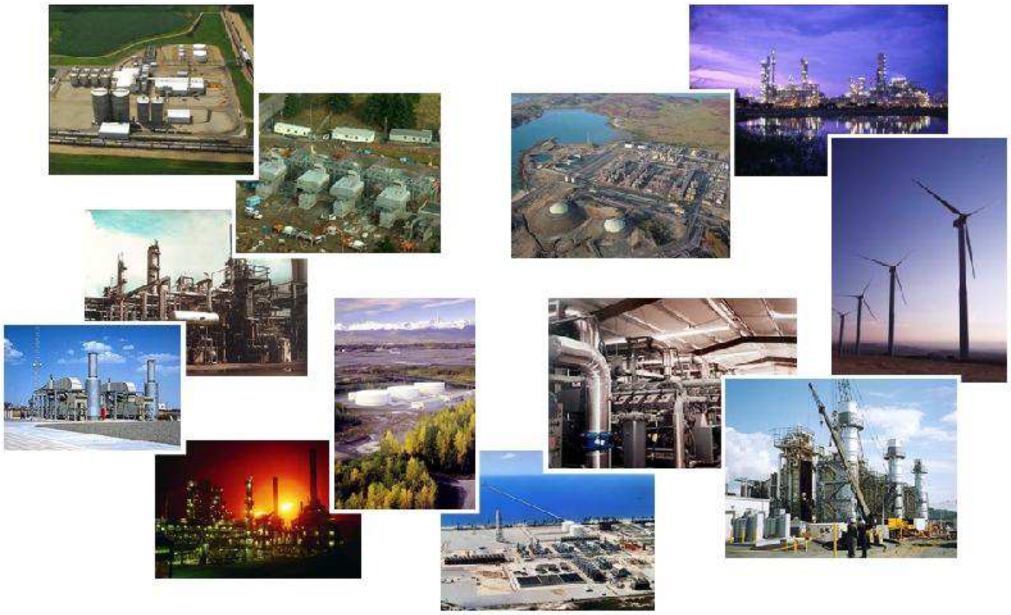
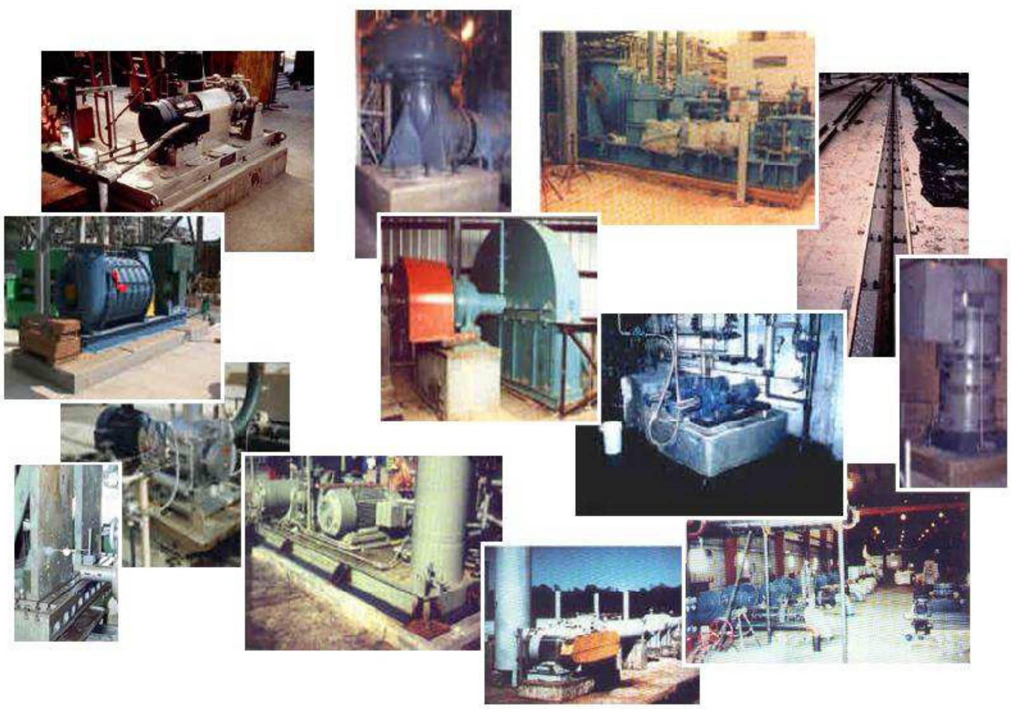
ITW Polymers Coatings North America





Chockfast®

Industrial Grouts, Polymers & Foundation Systems

Engineering

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Printing this Manual

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Color Printer

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Engineering Manual / Table of Contents

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Section 1 / Machinery Basics

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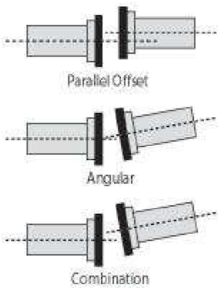
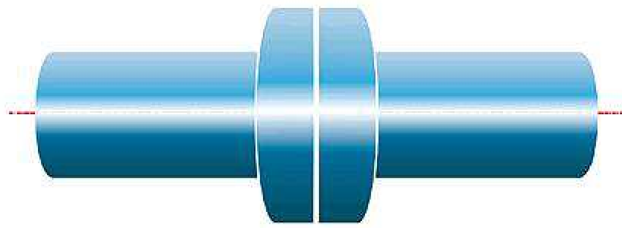
Section 1 / Machinery Basics

Alignment

The precise placing of one or more pieces of connected equipment relative to each other in order to obtain dependable operation. Proper alignment insures any bearing surfaces will be loaded to design levels.

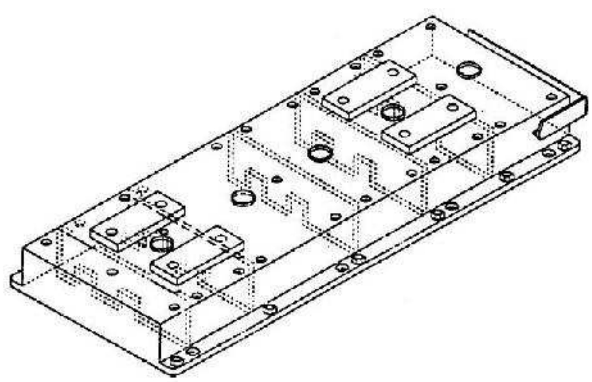




Rotating axes must be colinear during operation

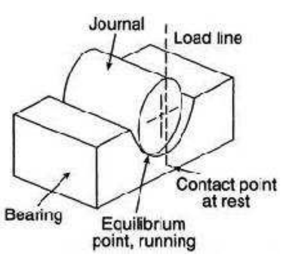
Base Plate

A metal fabrication on which machinery components are mounted. A pump base plate typically holds a motor, reduction gear, and the pump.

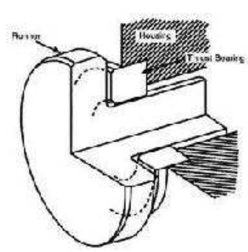


Bearing

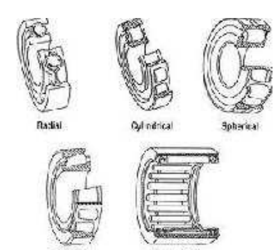
A support for a mechanism that transmits force through motion. The motion can be rotating or reciprocating. Typical bearings can be journal (sleeve) bearings, ball bearings, or pads.



Journal Bearing



Thrust Bearing



Roller Bearings

Chock

A spacer that is placed between the mounting surface of a piece of machinery and the foundation on which it sits. Chocks compensate for any differences between the elevations of the two surfaces and, as a result, each chock is individually manufactured to fit in its intended location. Chocks can be made from a variety of materials with steel and poured epoxy being the most common.



Foundation

A supporting structure usually made from concrete poured in place or a metal fabrication.


Hold Down Bolts

Fasteners which secure a piece of machinery to a foundation. There are several types of hold down bolts.

Anchor Bolts

Bolts that are cast into a foundation. Machinery is set down over the exposed threads and nuts are installed and tightened.

Fitted Bolts

Bolts installed in precisely machined holes so there is no possibility of the machine moving in any side-to-side direction.

Clearance Bolts

Bolts installed in holes larger than the body of the bolt.

Studs

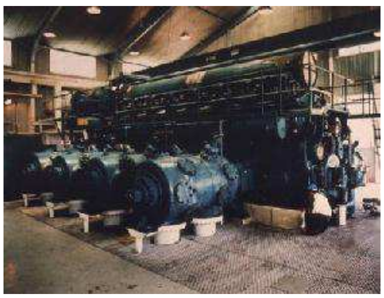
Bolts that have threads at each end.

Jack Screws (or Jack Bolts)

Bolts that are used to position a piece of machinery prior to final chocking. They are usually removed before the holds down bolts are tightened.

Reciprocating Equipment

Machinery in which the principle moving part operates in a back and forth motion.

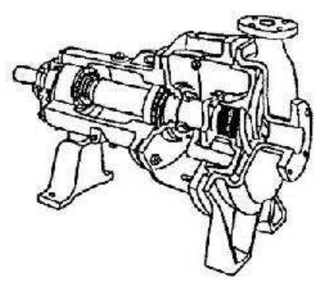


Examples:

- Compressors
- Diesel Engines
- Gasoline Engines

Rotating Equipment

Machinery in which the principle moving part operates in a circular motion.

Examples:

- Centrifugal Pumps
- Turbines
- Electric Motors
- Lathes

Shim

A thin piece of material which is placed between the mounting surface of a piece of machinery and the foundation on which it sits. Shims are available in fixed sizes and can be stacked to obtain the desired thickness. Shims are made from a variety of materials with steel and brass being the most common.

Sole Plate

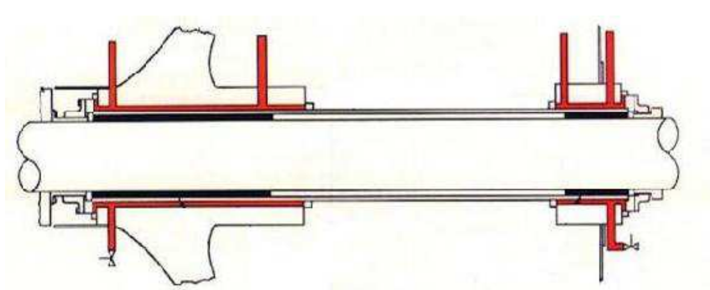
A steel plate on which machinery is mounted. Usually a sole plate is imbedded in a foundation with concrete or grout.

Stern Tube

A steel tube built into a ship’s structure for the purpose of supporting and enclosing the propulsion shafting where it pierces the hull of the ship.

Stern Tube Bearing

A bearing located at either end of a stern tube that supports the propeller shaft.



