Powder Actuated Fastening

INTRODUCTION

Powder actuated fastening systems provide a cost effective method of attaching fixtures for light duty, static load conditions. Powers' systems consist of specially designed fasteners, installation tools, and powder loads which are designed to function in combination to provide optimum performance. Historically, this method of fastening was developed commercially during the second World War for repairing damage to ships. The original application was the fastening of steel plates together using a direct acting tool system. After WWII, use of powder actuated fastening systems in the construction industry developed rapidly because of the significant speed of installation which resulted in considerable cost savings.

These systems provide the contractor with the ability to fasten into concrete, masonry, and structural steel without pre-drilling holes. For most applications, this eliminates time consuming layout or hole spotting resulting in faster installation and reduced costs. In addition, powder actuated fastening systems are completely portable and are ideal for locations that are difficult to access. Today, powder actuated fastening technology has become the standard method of attachment for many applications in the construction industry. Powers offers a complete line of high quality, low velocity powder actuated tools, fasteners, assemblies, and accessories.

SECTION CONTENTS Page No.

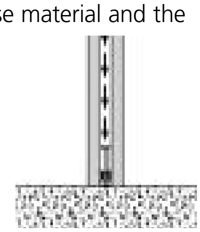
GENERAL FUNCTIONING PRINCIPLES

Operating Principle

Powder actuated systems, often described as forced entry systems, require special installation tools which are critical components of a successful fastening. Two types of tools have been used in the market which operate on different driving principles, direct acting and indirect acting. The basic design of the tools are similar in that each has a breech which holds the powder load and a barrel or guide mechanism to hold the fastener. However, the installation and safety characteristics of the tools are very different.

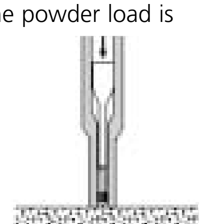
Direct Acting Principle

As the powder load is ignited in a direct acting tool, the expanding gases of the load act directly on the fastener to drive it down the barrel of the tool and into the base material. In a tool of this type, 100% of the energy developed by the powder load is transferred to the fastener. Penetration of the fastener into the base material is controlled primarily by the density of the base material and the load level selected. While the direct acting principle may allow fastenings to be made in very dense concrete and thick steel base materials, safety concerns have made the indirect principle the technology of choice. Powder actuated tools using this principle are no longer commercially available.



Indirect Acting Principle

In a tool which operates using the indirect acting principle, the expanding gases of the ignited powder load act directly on a captive piston which is housed within the barrel of the tool. The piston drives the fastener into the base material providing better control over the penetration of the fastener. In a tool of this type, most of the energy developed by the powder load is retained by the piston. Penetration of the fastener into the base material is controlled by the design of the piston, the load level selected, and the density of the base material. All Powers' powder actuated tools operate using the indirect acting principle and are classified as low velocity tools.



Tool Classification

Powder actuated tools can be classified as low, medium, or high velocity. This classification system can apply to either direct or indirect acting tools and is based on a ballistic test. Using the strongest powder load and the lightest fastener commercially available from the manufacturer for a specific tool, the velocity of the tool is determined by measuring the average velocity of the fastener for ten individual tests. The velocity classifications based on ANSI A10.3 are as follows:

1. **Low Velocity Tool**
   A tool in which the average test velocity does not exceed 328 feet per second (100 meters per second).

2. **Medium Velocity Tool**
   A tool in which the average test velocity exceeds 328 feet per second (100 meters per second) but is less than 492 feet per second (150 meters per second). Medium velocity tools are no longer commercially available.

3. **High Velocity Tool**
   A tool in which the average test velocity exceeds 492 feet per second (150 meters per second). High velocity tools are no longer commercially available.

Tool Safety

Powder actuated fasteners should be installed by properly trained and licensed operators as described in ANSI Standard A 10.3. Authorized Powers distributors offer complete training programs for end users. Contact your local Powers branch office or distributor for complete details. While the powder actuated tools are summarized in this section of the manual, only trained and licensed operators are allowed to use the tools. These summaries are for general information only.

