EPOXY CHOCK DESIGN IN INDUSTRIAL APPLICATIONS **REVISED: 04/2025**

TECHNICAL GUIDE #643 **VERSION: F**

DESCRIPTION

The following guide has been written as an aid for anyone planning, designing, calculating, or sizing installations of Chockfast two-component epoxy chocks, specifically with a focus on applications in the Midstream Gas Processing, Downstream Oil Refining, Petrochemical and Heavy Industries markets, as well as marine applications not requiring review or approval from a Classification Society, such as ABS, DNV, or Lloyd's Register. For specific guidance on applications requiring the review or approval from a Classification Society, please refer to Technical Guide 692.

OVERVIEW

Chockfast Black, Chockfast Gray, and Chockfast Orange are engineered, two-component, epoxy chocking materials used to create cast-in-place machinery supports for all sizes and types of dynamic and precisely aligned equipment. Because it conforms precisely to any surface profile, the usage of a Chockfast epoxy chock eliminates the need for precision machining of foundation and mounting out of plane surfaces, as well as the time-consuming fitting of steel or cast-iron chocks. This preserves the established precise alignment throughout the life of the equipment with reduced installation time and costs.

SELECTING THE RIGHT EPOXY CHOCKING SOLUTION

There are three distinct types of Chockfast used to mount machinery in Industrial Applications: Chockfast Black, Chockfast Gray, and Chockfast Orange. Selecting the right solution depends on the machinery's alignment requirements and the expected operating temperature at the feet of the equipment, otherwise known as the Foot Temperature.

Precisely Aligned Equipment is equipment that **CANNOT** tolerate movement after installation greater than 0.005 inches (0.127mm). In addition, Precisely Aligned Equipment also includes equipment aligned in relation to other equipment, such as an engine to a compressor. Examples of this class of machinery include electric motor driven equipment, turbine driven equipment, engines, compressors, and shaft bearings.

Non-Precisely Aligned Equipment are those that **CAN** tolerate movement after installation greater than 0.005 inches (0.127mm) and/or is not aligned in relation to other equipment. Typically, these types of equipment stand on their own, and are only connected to plumbing and/or electrical connections. Examples of these types of machinery include winches, pumps, skid mounted diesel generators and other self-contained equipment.

For the chocks, the *Maximum Expected Foot Temperature* is the expected maximum temperature that will be seen during equipment operating conditions and is the temperature specifically at the mounting pads, or the temperature that the Chockfast material will experience.

Where maintaining precise equipment alignment is required OR when the Maximum Expected Foot Temperature is greater than 125°F (52°C), Chockfast Black and Chockfast Orange are the typically recommended products. Where alignment does NOT have to be maintained precisely AND the foot temperature is below 125°F (52°C), Chockfast Gray may be used in addition to Chockfast Black and Chockfast Orange.

These recommendations apply to typical Chockfast installations supporting steel baseplates or sole plates on steel or concrete foundations where chock thickness is within the typical range, as shown in **Table 1**. Please note, these standard thickness recommendations are for individual pours or layers of Chockfast two-component epoxy chocks. Multiple layers may be poured to achieve greater installation thicknesses as needed, or on-site conditions dictate. For pours of Chockfast epoxy chocks outside of these typical ranges, or with assistance in selecting an appropriate product, please contact the local representative of the Worldwide Distributor Network or ITW Performance Polymers.