Section 2 / Mathematics

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Section 2 / Mathematics

Units

	English	Metric
Length	Inch Foot Yard Mile	Meter
Weight	Pound Ounce Ton	Newton
Mass	Slug	Gram
Capacity	Gallon	Liter
Temperature	Fahrenheit	Centigrade
Pressure	Lb / in^2	Kg / cm^2 Pascal Bar

Metric Prefixes

Decimal Form	Exponent or Power	Prefix	Symbol	Meaning
1 000 000 000	10^{9}	Giga	G	Billion
1 000 000	10^{6}	Mega	M	Million
1 000	10^{3}	Kilo	k	Thousand
100	10^{2}	hecto	h	Hundred
1				Base Unit
0.1	10^{-1}	Deci	d	Tenth
0.01	10^{-2}	Centi	c	Hundredth
0.001	10^{-3}	Milli	m	Thousandth
0.000 001	10^{-6}	Micro	m	Millionth

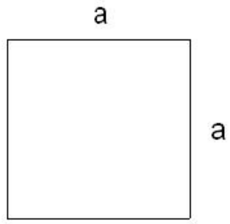
Most commonly used (shaded rows)

Area Calculations

Area (A); is a two-dimensional (2-D) number. As a result two dimensions are needed to calculate area.

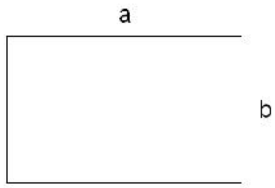
Common Formulas:

Square



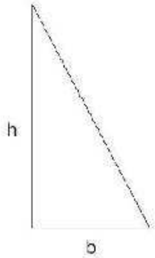
$$A = a \times a$$

Rectangle



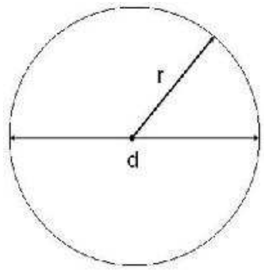
$$A = a \times b$$

Triangle



$$A = \frac{1}{2} b \times h$$

Circle



$$A = \frac{\pi \times d^2}{4} = \pi r^2$$

Where, $\pi = 3.14159$

Area Units

Area can be expressed in:

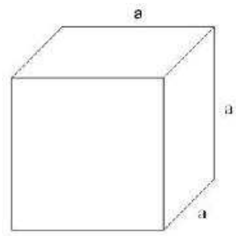
- Square Feet – ft^2
- Square Inches – in^2
- Square Centimeters – cm^2
- Square Millimeters – mm^2

Volume Calculations

Volume (V); is a three-dimensional (3-D) number. It is an area times its height or thickness which means three dimensions are needed.

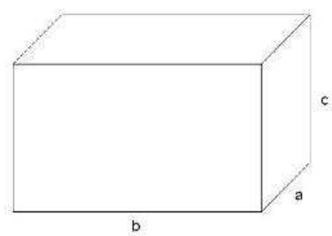
Common Formulas:

Cube



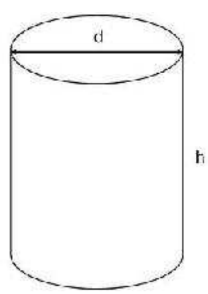
$$V = a \times a \times a$$

Box



$$V = a \times b \times c$$

Flat Bottomed, Cylindrical Tank



$$V = \frac{\pi \times d^2}{4} \times h$$

Where, $\pi = 3.14159$

Volume Units

Volume can be expressed in:

- Cubic Feet – ft^3
- Cubic Inches – in^3
- Cubic Centimeters – cm^3
- Cubic Millimeters – mm^3
- Gallons
- Liters

Example

What volume of coating is needed to cover a floor 100 ft. by 350 ft at a thickness of 0.005 in (5 mils)?

Solution: The calculation can be done in either ft^3 or in^3.

V = a x b x c, where we let:

a = 100 ft
b = 350 ft
c = 0.005 in.

Let's change feet to inches so the answer will be in cubic inches:

$V = (100 \times 12) \times (350 \times 12) \times 0.005 = \underline{25\,200\ in}^3$

This can now be converted to gallons:

$V = \frac{25\,200}{231} = \underline{109 \text{ Gallons}}$

Conversions

atmospheres	x 1.033	=	kg/sq. cm
atmospheres	x 1.47	=	pounds/sq. in.
bars	x 0.9869	=	atmospheres
bars	x 1.02	=	kg/sq. cm.
bars	x 14.5	=	pounds/sq. in.
centigrade(degrees)	(° C x 9/5) + 32	=	fahrenheit (degrees)
centimeters	x 0.03281	=	feet
centimeters	x 0.3937	=	inches
centimeters	x 0.00001	=	kilometers
centimeters	x 0.01	=	meters
centimeters	x 10	=	millimeters
centimeters	x 393.7	=	mils
cubic centimeters	x 0.00003531	=	cubic feet
cubic centimeters	x 0.06102	=	cubic inches
cubic centimeters	x 0.000001	=	cubic meters
cubic centimeters	x 0.0002642	=	gallons
cubic centimeters	x 0.001	=	liters
cubic feet	x 28320	=	cubic centimeters
cubic feet	x 1728	=	cubic inches
cubic feet	x 0.02832	=	cubic meters
cubic feet	x 7.48052	=	gallons
cubic feet	x 28.32	=	liters
cubic inches	x 16.39	=	cubic centimeters
cubic inches	x 0.0005787	=	cubic feet
cubic inches	x 0.00001639	=	cubic meters
cubic inches	x 0.004329	=	gallons
cubic inches	x 0.01639	=	liters
cubic meters	x 10000	=	cubic centimeters
cubic meters	x 35.31	=	cubic feet
cubic meters	x 61023	=	cubic inches
cubic meters	x 264.2	=	gallons
cubic meters	x 1000	=	liters
fahrenheit (degrees)	(° F - 32) x 5/9	=	centigrade (degrees)
fathoms	x 6	=	feet
feet	x 30.48	=	centimeters
feet	x 0.0003048	=	kilometers
feet	x 0.3048	=	meters
feet	x 304.8	=	millimeters
feet	x 12000	=	mils
foot-pounds	x 0.1383	=	kilogram-meters
gallons	x 3785	=	cubic centimeters
gallons	x 0.1337	=	cubic feet
gallons	x 231	=	cubic inches
gallons	x 0.003785	=	cubic meters
gallons	x 3.785	=	liters
gallons of water	x 8.337	=	pounds of water
grams	x 0.001	=	kilograms
grams	x 0.002205	=	pounds

Conversions

inches	x 2.54	=	centimeters
inches	x 0.0254	=	meters
inches	x 25.4	=	millimeters
inches	x 0.001	=	mils
kilograms	x 1000	=	grams
kilograms	x 2.2	=	pounds
kilograms/sq. cm.	x 0.9678	=	atmospheres
kilograms/sq. cm.	x 14.22	=	pounds/sq. in.
kilogram-meters	x 7.233	=	foot-pounds
kilometers	x 100000	=	centimeters
kilometers	x 3281	=	feet
kilometers	x 39370	=	inches
kilometers	x 1000	=	meters
kilometers	x 1000000	=	millimeters
kilopascals	x 0.145	=	pounds/sq. in.
knots	x 1.151	=	mile/hour
liters	x 1000	=	cubic centimeter
liters	x 0.03531	=	cubic feet
liters	x 61.02	=	cubic inches
liters	x 0.001	=	cubic meters
liters	x 0.2642	=	gallons
liters	x 1.06	=	quarts
megapascals	x 145	=	pounds/sq. in.
meters	x 100	=	centimeters
meters	x 0.54681	=	fathoms
meter	x 3.281	=	feet
meters	x 0.3937	=	inches
meters	x 0.001	=	kilometers
meters	x 1000	=	millimeters
microns	x 0.000001	=	meters
milligrams	x 0.001	=	grams
millimeters	x 0.1	=	centimeters
millimeters	x 0.003281	=	feet
millimeters	x 0.03937	=	inches
millimeters	x 0.000001	=	kilometers
millimeters	x 0.001	=	meters
millimeters	x 39.37	=	mils
mils	x 0.00254	=	centimeters
mils	x 0.0000833	=	feet
mils	x 0.001	=	inches
newtons	x 0.2248	=	pounds
ounces	x 28.349	=	grams
ounces	x 0.0625	=	pounds
pounds	x 4.448	=	newtons
pounds	x 453.6	=	grams
pounds	x 0.4536	=	kilograms
pounds	x 16	=	ounces
pounds of water	x 0.01602	=	cubic feet

Conversions

pounds of water	x 27.68	=	cubic inches
pounds of water	x 0.1198	=	gallons
pounds/sq. in.	x 0.06804	=	atmospheres
pounds/sq. in.	x 0.0703	=	kg /sq. cm.
pounds/sq. in.	x 6.895	=	kilopascals
pounds/sq. in.	x 0.006895	=	megapascals
square centimeters	x 0.001076	=	square feet
square centimeters	x 0.155	=	square inches
square centimeters	x 0.0001	=	square meters
square centimeters	x 100	=	square millimeters
square feet	x 929	=	square centimeters
square feet	x 144	=	square inches
square feet	x 0.0929	=	square meters
square feet	x 92900	=	square millimeters
square inches	x 6.452	=	square centimeters
square inches	x 0.006944	=	square feet
square inches	x 645.2	=	square millimeters
square meters	x 10000	=	square centimeters
square meters	x 10.76	=	square feet
square meters	x 1550	=	square inches
square meters	x 1000000	=	square millimeters
square millimeters	x 0.01	=	square centimeters
square millimeters	x 0.0000108	=	square feet
square millimeters	x 0.00155	=	square inches
tons (metric)	x 1000	=	kilograms
tons (metric)	x 2205	=	pounds
tons	x 2000	=	pounds

Section 3 / Engineering

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Section 3 / Engineering

Engineering

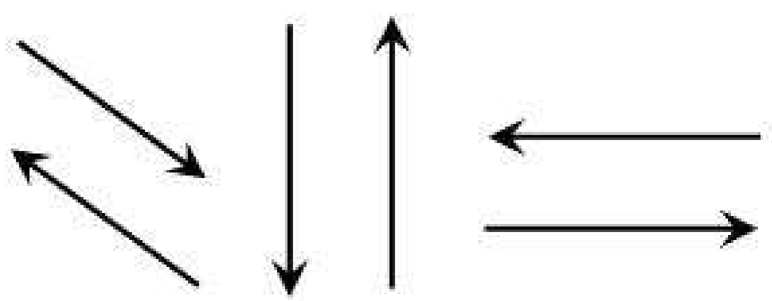
The science concerned with putting scientific knowledge to practical use.

