Metal Buildings Institute

Certified Apprenticeship Program
Task Module
Bolting & Aligning
Rapids Code: 0877
O*Net/Soc Code 47-2221.00

Revised November 2015

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Task Module

Bolting & Aligning

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Objective

Upon completion of this task module, we will be able to:

- Size nuts & bolts properly.
- Handle & store fasteners.
- Identify high strength bolts.
- Why we now use “Turn of the Nut”.
- Align and tighten structural steel members using “Turn of the Nut” method.
- Discuss other methods of obtaining desired torque.

Bolts and nuts used in the erection of metal buildings form an integral part of the structure. They must be chosen carefully and installed in a correct,uniform manner and never be interchanged.

Hex Bolts

Hex bolts are bolts with a hexagonal head on one end and a threaded shaft on the other end. Hex bolts are tightened with a wrench and are used to connect metal parts. (The body tolerances of hex bolts are not as close as those of hex cap screws.)

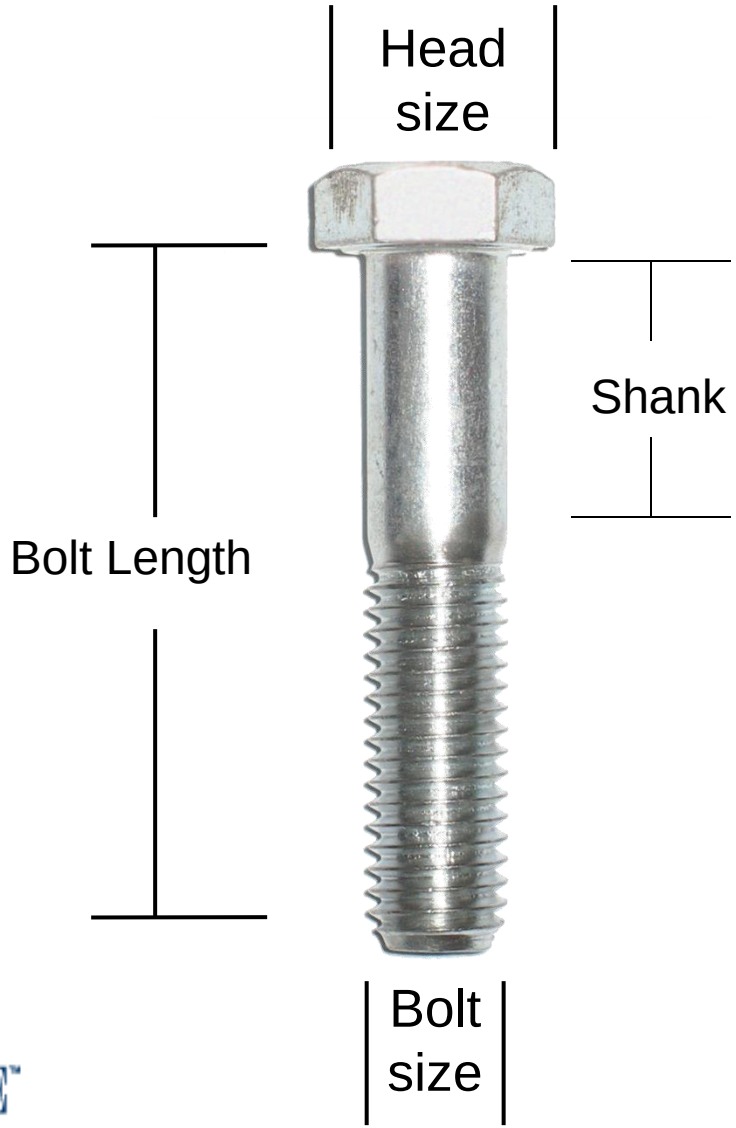
Bolt Composition

A bolt has three parts:

- The head
- The threads
- The shank

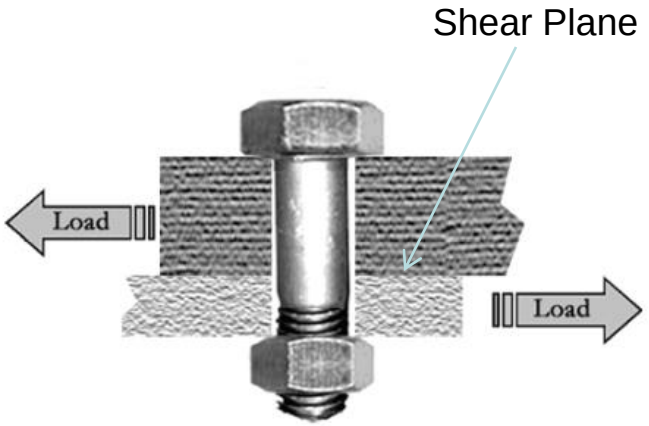
The shank of a bolt is any unthreaded part.