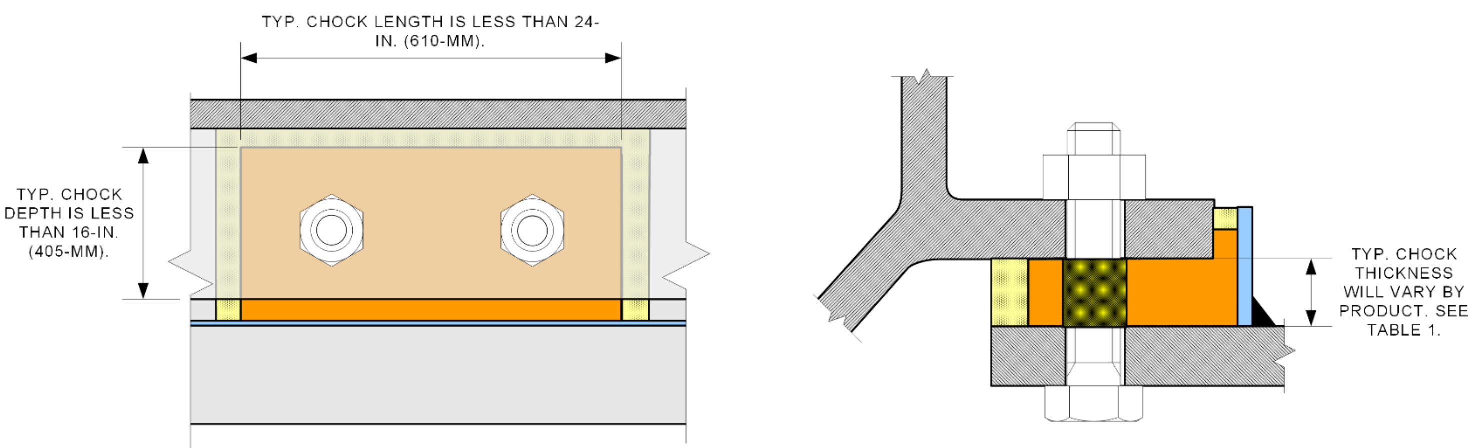
TABLE 1: STANDARD THICKNESS OF CHOCKFAST POURS

Chockfast Black	1-¼" to 2-½"	32 - 62 mm
Chockfast Orange	½" – 4"*	12 mm – 100* mm
Chockfast Gray	½" – 2"	12 mm – 50 mm

**While individual layers of Chockfast Orange may be poured up to 4" (100-mm) thick when installed between steel surfaces, typical pours of Chockfast Orange between a concrete foundation and a steel base are between ½" and 2" (1250 mm).*

INDIVIDUAL CHOCK SIZING & DESIGN RECOMMENDATIONS

For sizing of Chockfast epoxy chock installations, including Chockfast Black, Orange and Gray, it is recommended to segment lengths to ideally no more than about 24" (610 mm) and no more than about 16" (405 mm) under the equipment. Overall, it is recommended that *the total volume in a single individual chock section should be less than 780 in³ (12,782 cm³)*. See **Figure 1** for more details.



INDIVIDUAL CHOCK VOLUME (LENGTH X DEPTH X THICKNESS) SHOULD BE LESS THAN 780 IN³ (12.78 L).

FIGURE 1: SIZING RECOMMENDATIONS FOR CHOCKFAST EPOXY CHOCKS

Chockfast chocks should include at least one, and ideally two, machinery hold down or anchor bolts. For ease of installation, 1/2" to 2" (12 to 50 mm) thick chocks are recommended dimensions for starting initial designs, though this will depend on the field installation environment and alignment tolerances.

Good chock design requires that all edges and corners of mounting pads and foundations penetrating the Chockfast be rounded. Also, all grease, oil, mill scale, rust, flaking paint, burs, and welding slag must be removed. If necessary, a thin coat of epoxy primer may be applied to the machinery base and foundation to prevent rusting. More information on the recommendations for surface preparation of steel surfaces may be found in Technical Guide 641.

To ensure full contact with equipment base plates, overpours are recommended with any of the Chockfast epoxy chocking products. Overpours should be placed on a single side or parallel sides, be 1/2”-3/4” (12-18 mm) in width outside of the mounting plate, and have a reservoir height of 1/2”-3/4” (12-18 mm) above the bottom of the mounting plate (Please see Figure 2). Front damming material should always be metal, preferably steel angle iron. For normal chocks, it is recommended that the front dam be constructed of metal and have a thickness of at least 1/8” to 1/4" (3 to 6-mm). For larger volume chocks, including those with a chock height greater than 2” (50-mm), it is recommended to have a thicker metal front dam of at least 5/16” – 3/8” (7 to 8-mm) thickness. Side damming material should either be metal or open-cell foam damming. Open cell foam should allow air to escape the chocking area while preventing leakage of the epoxy chocking compound.