POWDER LOADS

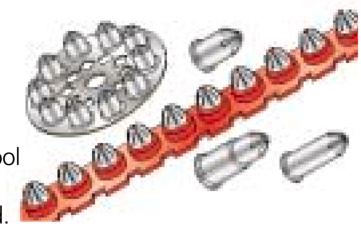
The energy source used to drive a powder actuated fastener into the base material is a self contained unit called a powder load. Specific load types are designed for each unique powder actuated tool. Powers tools use cased powder loads in which the propellant is housed in a crimped metal case.

Powder Load Identification

In the commercial market, cased powder loads are available in sizes ranging from .22 to .27 calibers. The power level or strength of a cased powder load is identified using a 12 level system in which a combination of six color codes and two case types are used. Power level 1/gray is the lowest with power level 12/purple being the highest. Only six color codes are used because there are not twelve easily distinguished colors available. The following table shows this identification system.

Power Level	Color Identification	
	Case Color	Load Color
1	Brass	Gray
2	Brass	Brown
3	Brass	Green
4	Brass	Yellow
5	Brass	Red
6	Brass	Purple
7	Nickel	Gray
8	Nickel	Brown
9	Nickel	Green
10	Nickel	Yellow
11	Nickel	Red
12	Nickel	Purple

Powder loads are available as single units for single shot tools and collated in groups of 10 into plastic strips or metal discs for semi-automatic tools. Powers tools use .22 caliber A, .25 caliber, and .27 caliber crimped, rim fire powder loads having power levels ranging from 1-6. Powder loads for other commercially available tools are also available such as .22 caliber Ladd and .27 caliber long. Consult the individual tool instructions for details on the caliber, range, and type of load.



The crimped tip on the load retains the powder in the casing. Wadded loads which have a plug in the front of the casing should never be used in tools designed for use with crimped loads such as low velocity, piston tools. The wadding material can cause the tool to clog or jam. Rim fire refers to the method of actuation. In a rim fire powder load, the primer is contained in the rim of the casing. When the tool is fired, the firing pin strikes the rim causing the primer to ignite which in turn ignites the powder contained in the main portion of the load. The power level of Powers powder loads is marked on each box. As the number increases, the power level also increases. Power level is also indicated by the color of the box, label, and the color on each individual powder load.

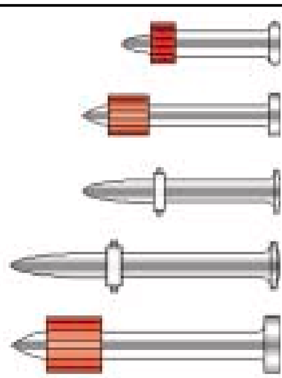
Powder Load Selection

Use of the proper power level is critical to the success of a powder actuated fastening. Prior to selecting the proper power level, conduct a center punch test as described in the upcoming section on base material suitability. To select the proper power level to be used with a specific fastener, always make a test firing using the lowest power level recommended for the tool being used. On tools which have a variable power control, use the lowest possible setting. If the lowest power level does not fully drive the fastener, try a powder load having the next higher power level. Continue this procedure until the proper fastener penetration is obtained.

FASTENER TYPES

Several fastener types are available including drive pins and threaded studs along with application-specific assemblies. According to ANSI A 10.3, only those types of fasteners and powder loads as recommended by the tool manufacturer for a particular tool, or those providing the same level of safety and performance, shall be used.

Typical Drive Pins



.300" Head Ballistic Point

.300" Head

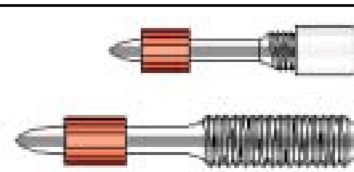
8mm Head

10mm Head

3/8" Head

Drive pins are one of the most commonly specified type of powder actuated fastener. They are used to fasten a fixture directly to the base material in one operation for permanent applications. Pins are available in several head configurations. Each of the head configurations has a corresponding shank diameter and a variety of lengths. Some drive pins designed for use in steel have a knurled shank to provide increase load capacities. Other drive pins have a narrow shank diameter close to its point and a wider shank diameter comprising the upper portion. This design is known as “step shank” and is used to penetrate denser base materials more consistently.

