8	65.9	2.593	36.5	1.438		
1 1/2	71.4	2.812	39.7	1.563		

Tolerances according PCC-1 – table M-6

### Dimensions metric washers

Nominal Size	OD	ID	Thickness (N)
	Mm	mm	
14	28	15	3
16	30	17	4
20	37	21	5
24	44	25	6
27	50	28	
30	56	31	
33	60	34	
36	66	37	
39	72	42	

Tolerances according PCC-1 – table M-5



## Tightening torques

Tightening torques are the responsibility of the end user. The represented values are intended for initial guidance and should be confirmed as a result of actual usage and experience. The theoretical values are based on the Yield load of the material and a friction coefficient on 0.2. The values in the tables are calculated to generate clamping loads of 30% and 60% of yield loads.

### Grade B7

Size	Yield load	30%		60%	
		ft.lb	Nm	ft.lb	Nm
3/8	8138	15	20	31	42
1/2	14910	37	50	75	102
5/8	23730	74	100	148	201
3/4	35070	132	179	263	357
7/8	48510	212	287	424	575
1	63630	318	431	636	862
1 1/8	82950	467	633	933	1265
1 1/4	105000	656	889	1313	1780
1 3/8	129465	860	1207	1780	2413
1 1/2	156660	1175	1593	2350	3168

Size	Yield load	30%		60%	
		ft.lb	Nm	ft.lb	Nm
M10	41.8	18	25	37	50
M12	60.7	32	44	64	87
M14	82.8	51	69	103	139
M16	113.0	80	108	160	217
M18	138.2	110	149	220	298
M20	176.4	156	212	312	423
M22	218.2	212	288	425	476
M24	254.2	270	366	540	732
M27	330.5	295	536	790	1071
M30	403.9	536	727	1072	1454
M33	499.7	729	989	1460	1979
M36	588.2	937	1271	1874	2541
M39	702.7	1213	1644	2425	3288

### Grade B8 and B8M class 2

Size	Yield load	30%		60%	
		ft.lb	Nm	ft.lb	Nm
3/8	7750	12	20	29	39
1/2	14200	36	49	71	96
5/8	22600	71	96	141	191
3/4	26720	100	136	200	271
7/8	36960	162	220	323	438
1	48480	242	328	485	658
1 1/8	51350	289	392	578	784
1 1/4	65000	406	550	813	1102
1 3/8	61650	424	575	848	1150
1 1/2	74600	560	759	1119	1517

## Dimensions table: ASME B16.5 stud bolts for blind flange use

Flange size	rating	D	L <sub>CSB</sub> (RF)	L <sub>CSB</sub> (RF)	L <sub>CSB</sub> (RJF) (mm)	L <sub>CSB</sub> (RJF)	pcs/flange	
0.5"	cl. 150	1/2"	55	2.25"	-		4	
	cl. 300		65	2.5"	75	3.0"		
	cl. 400-600		75	3.0"	75	3.0"		
	cl. 900-1500	3/4"	110	4.25"	110	4.25"		
	cl. 2500		120	4.75"	120	4.75"		
0.75"	cl. 150	1/2"	65	2.5"				
	cl. 300	5/8"	75	3.0"	90	3.5"		
	cl. 400-600		90	3.5"	90	3.5"		
	cl. 900-1500		115	4.5"	115	4.5"		
	cl. 2500	3/4"	125	5.0"	125	5.0"		
1.0"	cl. 150	1/2"	65	2.5"	75	3.0"		
	cl. 300	5/8"	75	3.0"	90	3.5"		
	cl. 400-600		90	3.5"	90	3.5"		
	cl. 900-1500		125	5.0"	125	5.0"		
	cl. 2500	7/8"	140	5.5"	140	5.5"		
1.25"	cl. 150	5/8"	70	2.75"	85	3.25"		
	cl. 300		85	3.25"	95	3.75"		
	cl. 400-600		95	3.75"	95	3.75"		
	cl. 900-1500	7/8"	125	5.0"	125	5.0"		
	cl. 2500	1.0"	150	6.0"	150	6.0"		
1.5"	cl. 150	1/2"	70	2.75"	85	3.25"		
	cl. 300	5/8"	90	3.5"	100	4.0"		
	cl. 400-600	3/4"	110	4.25"	110	4.25"		
	cl. 900-1500	1.0"	140	5.5"	140	5.5"		
	cl. 2500	1 1/8"	170	6.75"	170	6.75"		
2"	cl. 150	5/8"	85	3.25"	95	3.75"		
	cl. 300	5/8"	90	3.5"	100	4.0"		
	cl. 400-600	3/4"	110	4.25"	100	4.25"		
	cl. 900-1500	7/8"	145	5.75"	145	5.75"		
	cl. 2500	1.0"	180	7.0"	180	7.0"		
3"	cl. 150	5/8"	90	3.5"	100	4.0"	4	
	cl. 300	3/4"	110	4.25"	120	3.5"	8	
	cl. 400-600		125	5.0"	125	5.0"		
	cl. 900		7/8"	145	5.75"	145		5.75"
	cl. 1500	1 1/8"	180	7.0"	180	7.0"		
	cl. 2500	1 1/4"	220	8.75"	230	9.0"		
cl. 150	5/8"	90	3.5"	100	4.0"			
4"	cl. 300	3/4"	115	4.5"	125	3.75"		8
	cl. 400	7/8"	140	5.5"	135	5.5"		
	cl. 600		145	5.75"	145	5.75"		
	cl. 900		170	6.75"	170	6.75"		
	cl. 1500	1 1/4"	195	7.75"	195	7.75"		
	cl. 2500	1 1/2"	255	10.0"	260	10.25"		