Force

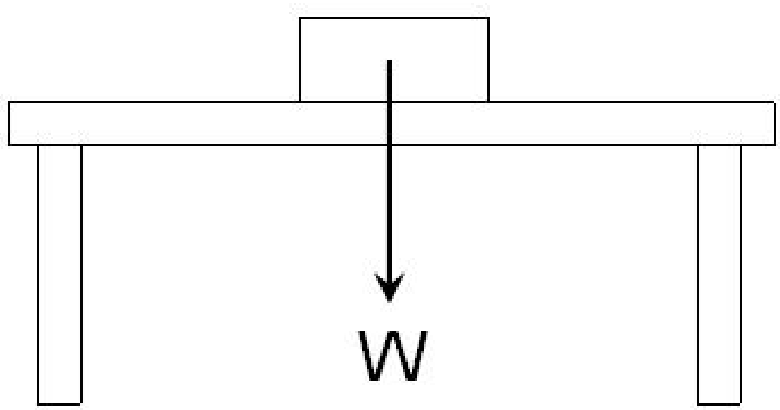
A push or pull on a body. There are different types of forces:

- Weight
- Gravity
- Magnetic
- Electrical

Force is represented by an arrow showing magnitude and direction (also called a vector quantity).



If we want to indicate a table which has a book on it is subjected to the weight of the book we can represent it as such:



Stress

Stress is the effect of an external force applied upon a solid material. The solid material has an internal resistance that absorbs the external force. This internal resistance is expressed in pounds per square inch (lb/in ^{2} or psi).

The level of stress in a solid depends upon the amount of force and the surface on which the force acts. There are several types of stress:

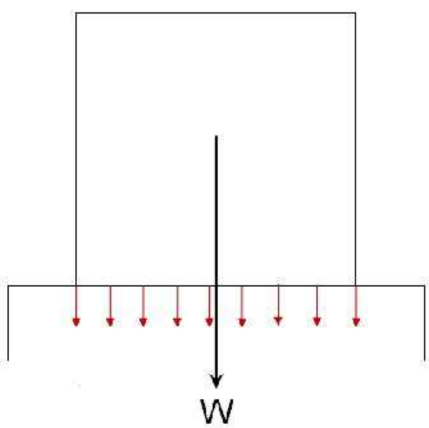
Compressive Stress - Compressive stress occurs when a force acts on a solid so as to squeeze the solid. This is the type of stress grouting materials normally see.

It is equal to the applied force divided by the surface area.

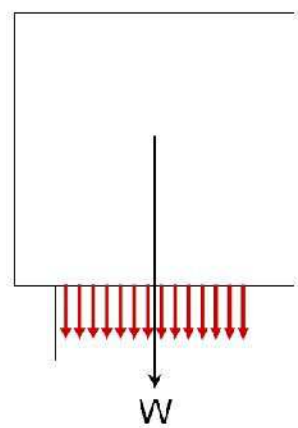
Or

$$\textbf{Stress} = \frac{\textbf{Force}}{\textbf{Area}} = \frac{\textbf{F}}{\textbf{A}}$$

What is the effect of weight and material size on compressive stress?

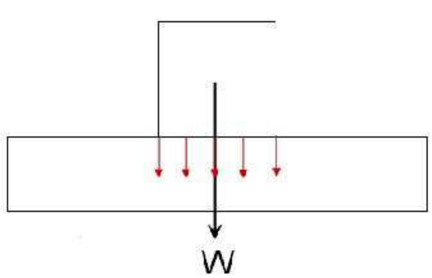


Less stress found on the bottom block here

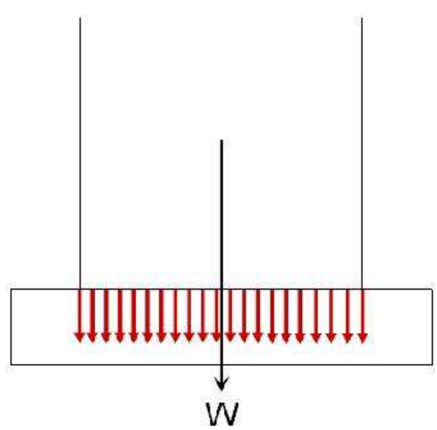


More stress found on the bottom block here

but



Less stress found on the bottom block here



More stress found on the bottom block here

Note that force by itself will not give a true picture of an application in regard to its strength. By saying a foundation has a load of 20 tons on it does not imply weather the structure is strong enough or not. It is necessary to know the area on which the force is acting.

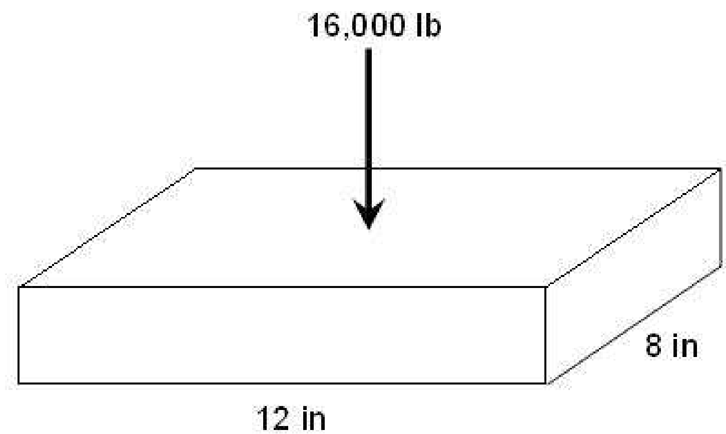
Example:

A load of 16,000 lb is placed on a **CHOCKFAST Orange** chock that is 12 inches long and 8 inches deep. What is the compressive stress on the chock?

$$\text{Stress} = \frac{F}{A}$$

Where: $F = 16{,}000$ lb
$A = 12 \text{ in} \times 8 \text{ in} = 96 \text{ in}^2$

$$\text{Stress} = \frac{16{,}000}{96} = \underline{166.6 \text{ psi}}$$



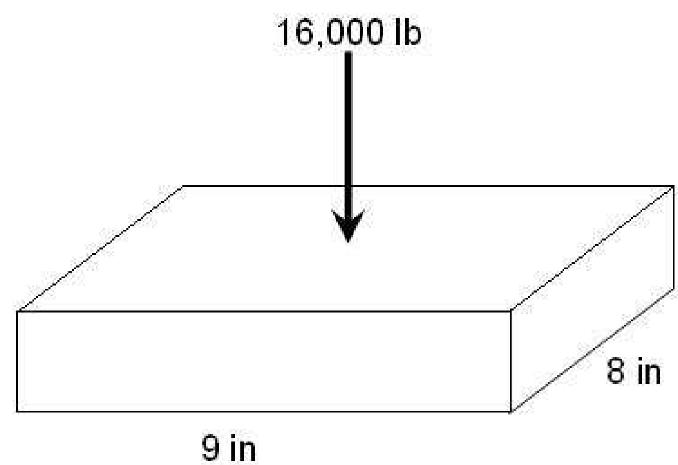
Example:

Suppose the chock is reduced in size to only 9 inches long. What is the new stress level?

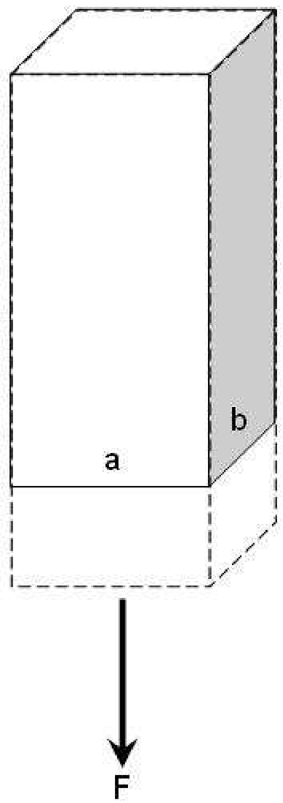
$$\text{Stress} = \frac{F}{A}$$

Where: $F = 16{,}000$ lb
$A = 9 \text{ in} \times 8 \text{ in} = 72 \text{ in}^2$

$$\text{Stress} = \frac{16{,}000}{72} = \underline{222.2 \text{ psi}}$$

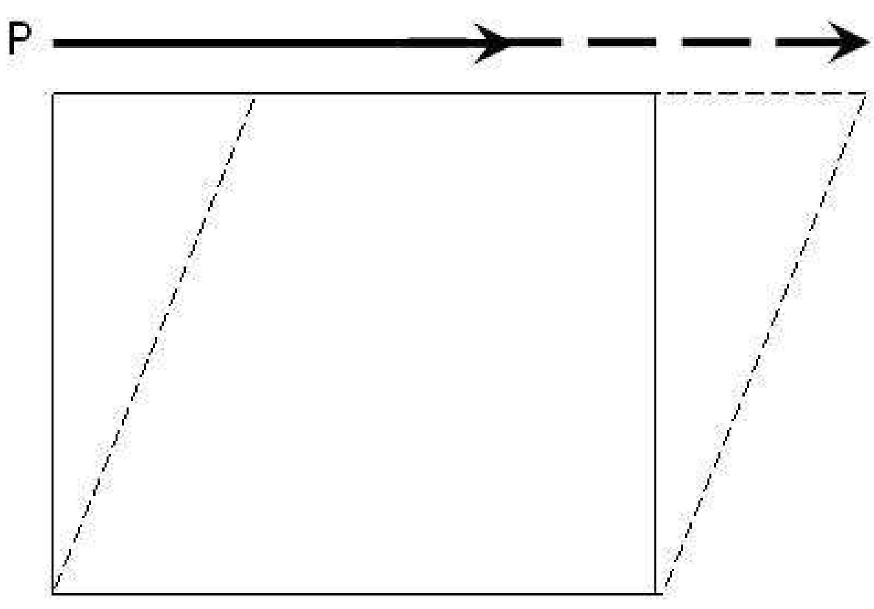


Tensile Stress - Tensile stress occurs when a force acts on a solid so as to stretch the solid

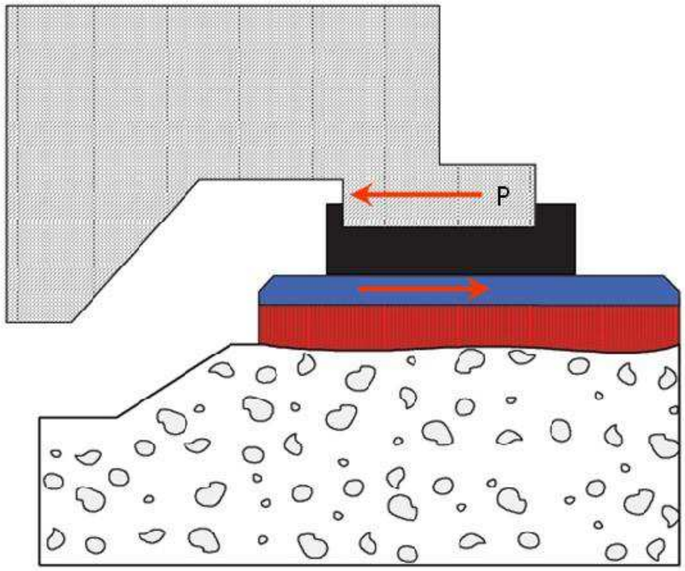


$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{F}{A} = \frac{F}{a \times b}$$