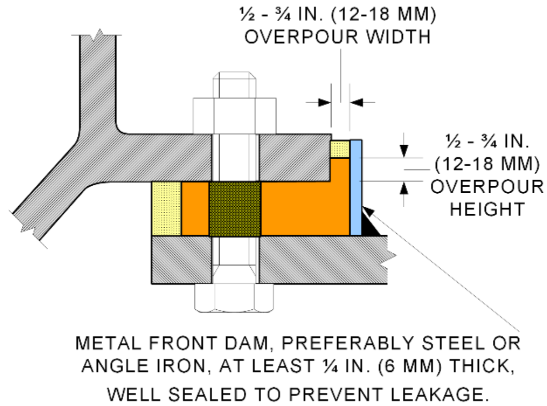
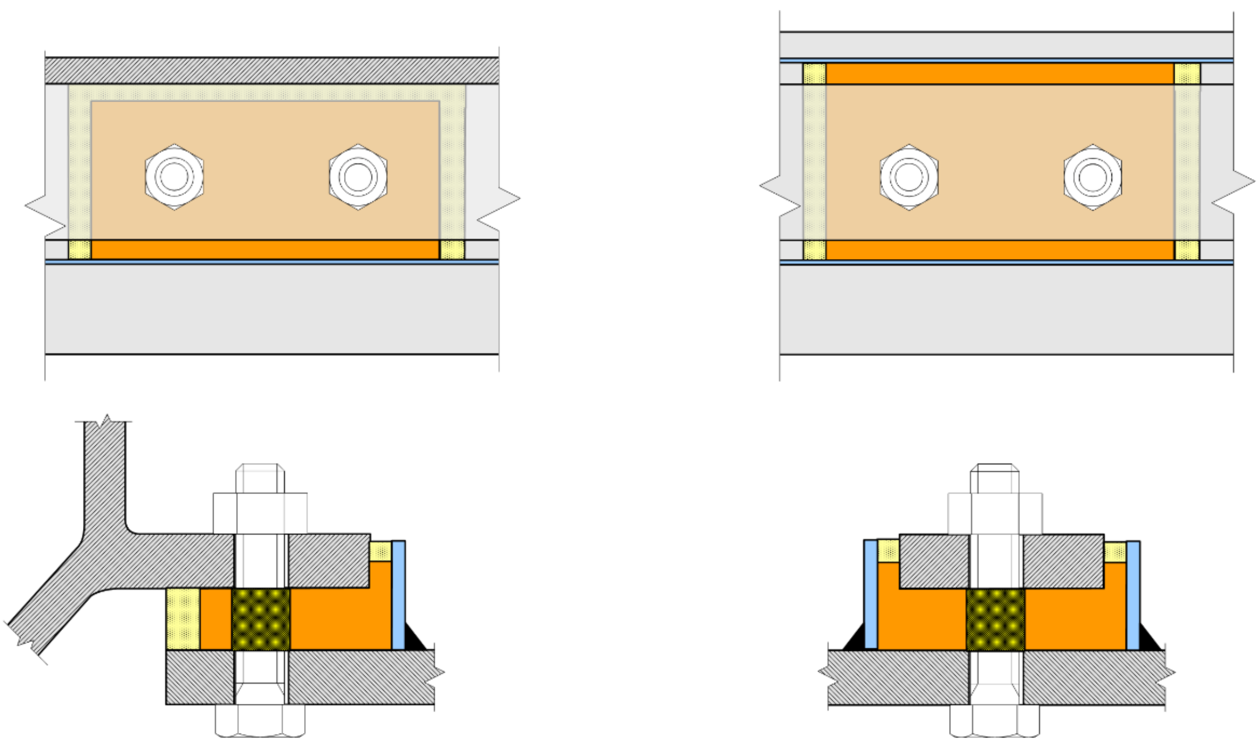


FIGURE 2: RECOMMENDED OVERPOUR DESIGN

The Chockfast in the overpour area must remain cool and liquid to feed material back under the mounting foot as needed. To do this, the overpour must be appropriately sized and kept cool with a thick metal front dam.

If overpour dimensions are greater than recommended or alternative damming material is used, there is a high potential that the material in the overpour will cure before the material under the equipment. This may result in the pull down of material away from the mounting foot, possibly leading to voids and, in extreme cases, loss of alignment preservation.

Overpours should be located on a single side only, or two parallel sides, as shown in **Figure 3**.



OVERPOUR ON A SINGLE SIDE | **OVERPOURS ON PARALLEL SIDES**

FIGURE 3: RECOMMENDED LOCATIONS OF OVERPOURS

Overpours should not be poured around a corner, or two perpendicular sides, as a corner will act as a wedge and will nearly always lead to cracking, as shown in **Figure 4**.