The length of the stud bolt does not include the height of the points  
 Stud bolt length are a suggestion and should be reviewed by the user at all times.  
 mm length sizes are based on the metric section of the ASME B16.5  
 Inch length sizes are based on the imperial section of the ASME B16.5

## Dimensions table: ASME B16.5 stud bolts for tapped hole use

Flange size	rating	D	L <sub>CSB</sub> (RF)	L <sub>CSB</sub> (RF)	L <sub>CSB</sub> (RJF) (mm)	L <sub>CSB</sub> (RJF) (inch)	pcs/flange
0.5"	cl. 150	1/2"	55	2.25"	-	-	4
	cl. 300		55	2.25"	55	2.25"	
	cl. 400-600	3/4"	65	2.5"	75	3.0"	
	cl. 900-1500		90	3.5"	90	3.5"	
	cl. 2500		110	4.25"	110	4.25"	
0.75"	cl. 150	1/2"	55	2.25"	-		
	cl. 300	5/8"	65	2.5"	75	3.0"	
	cl. 400-600		75	3.0"	75	3.0"	
	cl. 900-1500	3/4"	110	4.25"	110	4.25"	
	cl. 2500		110	4.25"	110	4.25"	
1.0"	cl. 150	1/2"	55	2.25"	55	2.25"	
	cl. 300	5/8"	65	2.5"	75	3.0"	
	cl. 400-600		90	3.5"	90	3.5"	
	cl. 900-1500	7/8"	110	4.25"	110	4.25"	
	cl. 2500		110	4.25"	110	4.25"	
1.25"	cl. 150	5/8"	70	2.75"	85	3.25"	
	cl. 300		70	2.75"	85	3.25"	
	cl. 400-600		90	3.5"	90	3.5"	
	cl. 900-1500	7/8"	110	4.25"	110	4.25"	
	cl. 2500	1.0"	125	5.0"	125	5.0"	
1.5"	cl. 150	1/2"	65	2.5"	75	3.0"	
	cl. 300	5/8"	75	3.0"	75	3.0"	
	cl. 400-600	3/4"	120	4.75"	120	4.75"	
	cl. 900-1500	1.0"	110	4.25"	110	4.25"	
	cl. 2500	1 1/8"	140	5.5"	140	5.5"	
2"	cl. 150	5/8"	90	3.5"	100	4.0"	
	cl. 300	5/8"	85	3.25"	95	3.75"	
	cl. 400-600	3/4"	110	4.25"	100	4.25"	
	cl. 900-1500	7/8"	115	4.5"	115	4.5"	
	cl. 2500	1.0"	145	5.75"	145	5.75"	
3"	cl. 150	5/8"	90	3.5"	100	4.0"	
	cl. 300	3/4"	90	3.5"	100	4.0"	
	cl. 400-600		115	4.5"	125	3.75"	
	cl. 900	7/8"	115	4.5"	125	3.75"	
	cl. 1500	1 1/8"	180	7.0"	180	7.0"	
4"	cl. 2500	1 1/4"	170	6.75"	170	6.75"	
	cl. 150	5/8"	90	3.5"	100	4.0"	
	cl. 300	3/4"	90	3.5"	100	4.0"	
	cl. 400	7/8"	115	4.5"	125	3.75"	
	cl. 600		115	4.5"	125	3.75"	
	cl. 900	1 1/8"	140	5.5"	135	5.5"	
	cl. 1500	1 1/4"	170	6.75"	170	6.75"	
cl. 2500	1 1/2"	195	7.75"	195	7.75"		