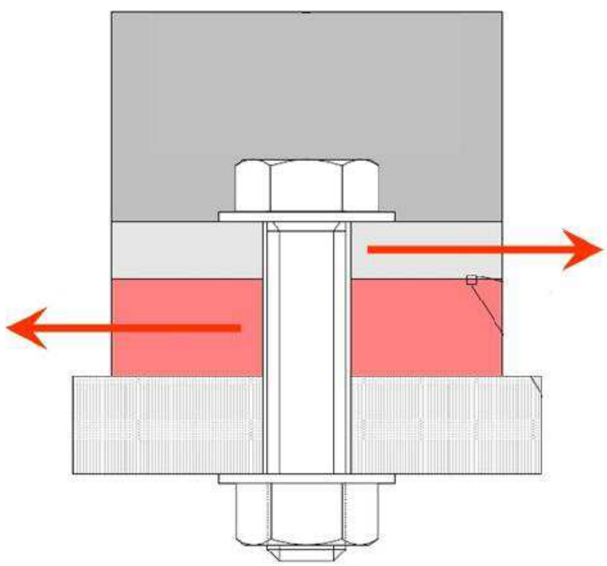
Shear Stress - Shear or Shearing Stress occurs when a force causes one side of a solid to "slide" in relation to the other side.



For grouts or chocking materials, shear stresses occur when the machinery imposes sideways forces on the epoxy. These forces can be caused by the machine when it's operating or if it grows or shrinks with temperature changes.



Hold-down Bolts running through the chocks can also be put into shear.

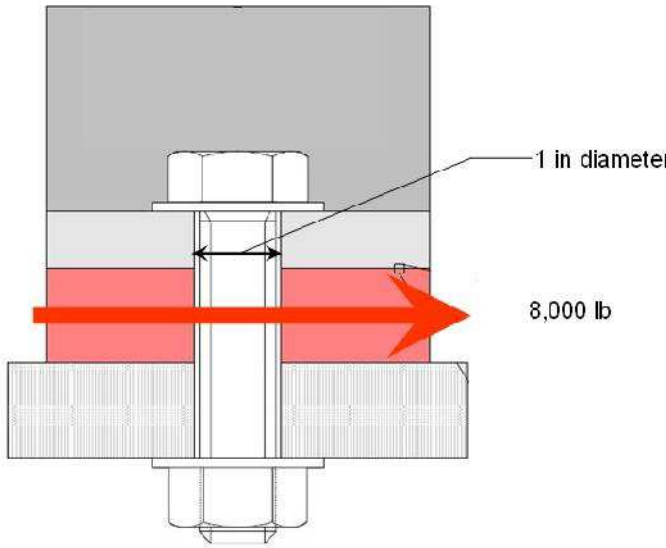


Like Compressive and Tensile Stress, the formula for Shear Stress is:

$$\textbf{Stress} = \frac{\textbf{Force}}{\textbf{Area}}$$

Example:

What is the shear stress on a 1 in. diameter bolt subjected to a shear force of 8,000 lbs.?

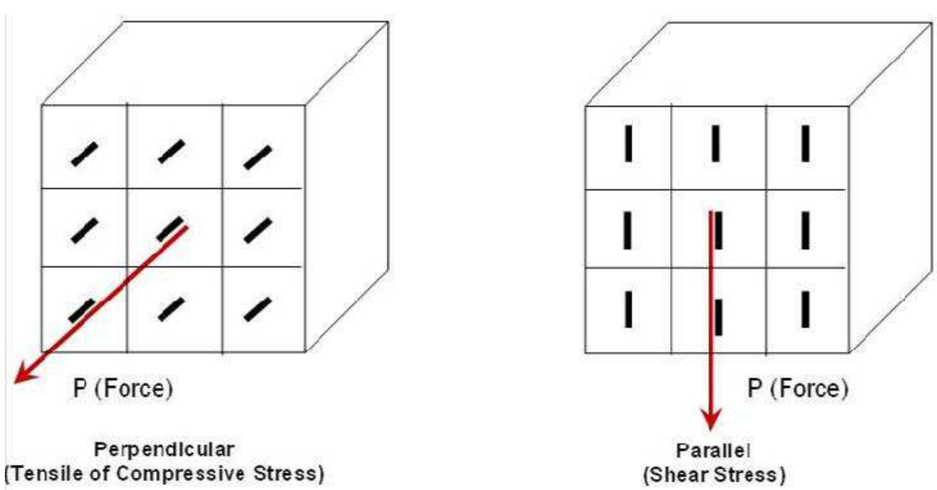


$$\text{Stress} = \frac{F}{A}$$

Where: $F = 8{,}000$ lb
$A = \pi \times (1\ \text{in})^2/4 = 3.1415/4 = 0.785\ \text{in}^2$ (Area of a Circle)

$$\text{Stress} = \frac{8{,}000}{0.785} = \underline{10{,}191\ \text{psi}}$$

Note that a shearing stress placed on a cross-sectional area of a solid is parallel to the surface, not perpendicular, as in the case of compressive or tensile stress.

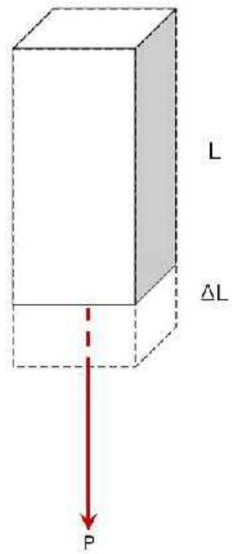


Strain

Strain is the deformation per unit length of a solid under stress.

Deformation is a change in dimension. In Engineering a change is a difference or delta. Delta is a Greek letter represented as,
For example a change in length is delta L or, **L**

Therefore:



Strain = $\frac{L}{L}$ or $\frac{\text{Change in Length}}{\text{Original Length}}$

Example:

Due to a tensile stress placed on it, a 25 in. long metal rod assumes a length of 25.025 inches. What is the strain on the rod?

Strain = $\frac{L}{L}$ or $\frac{\text{Change in Length}}{\text{Original Length}}$

Where:

L = 25.025 - 25.0 = 0.025 in. and L = 25 in.

Strain = $\frac{0.025 \text{ in}}{25.0 \text{ in}}$ = <u>0.001</u>

Modulus of Elasticity

The relationship between stress and strain is a term called the modulus.

The modulus of elasticity of a material is an index of its elasticity or the ability of a solid material to deform when an external force is applied to it, then return to its original shape after the removal of the external force. For a certain level of stress placed on a material there will be a certain amount of strain depending upon the modulus of elasticity.

The modulus of elasticity of a material is represented by E for Tension and Compression and ES for Shear. The units are lb/in ^{2}.

Material	Modulus of Elasticity in PSI	
	Tension & Compression	Shear
Steel	30,000,000	12,000,000
Copper	13,000,000	6,000,000
Aluminum	10,000,000	4,000,000
Concrete	3,000,000 - 6,000,000	-
PVC	300,000	-
CHOCKFAST Orange	533,000	100,000
CHOCKFAST Gray	520,000	-

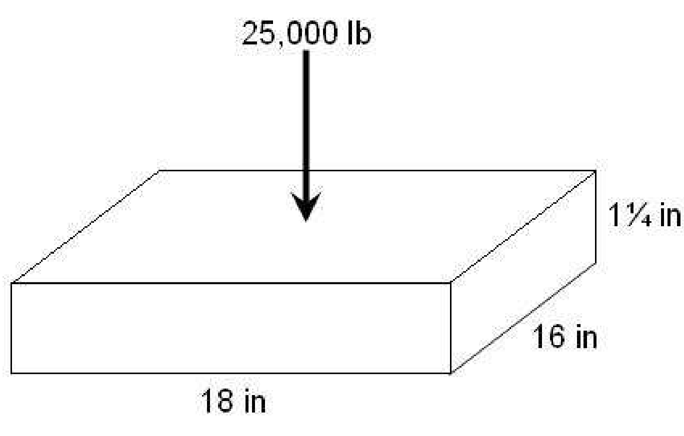
If we know the modulus of elasticity of a material we can calculate how much it will deflect for a given load. Another way to say this is for a given material we can calculate the strain if we know the stress.

The relationship between stress and strain is:

$$\text{Stress} = E \times \text{Strain} \quad \text{or} \quad E = \frac{\text{Stress}}{\text{Strain}} \quad \text{or} \quad \text{Strain} = \frac{\text{Stress}}{E}$$

Example:

A **CHOCKFAST Orange** chock will have a load of 25,000 lbs placed on it. The chock is 18 inches long and 16 inches deep. The thickness before it is loaded is 1-¼ inches. How much will the chock deflect due to the load?



We want to calculate   L (which in this example is thickness). From an earlier page we know:

$$\text{Strain} = \frac{L}{L} \quad \text{or} \quad L = \text{Strain} \times L$$

We know L = 1 ¼ or 1.25 inches, but we need to calculate strain.