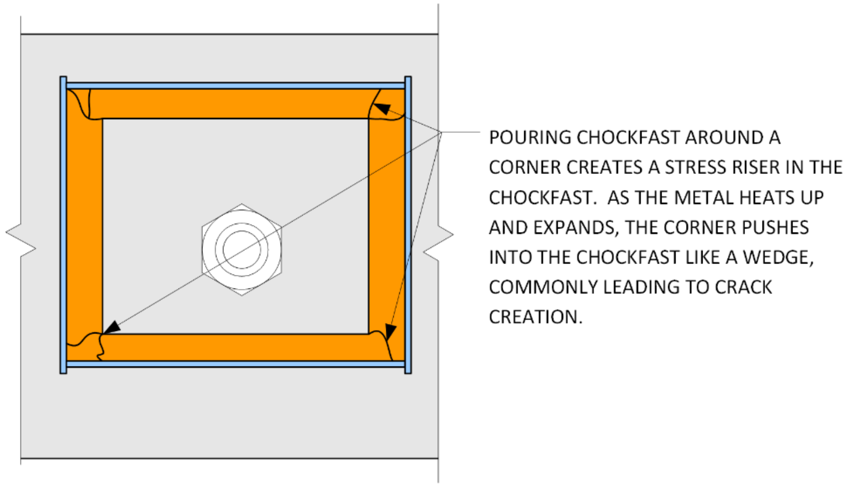


FIGURE 4: POURING CHOCKFAST AROUND CORNERS

Finally, it is recommended that chock overpours be located parallel to the line of thrust or primary motion of a piece of equipment, as shown in **Figure 5**.

One additional note- overpours only serve a function during the initial installation of the Chockfast epoxy chock. After the material has completed its exothermic cycle and solidified, there is no further need or use for the overpour. A common procedure, especially with equipment expected to experience high dynamics, increased thermal growth, or shear loading, is to remove the overpours using a diamond bladed angle grinder. This will also add the benefit of being able to visually verify the integrity of the Chockfast installed between the baseplate and the foundation.

If removing the overpour is not feasible, another alternative is to soften the sharp edge of the mounting plate with either foam back tape or a non-curing putty, such as a plumber's putty. This reduces the potential for horizontal crack development in the overpour, typically resulting form high machinery dynamics, thermal growth, or excessive shear loading, though this may still occur if the loads are high enough.

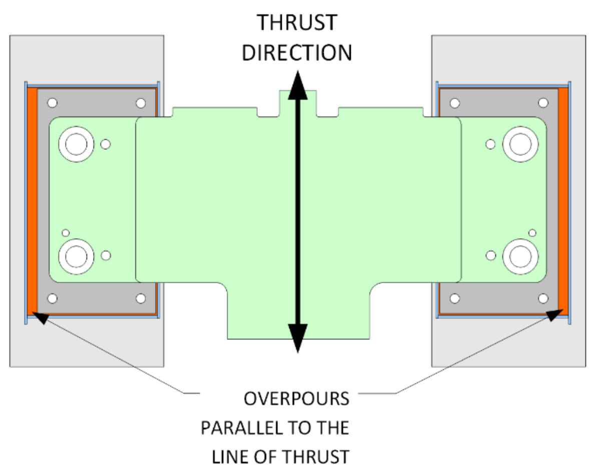


FIGURE 5: POSITIONING OF OVERPOURS PARALLEL TO THE LINE OF THRUST

Please contact your local representative of our Worldwide Distributor Network or ITW Performance Polymers for any questions or support.

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LOADING & DESIGN CALCULATIONS - PRECISELY ALIGNED EQUIPMENT

The following step-by-step calculations will aid in the determination of recommended anchor bolt preloading based on the design of the epoxy chocks. While these calculations are most typically used for Chockfast two-component epoxy chocks, the process is the same for Chockfast three-component epoxy grouts, including Chockfast Red, Chockfast Red Versaflow, or Escoweld 7505E/7530.

1. Using the wet mass of the equipment, convert into an equivalent weight force, such as from kg to N. This uses the wet mass of the equipment, which includes all fluids during operation.

$$\underset{(N)}{Equipment\ Weight} = \underset{(kg)}{Equipment\ Mass\ (Wet)} \times 9.81\ {}^{N}/_{kg}$$

Note - This step is only required when using mass units, such as kg. If using a standard weight measurement, such as lb force, then this step is not necessary.