How to measure a bolt

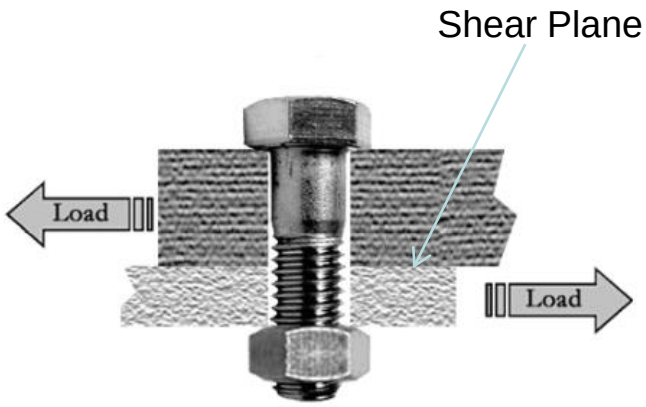


Threads in the Shear Plane

- The shear plane is the plane between two or more pieces under load where the pieces tend to move parallel from each other, but in opposite directions.
- The threads of a bolt may either be included in the shear plane or excluded from the shear plane.
- The capacity of a bolt is greater with the threads excluded from the shear plane.



Threads Excluded From The Shear Plane



Threads Included In The Shear Plane

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Thread Types

There are two types of threads you need to be familiar with

Coarse Thread and *Fine Thread*.

Of the two the coarse thread is more common.

In most cases, this can be determined visually.

Two ways coarse threads differ

- The grooves of coarse threads are cut deeper than the grooves of the fine threads.
- There are fewer coarse threads per inch.
- Because threads are cut by dies each type of thread has a given number of threads per inch.

American National Standards Institute

- ANSI has written exact standards concerning the manufacture of screw threads.
- These standards are used to specify types of bolts when they are needed for a particular application.

ANSI

ANSI standards give precise information concerning the following:

- The angle of the threads, which is called the *Pitch.*
- The depth of the grooves.
- Manufacturing tolerances, referred to as *Fit*

How to Describe a Bolt

Any bolt can be described by using the following notation, which is derived by ANSI standards.

3/4 - 20 UNC - 2a X 2 1/2

- ¾= inches in diameter.
- 20 is the number of threads per inch.
- UNC stands for Unified National Coarse.
- 2a designates the fit.
- 2 ½ = the length of the bolt in inches.

Grades & Materials

Bolts are available in all materials commonly used in the industry, such as various grades of carbon steel, galvanized steel, stainless steel, brass and nylon.

Grades & Materials

The strength of a bolt is determined by:

- The kind of material used in its composition.
- The kind of heat treatment performed during manufacture.

SAE Standards

The society of automotive engineers *(SAE)* has written standards that classify the various grades of Bolts.

SAE Standards

SAE classifications are based on the material used to make the bolt, type of heat treatment during manufacturing and the resulting *tensile strength* of the bolt.

A bolts' *tensile strength* is its ability to resist a force trying to pull it apart. The greater the *tensile strength*, the tougher the bolt.

Pre-engineered Buildings

There are three main types of bolts used in the erection of pre-engineered metal buildings.

A307 – Low carbon steel.

Only used for secondary members.

A325 – High strength medium carbon steel.

Most common bolts used in building construction.

A490 – High strength heat treated steel.

Cost more than A325's but are stronger so fewer bolts may be necessary.

Grade Markings A325

MFR Mark
Bolt Marking

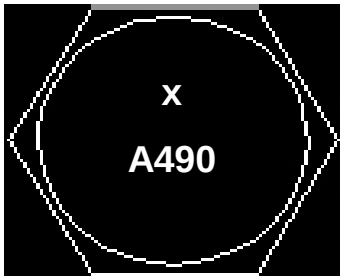
MFR Mark
Bolt Marking

TYPE # 1 These bolts are made from medium carbon steels. The three lines at 120° are optional

MFR Mark
Bolt Marking

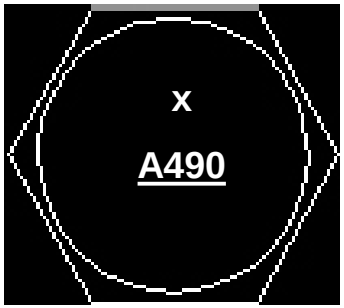
TYPE # 3 These bolts are “weathering” bolts, that is, they form a surface oxide over time and change color. These bolts are used with specially designated weathering steels.