Threaded Studs



1/4"-20

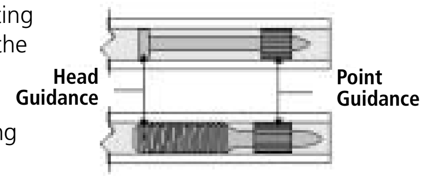
3/8"-16

For applications where adjustment or removability may be required, threaded studs are available with both a 1/4" or 3/8" thread diameter. Each thread size has a corresponding shank diameter and is available in a variety of shank and thread lengths.

FASTENER GUIDANCE AND MATERIAL SPECIFICATIONS

Fastener Guidance

Both types of fastener have pre-mounted plastic fluting or washers which hold the fastener centered in the tool guide prior to driving. During the driving process, the fluting or washers provide point guidance for the fastener. Generally, head guidance is provided by the diameter of the fastener head or threads. 1/4"-20 threaded studs also have a plastic cap to protect the threads of the fastener during the driving process providing head guidance.



Fastener Material Specifications

Mechanical Properties

Powder actuated fasteners are subjected to extremely high stresses as they are driven into the base material. A key aspect of their design is to manufacture them from a material that is tough enough to prevent deformation of the fastener during the driving process with ductility to prevent shattering. Powers fasteners are specially manufactured using a proprietary process to meet these requirements. The fasteners are manufactured from modified AISI 1062 steel and austempered to a core hardness of RC 53 to 55. To ensure ductility, samples of all fasteners are bend tested during Quality Control inspections to 60 degrees. Powder actuated fasteners have the following minimum mechanical properties:

Typical Tensile Strength – 282,000 psi
Typical Shear Strength – 162,000 psi

Corrosion Resistance

Powder actuated fasteners are designed to be used in a non-corrosive atmosphere unless application specific corrosion testing has been performed. To reduce the possibility of the embrittlement of a heat treated part, the standard finish for all Powers fasteners is mechanically applied zinc meeting the requirements of ASTM B 695, Class 5, Type 1 providing an average minimum thickness of 5 microns (0.0002") with no supplementary coating.

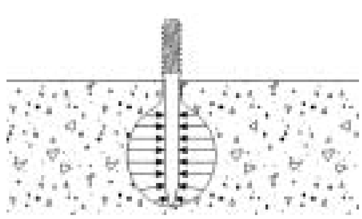
FUNCTIONING OF POWDER ACTUATED FASTENERS

Functioning in Concrete

The load capacity of a powder actuated fastener when installed into concrete or masonry base materials is based on the following factors:

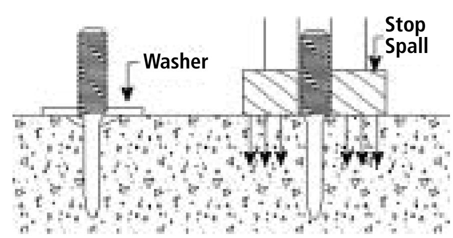
1. Strength of the base material
2. Hardness and concentration of the aggregate
3. Shank diameter of the fastener
4. Depth of embedment into the base material
5. Fastener spacing and edge distance

In addition to these factors, installation tool accessories such as a stop spall which reduces the tendency of the concrete surface to spall during the driving action can increase the performance of the fastener.



When a powder actuated fastener is driven into concrete, it displaces the volume of concrete around the embedded area of the fastener shank. As this occurs, the concrete directly surrounding the fastener is compressed and in turn presses back against the shank of the fastener. Additionally, the driving action generates heat which causes particles within the concrete to fuse to the shank of the fastener. This combination of compression and fusion holds the fastener in the concrete base material. A similar action occurs when fastening into block masonry.

Generally, the performance of the fastener in a given concrete strength will increase with greater embedment depths in a certain range. Depending on the fastener style and base material strength, embedment depths range from 5/8" to 1-1/2". For depths greater than this range, there is the possibility of fastener bending or "fishhooking" which may decrease expected load capacities. For typical embedment depths achieved, refer to the upcoming section on load capacities.