2. Determine the *Total Chock Area*. This is the entire chock area under the machinery mounts, which does not include the overpour areas. The area of each individual chock under the mounting footprint should be added together as shown in **Figure 6**.

$$\underset{(in^2\ or\ mm^2)}{Total\ Chock\ Area} = \sum Quantity \times \underset{(in\ or\ mm)}{Length} \times \underset{(in\ or\ mm)}{Depth}$$

3. Determine the *Total Bolt Hole Area*. This is the area taken up by the bolt holes, jacking bolts and anything else that is within the total chock area.

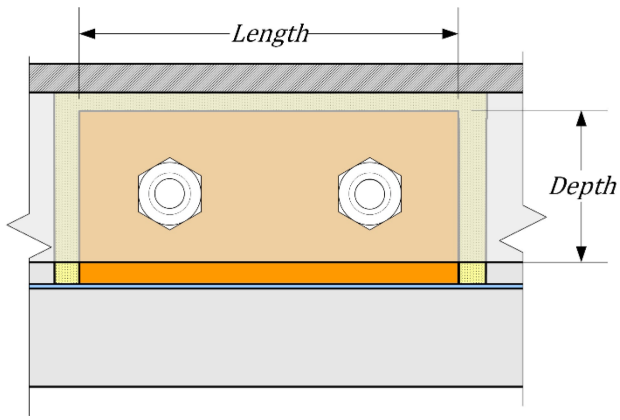

FIGURE 6: CHOCK DIMENSIONS

$$\underset{(in^2\ or\ mm^2)}{Total\ Bolt\ Hole\ Area} = \sum Quantity \times \left(\frac{\pi}{4}\right) \times \underset{(in\ or\ mm)}{(Bolt\ Diameter)^2}$$

4. Determine the *Effective Chock Area*. This is the actual chock area that is in direct contact with and supports the equipment. It is obtained by subtracting the *Total Bolt Hole Area* from the *Total Chock Area*.

$$\underset{(in^2\ or\ mm^2)}{Effective\ Chock\ Area} = \underset{(in^2\ or\ mm^2)}{Total\ Chock\ Area} - \underset{(in^2\ or\ mm^2)}{Total\ Bolt\ Hole\ Area}$$

5. The stress on the chocks due to the weight of the machinery is known as *Deadweight Loading*.

$$\frac{Equipment\ Weight\ (lbs\ or\ N)}{Effective\ Chock\ Area\ (in^2\ or\ mm^2)} = Deadweight\ Loading\ (psi\ or\ MPa)$$

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6. Next, determine the *Maximum Allowable Static Stress* allowed on the chocks. The *Maximum Allowable Static Stress* is the sum of *Deadweight Loading* and the *Anchor Bolt Stress* due to applied tension from all mounting bolts. Chocks are typically designed to a typical *Total Static Stress* of 500 psi (3.4 MPa) for precisely aligned machinery. However, research and experience has validated a sliding scale of Static Stress vs. Maximum Expected Foot Temperature. For example, Chockfast Orange can be used at a *Total Static Stress* up to 725 psi (5.0 MPa) with an expected Foot Temperature at the chock of 80°C (176°F). **Figure 7** shows the specific allowable chock load (surface pressure) based on Chockfast product.