Grade Markings A490



MFR Mark
Bolt Marking

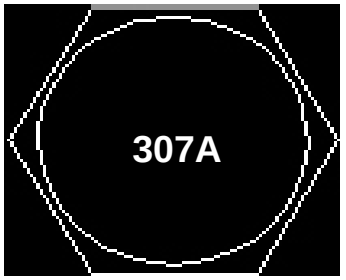
TYPE #1 These bolts are made from alloy steel. Greater clamping force is used with the A490 bolt than with the A325 bolt. A490 bolts are used in highly critical applications, such as multistory buildings. A490 bolts require hardened washers to be installed under both the nut and bolt to provide a bearing area. When A490 bolts are used with specified high-strength steels, a hardened washer must be placed under the turned area only.



MFR Mark
Bolt Marking

TYPE #3 As above but used in weathering steel applications.

Grade Markings A307

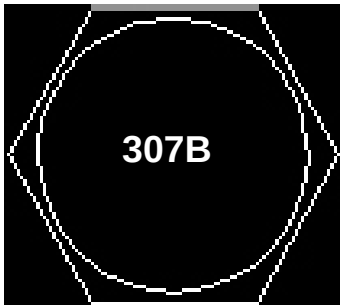


MFR Mark
Bolt Marking

A307 A typical machine bolt used in the erection of metal buildings is the A307 bolt.

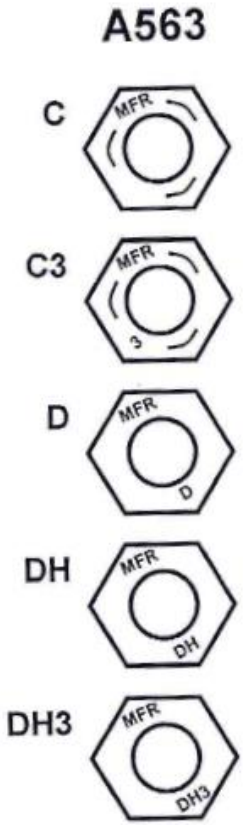
A307 bolts must have a 307A or 307B

A307 bolts are usually used to make connections in secondary framing members, such as purlins and girts. A307 bolts used for this purpose are usually 1/2” in diameter with a 3/4” head.



MFR Mark
Bolt Marking

Grade Markings



Heavy Hex Nuts

The location of the manufacturer's mark and grade identification may vary from that shown.

All nuts must have a manufacturer's mark.

A563 Grade C & C3 - 3 arcs at 120 degrees are mandatory.

A563 Grade D & DH & DH3 are marked on the nut.

Grade Markings

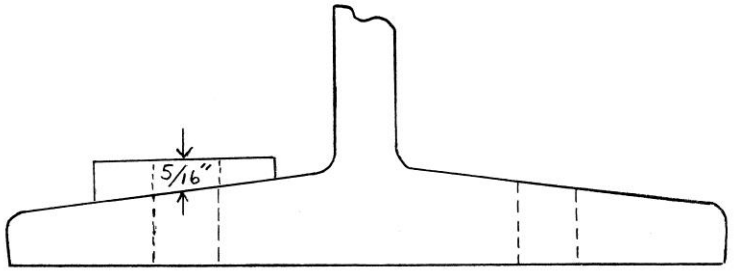
A325 & A490 heavy hex nuts may be either washer faced or double chamfered.
Only those washers used with type 3 A325 bolts need to be marked. These washers are marked with a #3 or three arcs at 120 degrees.

In some pretensioning cases, hardened F436 washers must be used. These will always have a manufacturer's mark, with an optional F436 marking.
A490 bolts may sometimes require a washer under both the head and nut.

Bevel Washers

A bevel washer provides a *square seat* for a bolt head or nut when either is put through a beam flange that has a *sloping face*.

Specifications require the use of a bevel washer when a flange has a *1 in 6 slope*. The length of a bolt must be *adjusted by 5/16”* when a bevel washer is used.