The length of the stud bolt does not include the height of the points

Stud bolt length are a suggestion and should be reviewed by the user at all times.

mm length sizes are based on the metric section of the ASME B16.5

Inch length sizes are based on the imperial section of the ASME B16.5

## Dimensions table: EN 1092-1 stud bolts for blind flange use

size	rating	D	L <sub>CSB</sub> (B1) (mm)	pcs/flange
DN20	PN10-40	M12	70	4
	PN63-100	M16	85	
DN25	PN10-40	M12	70	
	PN63-100	M16	90	
	PN160	M16		
	PN250	M20	105	
	PN320	M20	115	
DN32	PN10-40	M16	80	
	PN63-100	M20	100	
DN40	PN10-40	M16	80	
	PN63-100	M20	100	
	PN160	M20	105	
	PN250	M24	125	
	PN320	M24	135	
DN50	PN400	M30	165	
	PN10-40	M16	80	
	PN63	M20	100	
	PN100	M24	115	
	PN160	M24	115	
	PN250	M24	135	
DN80	PN320	M24	140	8
	PN400	M27	170	
	PN10-40	M16	90	
	PN63	M20	105	
	PN100	M24	120	
	PN160	M24	130	
	PN250	M27	155	
PN320	M27	175		
DN100	PN400	M30	205	
	PN10-16	M16	80	
	PN25-40	M20	100	
	PN63	M24	115	
	PN100	M27	135	
	PN160	M27	145	
	PN250	M30	180	
PN320	M33	205		
PN400	M36	240		

The length of the stud bolt does not include the height of the points  
 Stud bolt length are a suggestion and should be reviewed by the user at all times.

## Dimensions table: EN 1092-1 stud bolts for tapped hole use

size	rating		L <sub>CSB</sub> (B1)	pcs/flang
DN20	PN10-40	M12	55	4
	PN63-100	M16	70	
DN25	PN10-40	M12	55	
	PN63-100	M16	70	
	PN160	M16	70	
	PN250	M20	85	
	PN320	M20	90	
DN32	PN10-40	M16	65	
	PN63-100	M20	80	
DN40	PN10-40	M16	65	
	PN63-100	M20	85	
	PN160	M20	85	
	PN250	M24	100	
	PN320	M24	105	
	PN400	M30	130	
DN50	PN10-40	M16	70	
	PN63	M20	85	
	PN100	M24	95	
	PN160	M24	95	
	PN250	M24	105	
DN80	PN10-40	M16	70	
	PN63	M20	85	
	PN100	M24	100	
	PN160	M24	105	
	PN250	M27	120	
	PN320	M27	130	
DN100	PN400	M30	150	
	PN10-16	M16	65	
	PN25-40	M20	80	
	PN63	M24	95	
	PN100	M27	110	
	PN160	M27	115	
	PN250	M30	135	
	PN320	M33	155	
	PN400	M36	180	

The length of the stud bolt does not include the height of the points  
 Stud bolt length are a suggestion and should be reviewed by the user at all times.



## Change log

Date	Change
22-6-2020	Added B7M, L7M, B8MA cl.1 as NACE suitable bolting
8-12-2020	Added size f to the formula Lcsb for blind hole and added facing height reference table.

Holland – Romania – India – Thailand – Dubai – USA

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