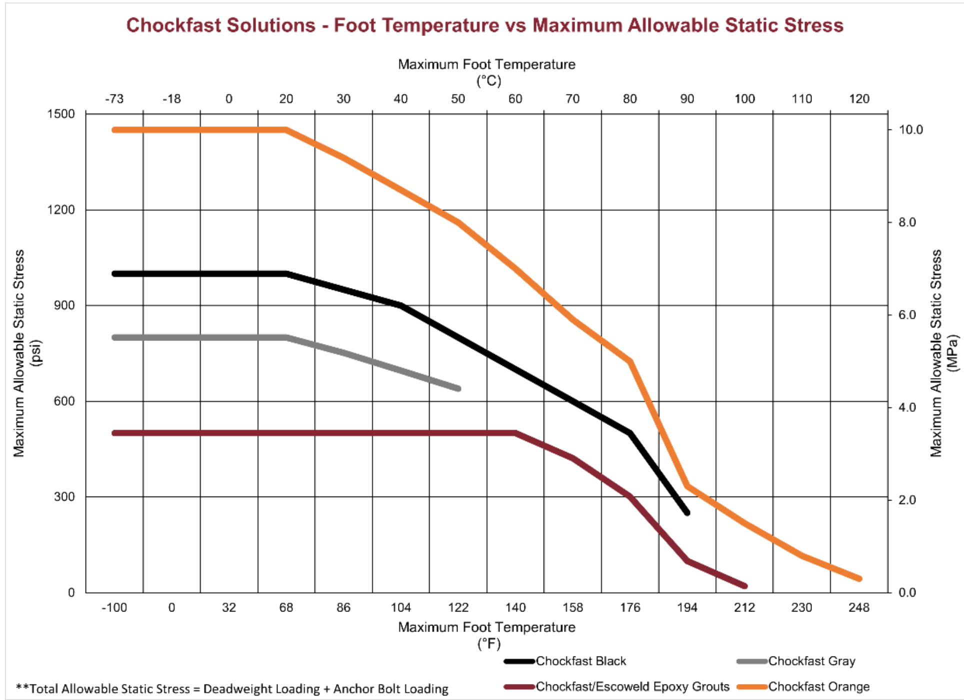

FIGURE 7: MAXIMUM ALLOWABLE STATIC STRESS VS MAXIMUM EXPECTED FOOT TEMPERATURE

7. Next, calculate the *Minimum Required Chock Area*. This is calculated by dividing the *Equipment Weight* (including water, oil, accessories, etc.) by the *Maximum Allowed Deadweight Loading*. Standard values for *Maximum Allowed Deadweight Loading* are from 100 psi to 130 psi (0.7 MPa to 0.9 MPa), or 20% of the *Maximum Allowable Static Stress*. Design the chocks to cover at least this minimum area and follow the General Guidelines for chock design. Remember, this is the <u>MINIMUM</u> *Effective Chock Area* necessary for keeping the *Actual Deadweight Loading* below the *Maximum Allowed Deadweight Loading*. This area may need to be increased while working through the calculations. The *Effective Chock Area* should be equal or greater than the *Minimum Required Chock Area* and be based on what is physically possible with the mounting surfaces of the equipment.

$$\frac{Equipment\ Weight\ (lbs\ or\ N)}{Maximum\ Allowed\ Deadweight\ Loading\ (psi\ or\ MPa)} = Minimum\ Required\ Chock\ Area\ (in^2\ or\ mm^2)$$

8. The *Total Allowable Bolt Stress* is what is left over after subtracting the *Actual Deadweight Loading* from the *Maximum Allowable Static Stress* given by **Figure 7**.

$$\underset{(psi\ or\ MPa)}{Maximum\ Allowable\ Static\ Stress} - \underset{(psi\ or\ MPa)}{Actual\ Deadweight\ Loading} = \underset{(psi\ or\ MPa)}{Total\ Allowable\ Bolt\ Stress}$$

9. Multiply the *Total Allowable Bolt Stress* by the *Effective Chock Area* to get the *Total Allowable Bolt Load*, which is total load on the equipment due to applied Bolt Tension. This is also known as Total Bolt Tension and is from the applied preload on all bolts holding the machinery in place.

$$\underset{(psi\ or\ MPa)}{Total\ Allowable\ Bolt\ Stress} \times \underset{(in^2\ or\ mm^2)}{Effective\ Chock\ Area} = \underset{(lbs\ or\ N)}{Total\ Allowable\ Bolt\ Load}$$

10. Then determine the individual *Allowable Tension per Bolt*, divide *Total Allowable Bolt Load* by the number of bolts.

$$\frac{Total\ Allowable\ Bolt\ Load\ (lbs\ or\ N)}{Total\ \#\ of\ Anchor\ Bolts} = Allowable\ Tension\ per\ Bolt\ (lbs\ or\ N)$$

11. Calculate the *Bolt Tensile Stress Area*. This will be used to determine the *Internal Bolt Stress* from the *Allowable Tension per Bolt*.

$$\left(\frac{\pi}{4}\right) \times \left[(Bolt\ Diameter\ ) - \left(\frac{0.9743}{Thread\ Pitch, n}\right)\right]^2 = \quad Bolt\ Tensile\ Stress\ Area$$

$$(in\ or\ mm) \qquad \left(\frac{threads}{in}\ or\ \frac{threads}{mm}\right) \qquad (in^2\ or\ mm^2)$$