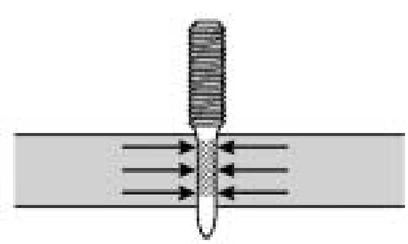


During the driving action, some localized surface spalling of the concrete may occur. Normally, this is a surface effect which does not affect the performance of the fastener. However, it may pose an aesthetic problem for exposed applications where a fixture is not used. In cases such as this, two methods can be used to improve the appearance of the fastening. A stop spall adapter mounted on the powder actuated tool can help to reduce surface spalling. Another method used is to drive the fastener through a steel washer to improve the appearance of the application.

Functioning in Steel

The load capacity of a powder actuated fastener when installed into steel base materials is based on the following factors:

1. Thickness of the steel
2. Tensile strength of the steel
3. Shank diameter of the fastener
4. Depth of point penetration through the steel
5. Fastener spacing and edge distance.



POWDER ACTUATED

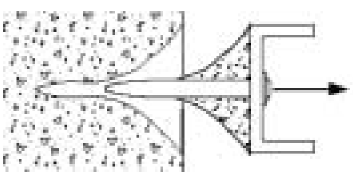
Functioning in Steel (Continued)

When a powder actuated fastener is driven into steel, it displaces the steel laterally 360 degrees around the shank of the fastener. Since steel is an elastic material, it presses back against the shank of the fastener to hold it in place. As the diameter of the fastener shank is increased, the load capacity obtained will generally increase provided the steel thickness is sufficient to accept the fastener. To further increase fastener performance in steel, some fasteners have a knurled shank which allows the steel to form a key lock into the grooves to provide higher capacities than those obtained with a smooth shank. For typical performance, the fastener point should completely penetrate the steel. Normally, a minimum of 1/4" is allowed for the point length. An increase in performance can be expected until the fastener no longer completely penetrates through the steel. At this point, the elastic properties of the steel can cause a compression force to be developed at an angle against the fastener point which reduces load capacity. In thicker steel base materials, adequate load capacities may be obtained for applications in which the point of the fastener does not fully penetrate the steel. Job site performance tests are recommended.

Fasteners should not be used in areas that have been welded or cut with a torch as these procedures may have caused local hardening of the steel. Over driving of the fastener should be avoided as the rebound created may reduce the load capacity or cause damage to both the fastener and the tool. When fastening into unsupported long steel members, it may be necessary to provide support in the area of the fastening to prevent spring action which can cause inconsistent penetration and a reduction in load capacity.

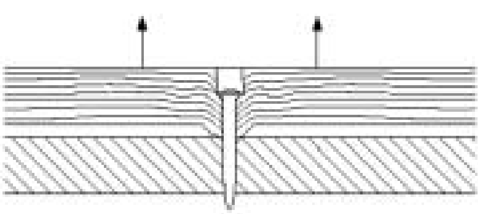
FASTENER BEHAVIOR

An understanding of the performance characteristics of a powder actuated fastener is an important aspect of the selection process. At ultimate failure, the following modes of failure can be expected.



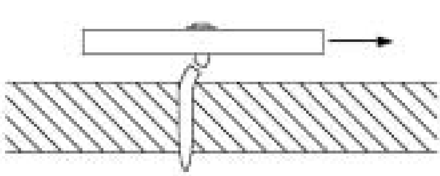
Base Material Failure Fastener Pullout

The fastener pulls out of the base material when subjected to a tension load. In concrete, a typical cone type failure can be expected while in steel the fastener pulls out cleanly.



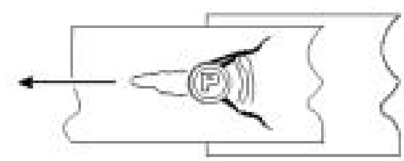
Pullover Failure

The fixture or material fastened pulls over the head of the fastener. This is a common occurrence when fastening lumber or thin metal materials. To help improve pullover resistance for applications such as this, Powers powder actuated fasteners are available with pre-mounted steel washers.