Re-Using High Strength Bolts

Black A325 bolts may be re-used once or twice if no appreciable stretch of the threads has occurred.

Galvanized bolts and A490 bolts may NEVER be re-used.

Lubrication of Uncoated Fasteners

- Uncoated fasteners should be oily to the touch prior to being installed.

- When compared to oily fasteners bolts that have lost their “lubrication” may require as much as twice the torque to install them.

- Should any bolts, nuts or washers show significant rust, dirt or other foreign material it should be cleaned off and new lubricant added.

Applying Torque

Torque is a turning or twisting force applied to a fastener. It can be measured in inch-ounces, inch-pounds or foot-pounds.

The measurement that assemblers use most often is the foot-pound.

Applying Torque

Torque specifications are an engineering consideration. They ensure the *uniform tightness* of all fasteners.

Tightness is, in many cases, an overall part of the *structural design*. An improperly tightened connection can lead to a *defective joint*.

Applying Torque

There are 5 main ways to apply torque

- Snug Tight
- Turn of Nut
- Direct Tension Indicators
- Tension Control Shear Bolt (TC Bolt)
- Calibrated Wrench

Snug Tight

The new definition of Snug Tight is the condition that exists when all of the plies in a connection have been pulled into firm contact by the bolts in the joint and all the bolts in the joint have been tightened sufficiently to prevent the removal of the nuts without the use of a wrench.

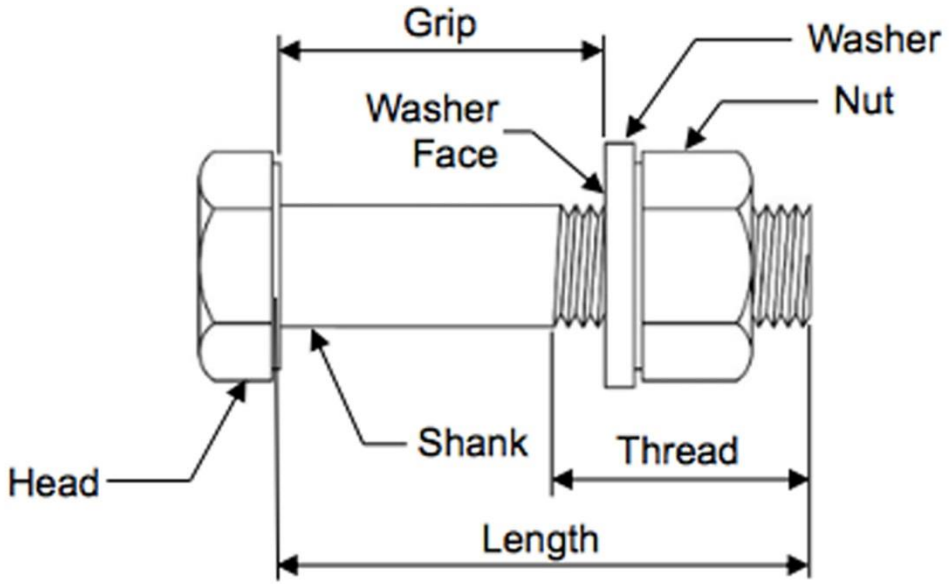
Turn-of-Nut

- The turn-of-nut method is a common procedure used to tighten high strength bolts in the field.

- With this method, each nut is turned with a wrench a specified fraction of a turn after the nut has been brought to the snug position.

- It is important to remember that the stationary element (usually the head) is to be held during tightening.