12. Calculate the *Internal Bolt Stress* due to *Allowable Tension per Bolt*.

$$\frac{Allowable\ Tension\ per\ Bolt\ (lbs\ or\ N)}{Bolt\ Tensile\ Stress\ Area\ (in^2\ or\ mm^2)} = Internal\ Bolt\ Stress\ \ (psi\ or\ MPa)$$

13. Calculate the *% of Tensile Strength* of the *Internal Bolt Stress* to the *Bolt Min. Tensile Strength*. **Table 2** features the *Min. Yield Strength* of bolts commonly used for mounting equipment.

$$\frac{Internal\ Bolt\ Stress\ \ (psi\ or\ MPa)}{Bolt\ Min.Tensile\ Strength\ \ (psi\ or\ MPa)} = \%\ of\ Tensile\ Strength$$

TABLE 2: YIELD STRENGTHS OF COMMON BOLT TYPES

Bolt Grade / Property Class	Min. Tensile Strength (psi)	Min. Tensile Strength (MPa)
EN ISO 898-1 (2013) Grade 6.8	87,023	600
EN ISO 898-1 (2013) Grade 8.8	116,030	800
EN ISO 898-1 (2013) Grade 9.8	130,534	900
EN ISO 898-1 (2013) Grade 10.9	150,839	1040
EN ISO 898-1 (2013) Grade 12.9	176,946	1220
ASTM A193 B7 Diameter ≤ 2-1/2”	125,000	862
ASTM A193 B7 2-5/8” ≤ Diameter ≤ 4”	115,000	794
ASTM A193 B7 4-1/8” ≤ Diameter ≤ 7”	100,000	689
SAE J429 Grade 5 ¼” ≤ Diameter ≤ 1”	120,000	827
SAE J429 Grade 5 1-1/8" ≤ Diameter ≤ 1-1/2	105,000	724
SAE J429 Grade 8 ¼” ≤ Diameter ≤ 1-1/2”	150,000	1034

14. Ensure that the *% of Tensile Strength* aligns with requirements of the application and industry best practices. Additional information is included in the **ANCHOR BOLT TENSION RECOMMENDATIONS** section later in this guide.

    If the *% of Tensile Stress* is too high, then reduce the *Static Stress* to less than the *Maximum Allowable Static Stress* in Step 0 and recalculate Steps 8 - 13.

    If the *% of Tensile Stress* is too low, then consider the following potential options for recalculating the loads:

    - Decrease the anchor bolt size.
    - Use a necked anchor bolt design.
    - Decrease the anchor bolt grade.
    - Change number of anchor bolts.
    - Increase the effective chock area.

15. To ensure that there is sufficient anchor bolt tension to keep the equipment in place, the *Total Bolt Tension* must be at least 2.5 times the machinery weight and at least 5 times the machinery weight for equipment with expected high dynamics or significant unbalanced loading in operation, such as compressors, engines, or crushers.

    For high-dynamically operating equipment,

$$\frac{Allowable\ Tension\ per\ Bolt\ (lbs\ or\ N) \times\ Total\ \#\ of\ Anchor\ Bolts}{Equipment\ Weight\ (lbs\ or\ N)} \geq\ 5$$

    For low-to-medium dynamically operating equipment,

$$\frac{Allowable\ Tension\ per\ Bolt\ (lbs\ or\ N) \times\ Total\ \#\ of\ Anchor\ Bolts}{Equipment\ Weight\ (lbs\ or\ N)} \geq\ 2.5$$

16. Finally, calculate the *Bolt Torque* required that to achieve the *Tension per Bolt*. While there is no absolute relationship between tightening torque and bolt tension, there is an accepted formula for calculating bolt torque. Using one of the following formulas, calculate the torque required to achieve that tension.

    For bolts sized in Metric units, use:

$$\frac{0.2\ \times\ Tension\ per\ Bolt\ (\ N) \times\ \ Bolt\ Diameter\ (mm)}{1000} = Bolt\ Torque\ (N - m)$$

    For bolts sized in Imperial units, use:

$$\frac{0.2\ \times\ Tension\ per\ Bolt\ (lbs) \times\ \ Bolt\ Diameter\ (in)}{12} = Bolt\ Torque\ (ft - lbs)$$

    Note: Due to the various unpredictabilities and frictional effects associated with torque, ±25-30% is typical for the accuracy of most torque tools. The following **Table 3** is based on information from NASA Report NSTS 08307, Revision A, showing the relative accuracy of different methods to apply preload.