From above:

$$\text{Strain} = \frac{\text{Stress}}{E}$$

For **CHOCKFAST Orange**, E = 533,000 lb/in^2

Now calculate stress on the chock:

$$\text{Stress} = \frac{F}{A}$$

Where: F = 25,000 lb
A = 18 x 16 = 288 in^2

Therefore:

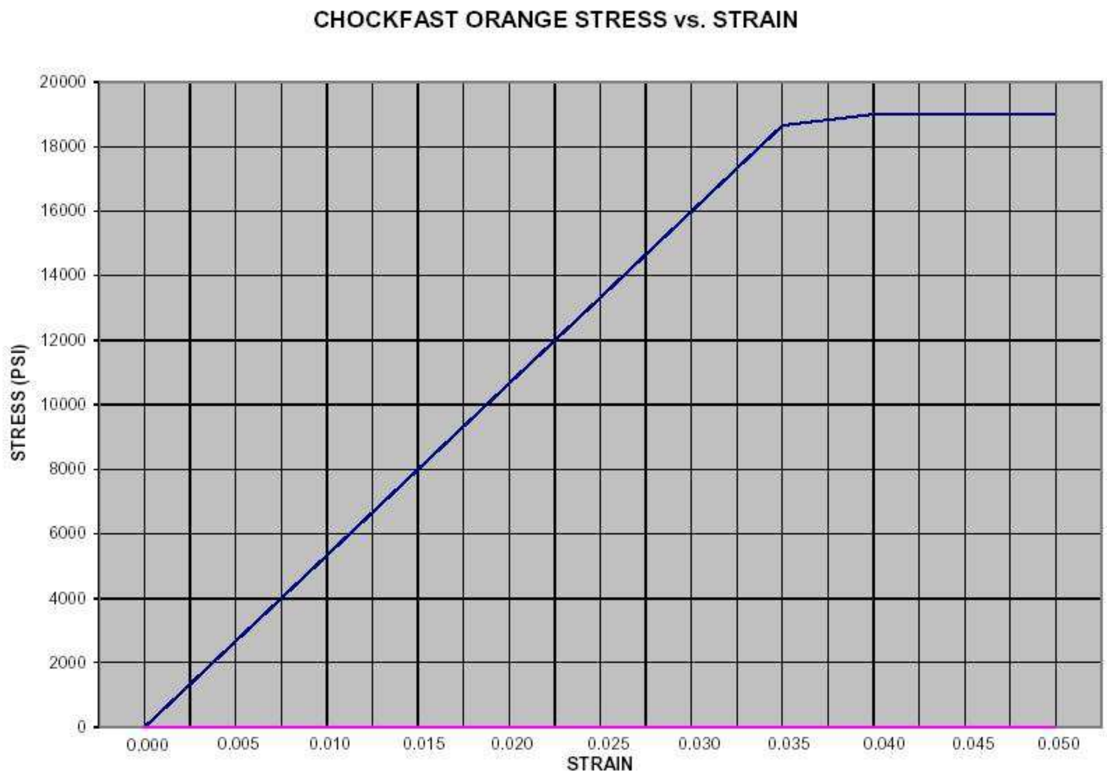
$$\text{Stress} = \frac{F}{A} = \frac{25{,}000}{288} = 86.8 \text{ psi}$$

$$\text{Strain} = \frac{\text{Stress}}{E} = \frac{86.8}{533{,}000} = 0.000163$$

Now substitute back into the original equation:

$$L = \text{Strain} \times L = 0.000163 \times 1.25 \text{ in} = \underline{0.0002 \text{ in}}$$

Stress and Strain for a particular material may be represented graphically as shown:



Linear Section - the straight-line portion of the curve is where the material still follows the formula:

Stress = E x Strain

Yield Point or Yield Stress - the portion of the curve where the linear section stops. It is at this point where the material begins to permanently deform under the load.

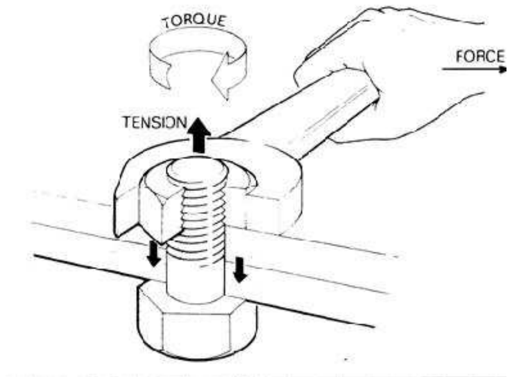
Ultimate Stress - the portion of the curve that is flat. The material has completely failed and cannot withstand additional load.

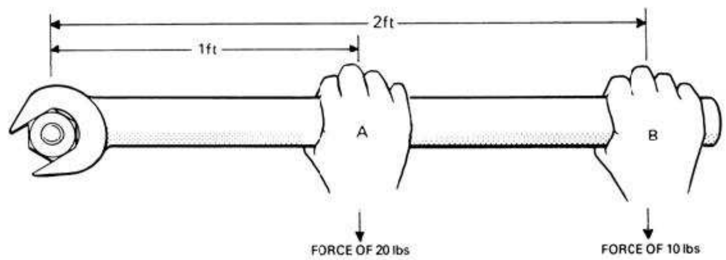
For epoxy compounds, the yield stress and ultimate stress are nearly equal. For other materials (for example: steel) the yield stress and ultimate stress can be quite different.

Typical Stress Values for Selected Materials		
Material	**Yield Stress (PSI)**	**Ultimate Stress (PSI)**
Cast Iron	40,000	60,000
Steel	40,000	70,000
Aluminum	21,000	24,000
Copper	5,000	32,000
Chockfast Orange	19,000	
Chockfast Red	15,250	
Chockfast Black	17,300	
ESCOWELD 7505E/7530	14,000	

Torque

Torque is the product of force times the distance from the axis around which it acts. Torque causes a solid to twist. The units for torque are Ft.-Lbs.





Here is one example of Torque. The most common application we encounter regarding torque is tightening bolts.

Thermal Expansion

The dimensions of most materials change with a change in temperature. If the temperature increases, the material will increase in size; and if the temperature goes down the material shrinks.

A good example is often seen in the summertime when the pavement buckles because of the heat. The change in dimension of a material due to a change in the temperature can be determined by the following formula:

L = COTE x L x T

Where:

L = Change in length
COTE = Coefficient of Thermal Expansion
L = Original length
T = Change in temperature, final – initial

The COTE is a number that can be measured experimentally. Some typical values for various materials are as follows:

Material	COTE (in/in-°F)
Cast Iron	5.9×10^{-6}
Steel	5.9×10^{-6}
Aluminum	9.4×10^{-6}
Copper	10.7×10^{-6}
Chockfast Orange	17.1×10^{-6}
Chockfast Red	11.2×10^{-6}
Chockfast Black	15.0×10^{-6}
ESCOWELD 7505E/7530	14.0×10^{-6}

Notice if the change in temperature (final temperature - initial temperature) is positive, the change in length is positive. If the change is negative (meaning the material is cooling) the length change is negative.

Example:

A **CHOCKFAST Black** chock 1-¼ inches high cools from 125 ° F down to 70 ° F. What will be the change in height?

L = COTE x L x T

For **CHOCKFAST Black**:

COTE = 15 x 10-6 in/in - ° F
L = 1.25 in.
T = 70 - 125 = -55 ° F

L = 15 x 10^{-6} x 1.25 x -55 = <u>- 0.001 in</u>.

Some Additional Engineering Concepts

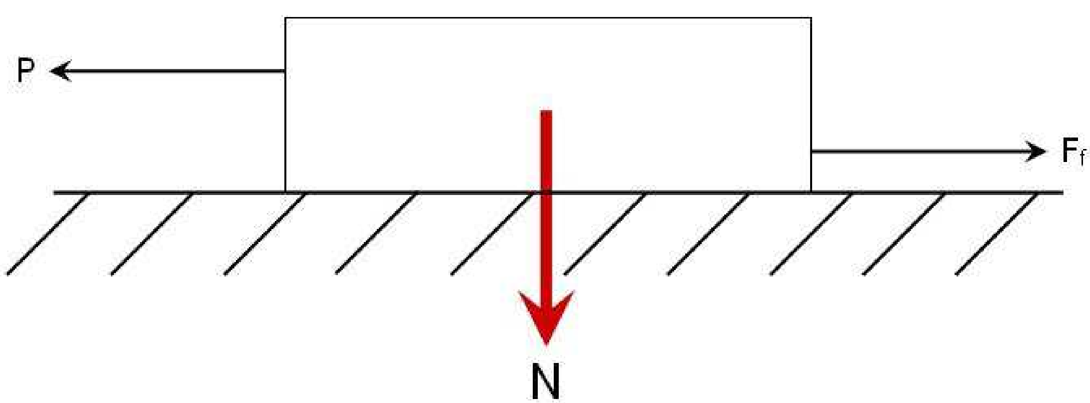
Creep - The gradual and permanent deformation of a material that is subjected to a stress less than yield stress. This phenomenon usually occurs over periods of years.

A good example is the springs in your car. We generally say they are "worn out" when the car starts to bottom out on bumps even though it is not fully loaded.

It is usually because of creep considerations that epoxies are loaded far below their yield points.

Friction - That force which opposes the motion of one material across another.

The formula for friction is: $F_f = \mu N$

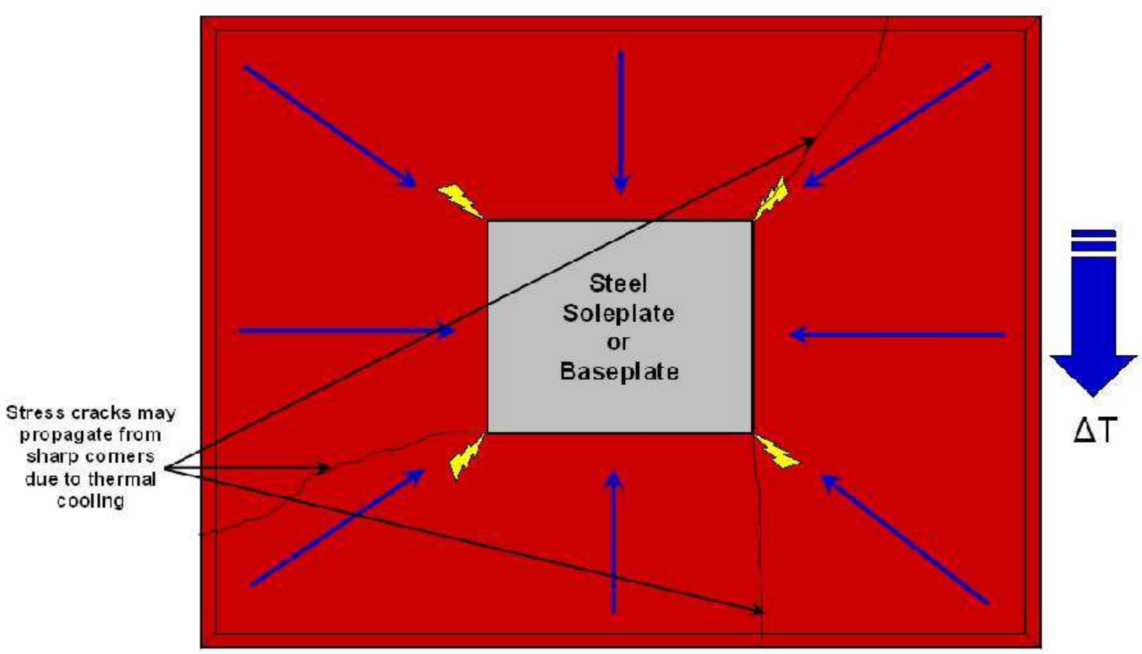


Where:

F_f = Friction Force
P = Pulling (or Pushing) Force
N = Normal Force (weight)
µ = (Mu) Coefficient of Friction

The coefficient of friction is an experimental number and is dependent upon both surfaces. The coefficient of friction of **CHOCKFAST Orange** on steel is different from the coefficient of friction of **CHOCKFAST Orange** on wood.

Stress Concentration - an irregularity in stress distribution caused by an abrupt change of form.