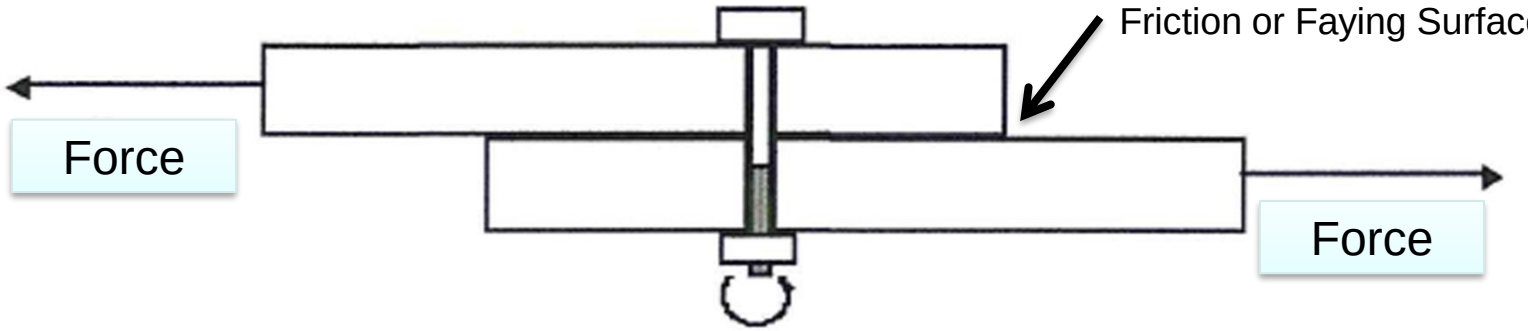
Parts of the Bolt Assembly



- Grip is the distance from behind the bolt head to the back of the nut or washer.
- It is the sum of the thickness of all the parts being joined exclusive of washers.
- Thread length is the threaded portion of the bolt.
- Bolt length is the distance from behind the bolt head to the end of the bolt.

Slip Critical Bolted Connections

- High strength (A325 & 490) bolts can be installed with such a degree of tightness that they are subject to large tensile forces.
- These large tensile forces in the bolt clamp the connected plates together. The shear force applied to such a tightened connection will be resisted by friction as shown below.



Turn-of-Nut Requirements

- If the bolt length is up to and including 4 bolt diameters, tighten the nut 1/3 turn.
- If the bolt length is over 4 diameters, but does not exceed 8 diameters, tighten the nut 1/2 turn.
- If the bolt length is over 8 diameters, but does not exceed 12 diameters, tighten the nut 2/3 turn.

Match Marking

Following the initial snug tightening, the bolts have to be match marked to show that the right amount of rotation was applied.

Snug Tight

Snug Tight
&
Match Marked

1/3 Turn Applied

ASTM Standard Tolerances for Turn-of-Nut

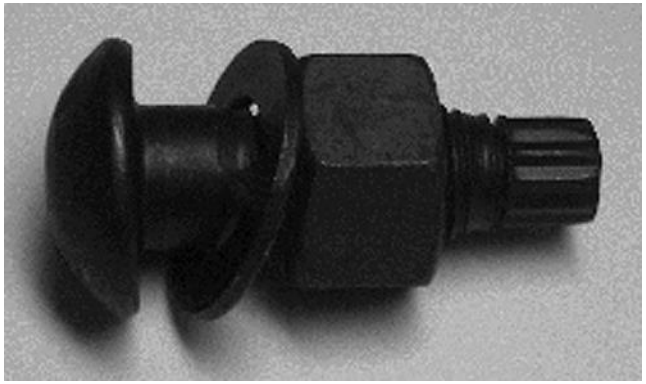
- American Society for Testing and Materials Tolerance for Turn-of-Nut
- 30° for elements installed by ½ turn or less
- 45 ° for elements installed by 2/3 turn and more

Direct Tension Indicators

- Another way to try to ensure proper pretensioning of a bolt is through the use of Direct Tension Indicators (DTI's).
- These washers have protrusions that must bear against the unturned element.
- As the bolt is tightened the clamping force flattens the protrusions and reduces the gap.
- The gap is measured with a feeler gage.
- When the gap reaches the specified size the bolt is properly pretensioned.
- Load indicator washers with a visible dye that squirts out when the washer has sufficiently flattened is another type of DTI.

Torque Control Bolts

High Strength Positive Tension Shear Bolts have their own built in torque control device and are installed without the use of torque-controlled tools. The torque requirements of the bolts are achieved by engaging the bolt and nut with inner and outer sockets and driving with the electric shear wrench until the control groove shears off the spline.



Calibrated Wrench

Another method used to tighten high strength bolts employs a *calibrated wrench* to tighten bolts to a given torque.

Electric Impact

Pneumatic Impact

Dial Torque

Click Torque

Special Requirements

- Calibrated wrenches must be set to provide a tension at least *5-10%* in *excess* of the minimum bolt tension required.
- The wrenches *must* be calibrated at least *once each working day* for *each* bolt diameter being installed.
- All Calibrated wrenches must be tested using a “Bolt Tension Calibration” device.
- Since all erectors do not have access to these devices it is not always possible or economical to employ the calibrated wrench method of fastener tightening.

Hole Making & Enlarging

- There is specific nominal hole sizes for the various bolt diameters. A tolerance of 1/32” larger than the stated nominal hole diameter is permitted to allow for hole deformation & reaming.