TABLE 3: BOLT LOADING METHOD

Method	Accuracy
Torque-measurement of unlubricated bolts	±35%
Torque-measurement of lubricated bolts	±25%
Hydraulic tensioners	±15%
Preload indicating washers	±10%
Ultrasonic measurement devices	±10%
Bolt elongation measurement	±5%
Instrumented bolts	±5%

DESIGN CALCULATIONS– NON-PRECISELY ALIGNED EQUIPMENT

In designing chocks for non-precisely aligned equipment, *Deadweight Loading* is not limited as discussed and, unless it is significant, need not be considered in the calculations. The primary consideration is the *Total Continuous Static Stress* on the chocks caused by the *Bolt Tension*. *Bolt Tension* is related to the *Operational Loading* of the equipment.

Operational Loading is the force applied to the equipment during its normal operation. For example, the load applied by the line on a capstan, the wire on a winch, the chain on a windlass, or the load on a crane. *Operational Loading* is classified into 3 groups by how frequently the load is applied: Continuous, Intermittent and Shock. **Table 4** shows the *Maximum Static Stress* allowed on chocks used under non-precisely aligned machinery and equipment.

TABLE 4: MAXIMUM ALLOWABLE STRESSES FOR NON-PRECISELY ALIGNED EQUIPMENT

	Continuous MPa (psi)	Intermittent MPa (psi)	Shock MPa (psi)
Chockfast Black & Chockfast Orange	8.27 (1,200)	24.52 (3,556)	68.95 (10,000)
Chockfast Gray	5.52 (800)	20.00 (2,900)	40.00 (5,800)

Static Stress on a chock is the sum of the *Deadweight Loading* and the *Total Bolt Stress*. The *Total Bolt Stress* on a piece of equipment may be increased up to a point where the *Static Stress* reaches either the *Maximum Allowable Stress* allowed in **Table 4** above or where the *Total Bolt Tension* is equal to 80% of the Proof Load of the mounting bolt.

The primary focus on evaluation and verification has been on static loading only, and the difference between the recommended static (or continuous) loading and the ultimate physical properties of the material is the safety factor to account for the dynamic loading of the application. Here is further clarification on the recommended classifications of loading type:

- **Continuous Loading** = Weight plus bolt tension
- **Intermittent Loading** = Weight plus bolt tension plus normal operational dynamic loads assuming the machine is not operated 24 hours a day 7 days a week.
- **Shock Loading** = Weight plus bolt tension plus the worst-case dynamic load.

ANCHOR BOLT TENSION RECOMMENDATIONS

When considering and evaluating an appropriate preload, it is important to consider factors including the tension in the bolt and therefore the clamping force, fatigue concerns (higher preload is generally preferable), how much torque can easily be applied without risking damaging another part if the tool slips while applying the load, etc (from Guideline for Bolted Joint Design and Analysis: Version 1.0 by Sandia National Laboratories). The standard ITW recommendation is to design for an optimum preload of 60-65% for the *% of Tensile Strength*, but at ideally greater than 50%. A basic guideline for preloading bolts, as given in the Machinery's Handbook (pg 1523 in 29th Edition), is to use 50 – 80 percent of the minimum tensile ultimate strength.

The primary considerations for the bolt preload are that it should be as high as is possible, but not greater than the capabilities of the equipment to accurately maintain the preload or the capabilities of the bolt. At an absolute minimum, one must ensure that the preload is sufficient to maintain the connectivity of the bolted joint system.

Initial bolt preload will typically be applied before the equipment is in operation and then verified once the equipment has reached its operating temperature. The following steps are the recommendations as found in The Grouting Handbook, a Step-by-Step Guide to Heavy Equipment Grouting, by Don Harrison.

1. Tension and release the bolt two times. Perform final tensioning or preload on the third try.
2. Check the anchor bolt for proper tension and make any necessary adjustments seven days after the equipment has been placed in service.
3. Thirty days after the initial tensioning, re-check the anchor bolt for proper tension with the equipment at operating temperature.
4. Six months after initial tensioning, check the anchor bolts for proper tension and adjust if necessary.
5. Check the anchor bolts for proper tension every six months thereafter and adjust if necessary.

REFERENCE

For any additional recommendations or applications beyond the typical ones listed in this document, please contact your local representative of our Worldwide Distributor Network or ITW Performance Polymers for further support.

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