As the temperature cools and the epoxy contracts around corners of an embedded steel soleplate, a stress concentration occurs at each sharp corner. This could cause cracks to develop if the stress is high enough.

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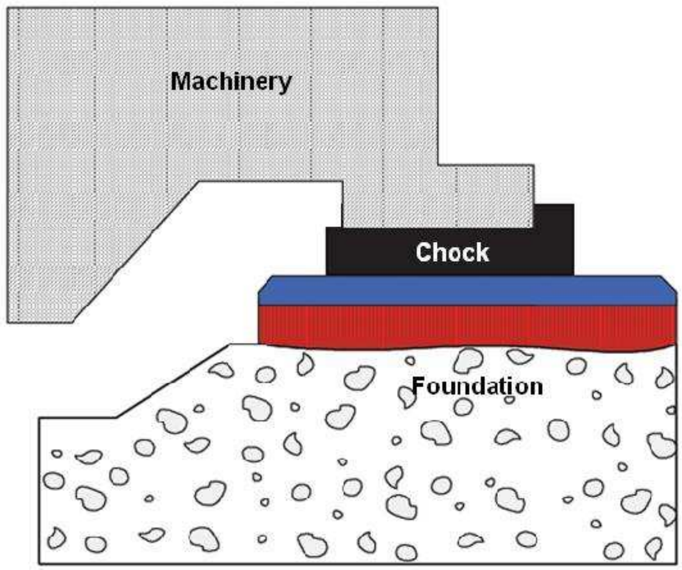
Section 4 / Applications

Chocks

In order for a piece of rotating machinery to operate correctly it needs to be properly positioned and supported on its foundation. After the machine has been aligned there is always a gap between the bottom mounting surface and the top of the foundation.

A chock is used to fill this space.



Note that the machine supporting foot is typically not completely parallel to the foundation. The chock must still fit as close as possible to both surfaces.

If the chocks were made of steel, each chock would have to be fitted by hand.

Epoxy can be poured into the gap and create nearly a 100% fit.

Products typically used for chocking:

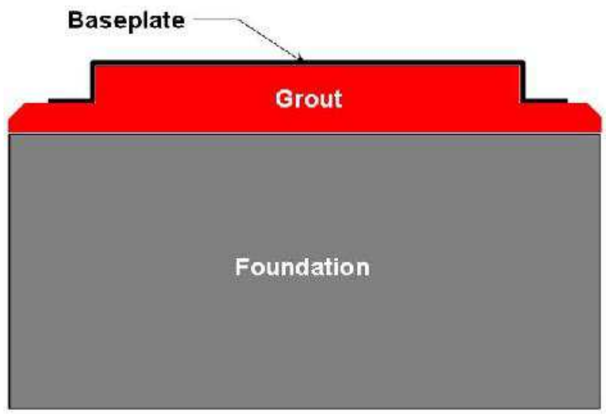
- **CHOCKFAST Orange**
- **CHOCKFAST Black**
- **CHOCKFAST Gray**

Grouts

A grout is a flowable mixture of materials used to fill void areas when installing machinery. After a given period of time the material hardens and helps the machinery retain its position.

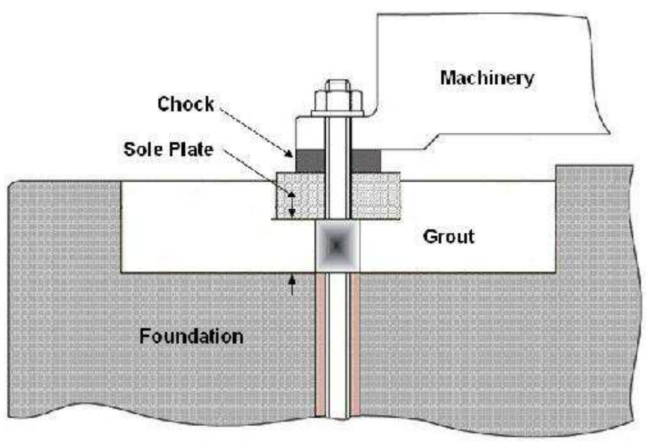
Grouts differ from chocks in the volume of material used. Where chocks are discreet units of material, grouts tend to be one large volume. Grouts are also used to fill inside machinery foundations and not just underneath.

In the case of a machinery base plate, oftentimes the complete inside is filled with grout when the equipment is installed.



The grout provides complete contact for the base plate to the foundation itself.

When machinery is installed on sole plates, the soleplates are grouted into the concrete foundation, and then the machinery is chocked to the soleplate.



In many cases the grout application can be very deep. Most grouts get too hot when they cure and therefore contract too much when they cool, causing cracks and poor bonds. The solution for these grouts is to pour in layers.

Epoxy Grout products typically used for grouting:

CHOCKFAST Red – Large volume, single pours of 2" to 18” (51 mm to 457 mm).
ESCOWELD® 7505/7530 - Large volume, single pours of 2" to 18” (51 mm to 457 mm).
CWC 604 Machine Bond - Large volume, single pours of 2" to 18” (51 mm to 457 mm).
CHOCKFAST Red HF - Large volume, single pours of 1" to 4" (25 mm to 102 mm)
CHOCKFAST Red SG – Medium to small volume; single pours of 1” to 3 “(25 mm to 76 mm)
CHOCKFAST Blue – Smaller volume pours of 1” to 1 ½” (25 mm to 38 mm).

Control Joints

Epoxy grouts develop heat during the curing process (Also refer to "Curing" under Section 6). During this time, they will typically phase from a plastic, workable material to an eventual solid material as the chemical reaction taking place enables the grout develop its structural strength & integrity. This is considered the "gel" time; and it is also the point where the maximum temperature is attained. The maximum temperature reached is dependent on a number of variables:

- Amount or mass of epoxy grout used, (l x w x d)
- Temperatures:
  - Epoxy grout components at the time of mixing
  - Ambient air
  - Adjacent surfaces that come in contact with the curing grout

All of these variables can affect the temperature and rate of cure of an epoxy grout. The higher the temperature value for one or more of these variables; the higher the maximum exothermic temperature becomes as well.

After the gel point is reached and the epoxy grout becomes a solid material, the temperature goes down. As the temperature decreases, the epoxy grout will contract. As the material cracks, increasing stresses develop and are locked into the epoxy grout until its physical limits are reached. This concludes in the form of a thermal stress crack.

The differential between initial peak exothermic temperature during installation and lower potential temperatures that may be experienced in the environment later; will influence the probability and frequency of crack development.

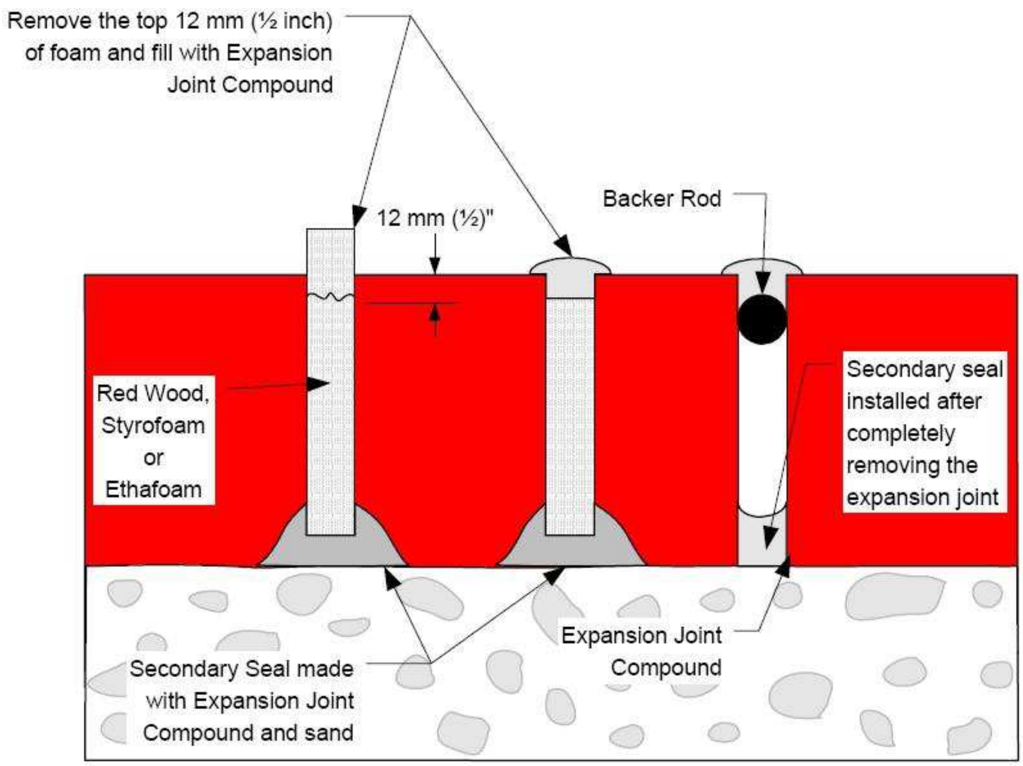
Cracks can develop as soon as the epoxy grout cools down after the initial exothermic episode. They can also occur weeks, months and even years after installation if ambient conditions in the immediate area drop far enough to continue building stresses to where the physical limits of the cured grout are overcome.

This is a known occurrence and is common in many materials that react chemically and undergo a heat-related cure. Concrete is a most common example. Thermal cracks can and will occur, but they can be anticipated and planned for through the considerate and intentional placement of prefabricated control joints (sometimes more commonly referred to as expansion joints) in the epoxy grout. Control joints can also be thought of as an "engineered crack".

Joint placement and frequency may be determined with careful consideration to the following variables:

- **Initial cure environment of the epoxy grout**
- **Equipment type and configuration**
- **Operating temperatures of the equipment and its environment.**
- **Magnitude and frequency of possible thermal changes that may occur within the operating environment.**
- **Coefficient of Thermal Expansion of the Epoxy Grout.**

Also, the thermal coefficients of epoxy grout, concrete and steel can contribute to the potential for grout cracking due to the differential in expansion and contraction rates of each. However, strategically control joints can help to reduce this possibility as well. Joints may be constructed as shown:



Products typically used for sealing control & expansion joints:

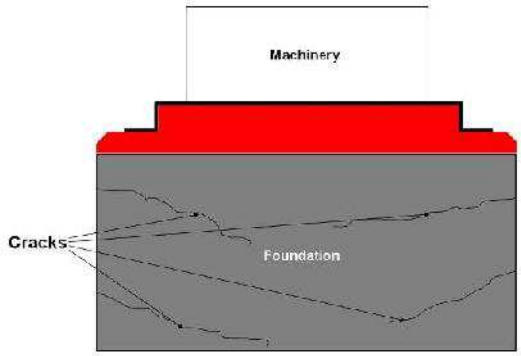
- **ITW PRC Expansion Joint Compound**

Vertical thermal cracks do not affect the structural integrity and the ability of the epoxy grout to counter imposed static and dynamic loads. The major shortcoming of a crack is it becomes a direct path for oils, water and other chemicals to reach, attack and weaken the porous concrete substrate.