- If reaming beyond the specific hole size is necessary than the Engineer of record must be contacted.

- Torch cutting holes should not be done without Engineers permission.

Hole Making & Enlarging

Table H-1. Nominal Hole Size (inches)

Hole Type	Bolt Diameter				
	1/2	5/8	3/4	7/8	1
STD standard	9/16	11/16	13/16	15/16	1-1/16
OVS oversized	5/8	13/16	15/16	1-1/16	1-1/4
SSL short slot	9/16 x 11/16	11/16 x 7/8	13/16 x 1	15/16 x 1-1/8	1-1/16 x 1-5/16
LSL long slot	9/16 x 1-1/4	11/16 x 1-9/16	13/16 x 1-7/8	15/16 x 2-3/16	1-1/16 x 2-1/2

Hole Type	Bolt Diameter			
	1-1/8	1-1/4	1-3/8	1-1/2
STD standard	1-3/16	1-5/16	1-7/16	1-9/16
OVS oversized	1-7/16	1-9/16	1-11/16	1-13/16
SSL short slot	1-3/16 x 1-1/2	1-5/16 x 1-5/8	1-7/16 x 1-3/4	1-9/16 x 1-7/8
LSL long slot	1-3/16 x 2-13/16	1-5/16 x 3-1/8	1-7/16 x 3-7/16	1-9/16 x 3-3/4

Bolt Stick-out

- Stick-out is the amount of thread sticking out beyond the face of the nut after tightening
- The specification required is that the end of the bolt be at least flush with the face of the nut.
- It is not permitted for the bolt end to be below the face of the nut after tightening.
- There is no maximum stick-out by specification …. BUT excessive stick-out indicates a risk that the nut has actually met the thread runout.

Connection Procedure

- The connection is made in the field by rigging the member in place, aligning it with spud wrenches or connecting bars, and driving a number of barrel drift pins into the holes.
- Then, a number of bolts are placed into the connection to hold it in place.

Connection Procedure

- Fill the holes that do not contain drift pins with bolts. Be sure to use washers, if required.
- With an impact wrench, snug the bolts. A spud wrench should be held on the element not being turned. Snug is the point at which an impact wrench just begins to impact. If, for some reason, an impact wrench is not being used, then snug is tightened sufficiently to prevent the removal of the nuts without the use of a wrench.
- When the bolts are all snug, all surfaces of the connection should be in full contact. Knock out the drift pins with a hammer and replace them with bolts.
- Snug these bolts.

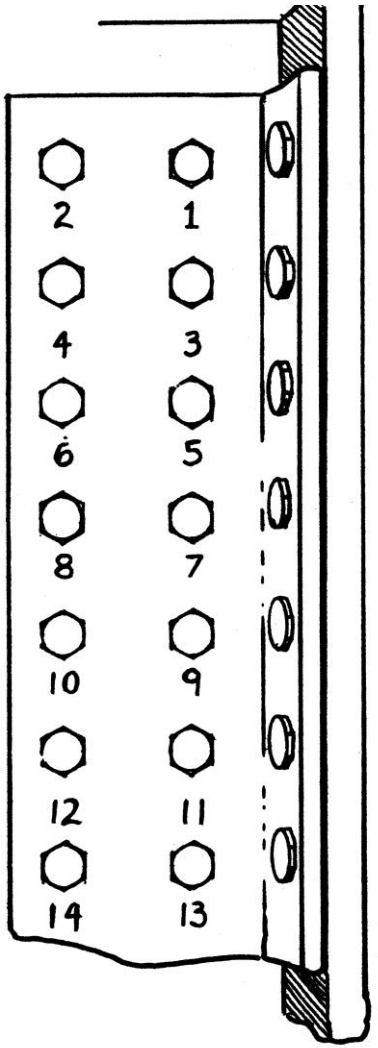
Tightening Sequence

The connection is now ready for final tightening in order for the connection to develop its full strength. There is a proper sequence to follow:

Tighten bolts and nuts progressively *away* from *ridged* points to *free edges.*

Tightening Sequence

The diagram shows a suggested sequence for tightening bolts in a connection.



Jobsite Storage

- Fastener components must be protected from dirt & moisture in closed containers.
- Only the number of fasteners required to be installed and tightened during a work shift should be removed from storage.
- Unused fasteners should be returned to protected storage at the end of a shift.
- Lubricant should never be removed.

Questions / Answers
Discussion