Repairs

Foundation Repairs:

All concrete foundations have cracks particularly in large pours where the amount of concrete shrinkage is significant. These cracks are not serious except from an esthetic point of view. However, cracks that occur because of equipment vibration must be repaired. If not the crack will continue to grow until the foundation becomes structurally inadequate. Injecting epoxy into the cracks is a proven repair method. There are many ways to inject epoxy. Here, injection ports have been placed to be used as injection points.



Products typically used for injection repairs:

- **ITW Quickset**
- **CHOCKFAST Red - Liquids only**

Hairline Cracks:

Cracks that occur on the surface of either epoxy or steel are usually repaired in the same manner but with different materials.

In order to give the repair compound a large enough surface to adhere to, the crack is "Vee'd" out and the repair compound placed into it.

In the case of a metal casting such as a pump casing, small holes are first drilled at the ends of the crack to relieve the stress and stop the crack from moving any farther.

Products typically used for hairline surface crack repair:

Concrete and Epoxy Repairs:

- **ITW PRC Expansion Joint Compound**
- **ITW PRC Repair Compound**

Metal:

- **Phillybond #6**
- **Super Alloy Titanium Repair**

Secondary Containment

A catch basin built around a tank (or tanks) sized to contain all of the contents of the tank in the event of a leak or rupture.

The secondary containment system must be able to contain the contents for a minimum period of time of 24 hours even if the materials are corrosive.

Products typically used for secondary containment coating systems:

- **PolySpec NovoRez 351 -** High Solids Novolac Epoxy
- **PolySpecTuff Rez 200CR -** Acid Resistant Epoxy Floor Resurfacer

Fairing Materials

Fairing is a marine term that means to make smooth or streamlined. An abrupt change in shape of a surface can create turbulence as it moves through the water causing erosion.

A fairing material is basically a filling material.

Products typically used for a fairing material:

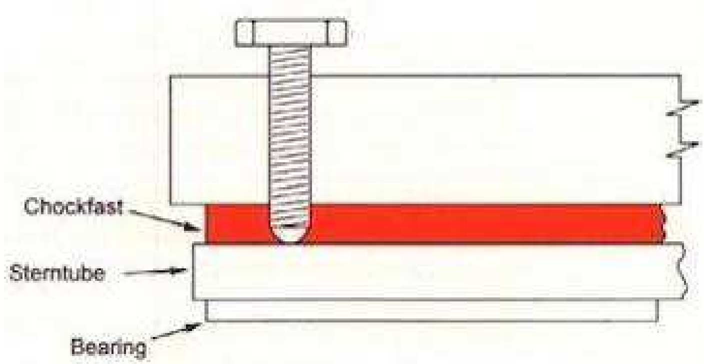
- **ITW PRC Repair Compound**

Bearings

Bearings are usually held in place by an *interference* fit – the bearing is a little bit bigger than the structure that holds it.

The problem arises when the bearing needs to be located off-center from the bore that was made for it.

The answer is to make the bore larger than necessary, position the bearing where it needs to be, and fill the gap with epoxy.



This will work for any size bearing but is particularly helpful for the large applications where it is very expensive and difficult to precisely machine the components.

Bearings, which can be done this way range in size from ½ inch to 24 feet (or more) in diameter.

Products typically used to chock bearings are:

- **CHOCKFAST Orange**
- **CHOCKFAST Black**

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Section 5 / Testing

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Section 5 / Testing

ASTM - American Society for Testing and Materials.

- The headquarters is in Conshohocken, PA.
- Organized in 1898
- Voluntary standards development organization
- Not-for-Profit
- 134 standards-writing committees, 8,500 standards, organized by discipline.
- Has no technical or testing facility. All work is done voluntarily by 33,000 ASTM members located throughout the world

Philosophy behind ASTM Testing

Some tests produce results of a practical nature that can be used as actual design criteria:

- Compressive Tests
- Tensile Tests
- Coefficient of Thermal Expansion

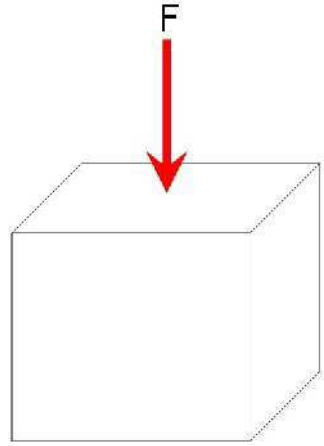
Some tests produce results of a comparative nature. The results cannot be used for actual design, but can be helpful to compare different materials to each other:

- Shrink on cure
- Gel Time
- Creep

Commonly Used Tests

Compressive Tests

These tests require a 2-inch cube for a test specimen. The cube is then loaded by a test machine (e.g. Tinius Olsen) until it breaks.



Typical ASTM test methods used:

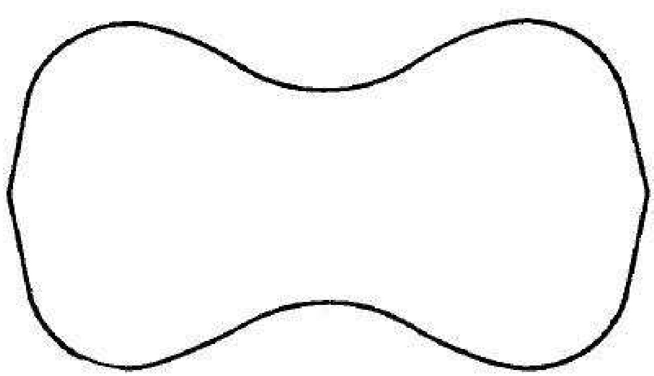
ASTM C 579 - Chemical Resistant Mortars, Grouts, Polymer Concrete
ASTM D 695 - Rigid Plastics

Tensile Tests

These tests require specimens be prepared according to specific dimensions. They are placed in a test machine and pulled until they break.

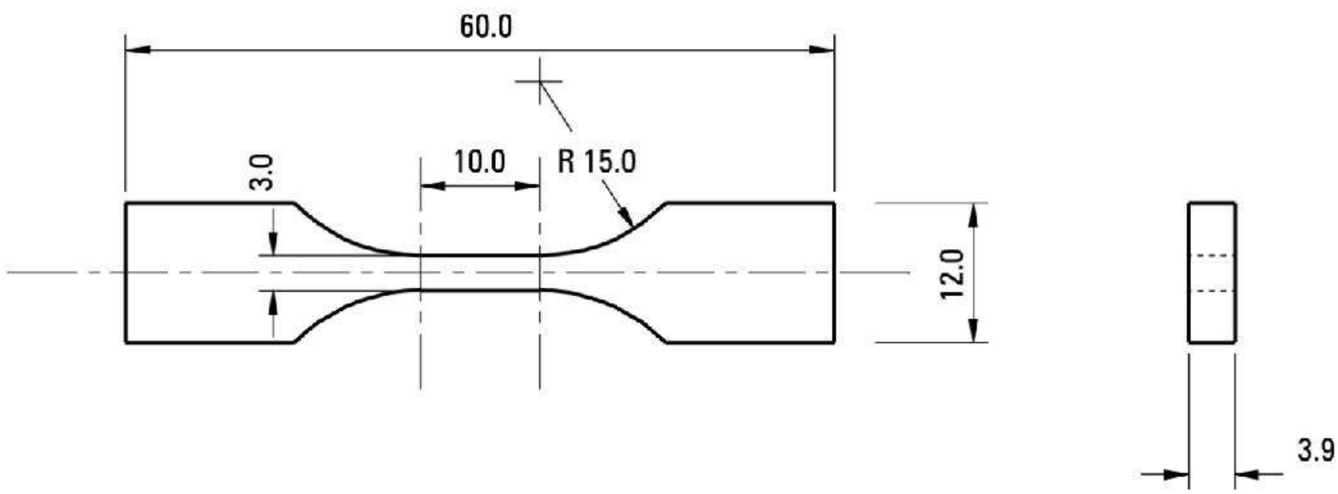
Typical ASTM test methods used:

ASTM C 307 - Chemical Resistant Mortars, Grouts, Polymer Concrete



"Dog Bone" Type Specimen

ASTM D 638 – Plastics



Rod Type Specimen

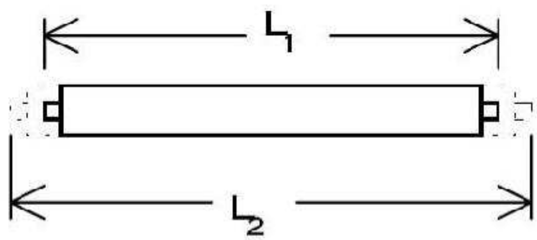
Shrinkage and Linear Coefficient of Thermal Expansion

Typical ASTM test methods used:

ASTM C 531 - Shrinkage and Linear Coefficient of Thermal Expansion

For shrinkage this test requires a test specimen be poured to an exact length. After cure, the length is measured. The difference between the lengths before and after is the shrinkage. This test is best used for comparative purposes.

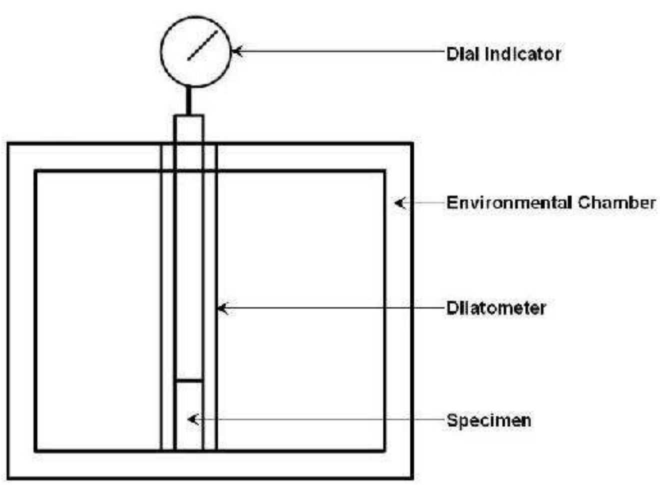
For the Coefficient of Thermal Expansion the bar is heated to a specified temperature and the length is measured. The change in length for the specified change in temperature results in the coefficient. The results from this test can be used in actual applications.



$$L_2 - L_1 = \quad L$$

ASTM D 696 - Coefficient of Linear Thermal Expansion

This test determines the change in length of a specimen due to a change in temperature without removing the specimen from the elevated temperature environment. The specimen is placed into an environmental chamber and an extension rod, called a dilatometer, is placed so it sits on top of the specimen. The dilatometer extends outside the chamber and a dial indicator shows the change in length.



Gel Time and Peak Exothermic Temperature

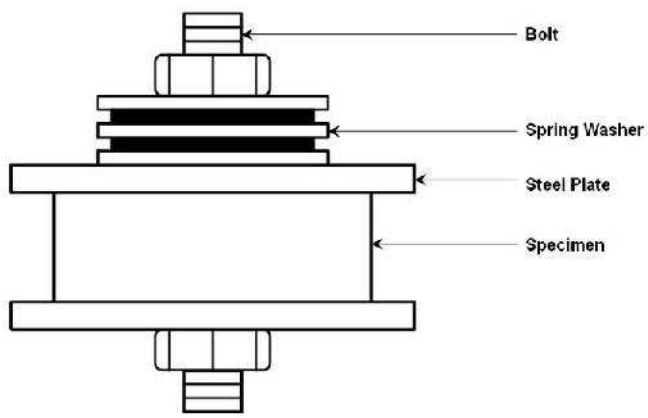
This test determines the time from initial mixing of the material components to the time when solidification commences. It also provides a means for measuring the maximum temperature reached during the reaction. This temperature is best used for comparison purposes.

Creep

Typical ASTM test methods used:

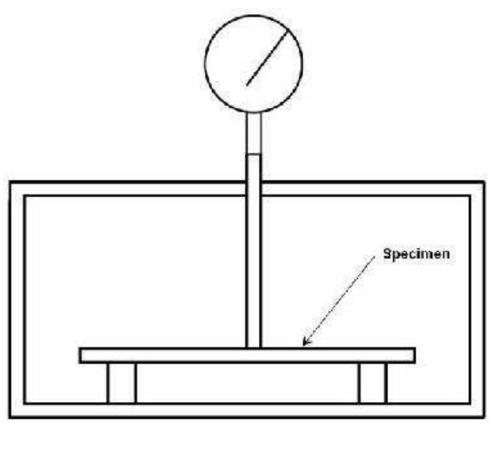
ASTM C 1181 - Compressive Creep

This test is only a comparative test which determines the creep of a material for a given stress level and temperature. A specimen in the shape of a doughnut is cast and constant load is maintained using a torqued bolt and spring washers. The change in height of the specimen is measured over a time period of 28 days.



ASTM D 648 - Deflection Temperature

This test is a means to determine the temperature at which a material begins to lose its strength properties. The size of the specimen is 5” long x ½” high x ½” wide. It is placed on supports 4” apart in a temperature-controlled bath. A load is applied to the middle of the bar as the temperature of the bath is slowly increased. The temperature of the bath when the bar has deflected 0.010” is the deflection temperature.



Curing of Test Samples

It is essential that test specimens be completely cured before performing any tests for physical properties otherwise the results will be misleading.

The problem is test specimens that have been cast in molds, normally do not develop a high enough exothermic heat needed for complete cure with a 24-hour period (or longer).

Small test specimens should always be placed in an oven and heated to 170 ° F for four hours. After complete cooling, the test may be performed.

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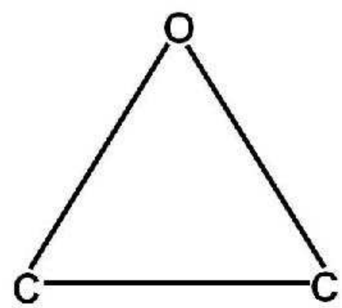
Section 6 / Epoxy Chemistry

Epoxy

Epoxy is of Greek derivation:

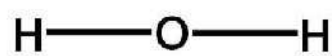
- "Epi" - on the outside of
- "Oxy" - oxygen atom in the molecular group

It is basically a description of the chemical symbol for the family of epoxies.



Atom - the smallest particle of an element
Molecule - smallest particle of a compound

For example: a water molecule is made of 2 Hydrogen atoms and one Oxygen atom



Epoxy Resin - a material containing epoxy groups

When an epoxy resin is combined with a catalyst (hardener), the epoxy groups combine with each other to form long molecular chains. This material is called a polymer.

The process is called "*Polymerization"*.

The molecular chains form in all directions. This is called "*cross-linking*".

Epoxies can have many characteristics:

- High heat resistance
- Flexibility
- Those that cure at room temperature, high heat, or even with light

Curing

The epoxy groups are like chemical springs storing energy. The hardener releases the spring causing the chain reaction that forms the long molecular chains.

The release of energy is in the form of heat. A reaction that releases heat is called "*exothermic*".

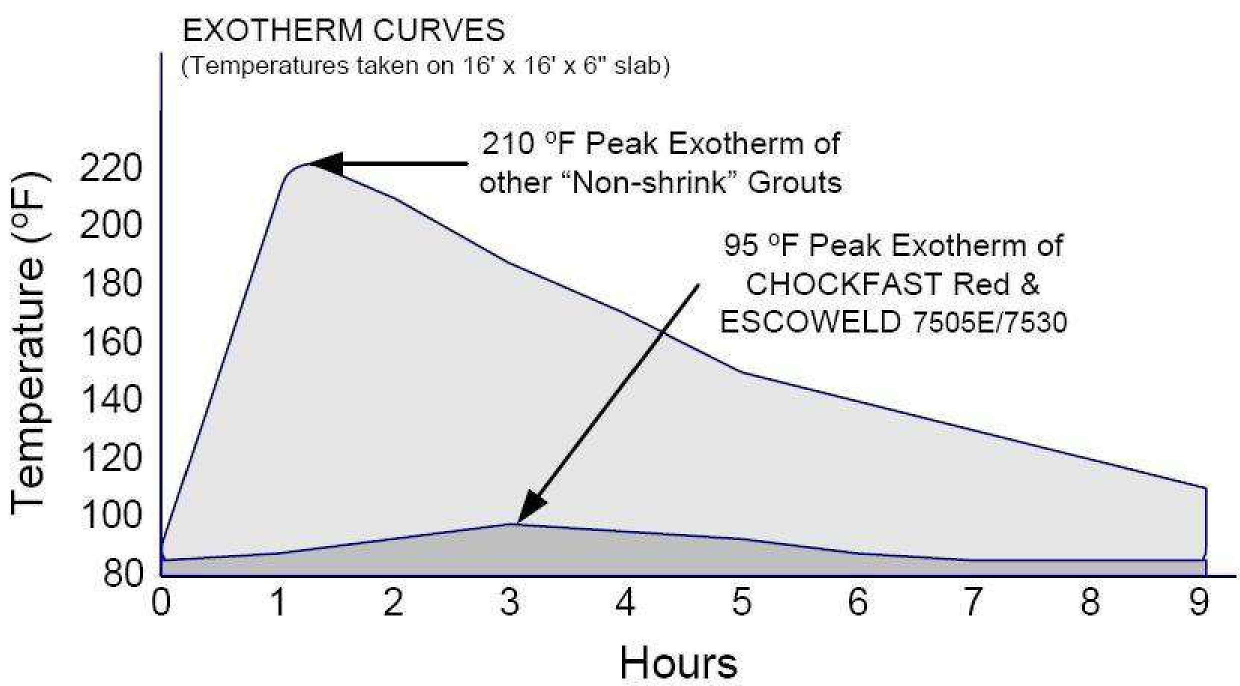
The practical amount of heat that is experienced as the temperature rises depends upon several things:

- The amount (mass) of epoxy
- The ambient (surrounding) temperature
- The ability of the surrounding surfaces to absorb the heat (heat sink)

Mass - the larger the mass of epoxy there is; the higher the maximum exothermic temperature. As the polymerization process continues and heat is released, the epoxy begins to turn from a liquid to a solid. This is the gel point. It is also the point at which the maximum temperature is reached.

After the gel point is reached, the temperature goes down. Complete curing is accomplished by ambient heat, or if it is too low, by externally applied heat.

A high exothermic cure temperature can both help and hurt an epoxy grout installation. The higher the exothermic cure temperature, the faster the epoxy grout will cure. Also, the higher the exothermic cure temperature, the more the epoxy grout will contract and shrink as it cools to ambient temperature.

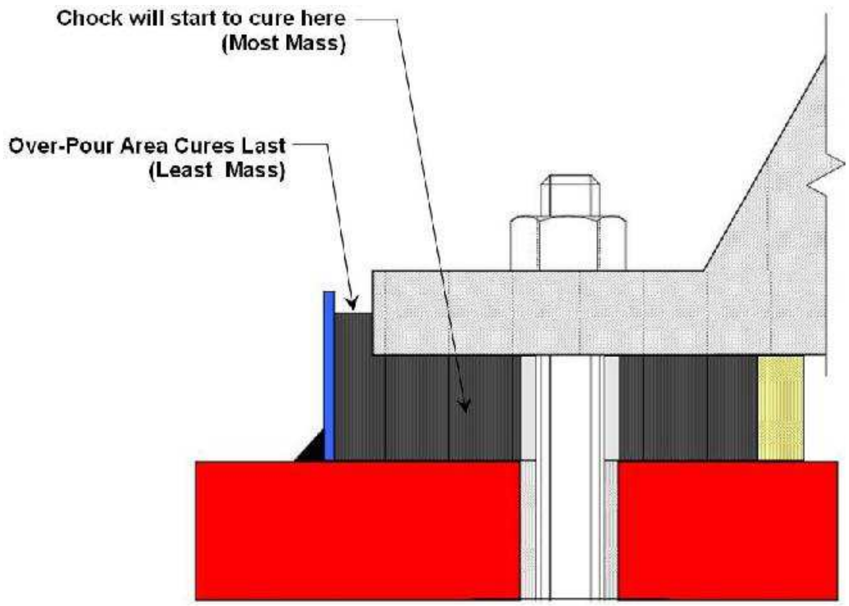


Application Techniques

Because of the nature in which epoxy cures, there are some application techniques which minimize the effects of shrinkage.

Chocking materials

Because curing is dependent upon the mass, an epoxy chock will begin curing from the center (where the mass is concentrated) out. This is why we use an "Over-pour" or liquid reservoir when pouring the chocking materials.



Because it is the last to cure, the over-pour will act as a reservoir from which the chock can pull additional epoxy.

Grouts

Some epoxy grouts (CHOCKFAST Red, for example) have very low exothermic cure temperatures and as a result, do not contract or shrink as much as the temperature returns to ambient. However, for any large volume pours that go deeper than 4 inches under critical alignment conditions; it is a good rule of thumb to perform an initial pour that fills all but the last 4 inches from the equipment base. The final 4 inches is poured when the initial pour has cooled.) This is because the deepness of pour and large volume of grout used creates increased mass. This can cause excess heat buildup even in grouts that typically exhibit lower exothermic cure temperatures.

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