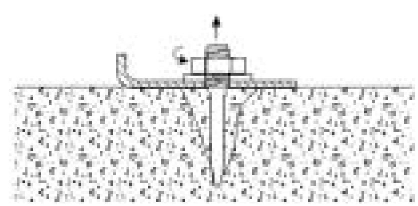
Shank Failure

The shank of the fastener is broken due to an applied lateral load such as shear. This can also happen when a bending load is created.



Bearing Failure

The fixture or material fastened tears as a lateral load is applied and is pulled over the head of the fastener.



Tightening Failure

On threaded studs, the tightening torque applied must be limited to prevent over tightening of the connection. This will prevent the development of a clamping force greater than the tension or pullout load resistance of the fastener.

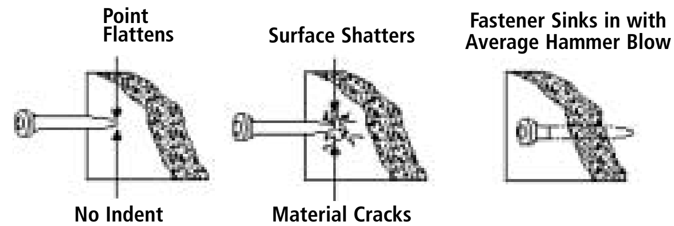
POWDER ACTUATED

BASE MATERIAL SUITABILITY

While powder actuated fasteners can be used successfully in concrete, certain masonry materials, A 36 and A572 steel, some materials are completely unsuitable. Fasteners should never be fired into hard or brittle materials such as cast iron, tile, glass, or rock. These materials can shatter easily resulting in a potential safety hazard. In addition, soft base materials such as wallboard, plaster, or wood are not appropriate as the fastener could pass completely through these materials. The user should never guess when fastening into any base material.

A Center Punch Test should always be performed to determine the suitability of the base material for a powder actuated fastening. This test is relatively simple and can help to ensure a safe, successful fastening. Be sure to wear the appropriate eye protection when performing this test. To begin, select the fastener to be used for the job. Then place the point of the fastener against the proposed base material. Strike the fastener with a single hammer blow and then examine the point. If the point of the fastener is not blunted and the base material has a clear point indentation, it is acceptable to proceed with the first test installation.

Use of a powder actuated system is not recommended if the following occurs during the Center Punch Test:

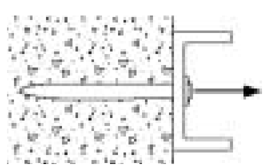


1. The fastener point has been blunted. This indicates that the base material is too hard.
2. The base material cracks or shatters. This indicates that the base material is too brittle.
3. When using an average hammer blow, the fastener penetrates the base material easily. This indicates that the base material is too soft.

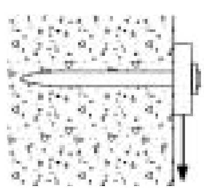
APPLIED LOADS

The type of load and the manner in which it is applied by the fixture or other attachment is a primary consideration in the selection of a powder actuated fastener. Powder actuated fastening systems provide a cost effective method of attaching fixtures for light duty, static load conditions. The load capacities for powder actuated fasteners published in this manual represent the results of laboratory testing conducted according to ASTM Standards E 488 and E 1190. As always, the suitability of a fastener for a specific application should be determined by a qualified design professional responsible for the product installation.

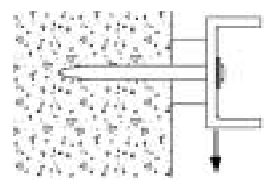
Tension Load
A tension load is applied directly in line with the axis of the fastener.



Shear Load
A shear load is applied perpendicular to the fastener directly along the surface of the base material.



Bending Loads
For fixtures 5/8" or greater, the effect of bending resulting from the application of static shear load should be considered. This can occur in softer material such as lumber used for sill plates or when shims or spacers are placed between the fixture and the base material. In situations such as this, the load is applied at a distance from the surface of the base material creating a lever type action on the fastener. When a bending load is applied to a fastener, it is often the physical strength of the fastener material, not the tension or shear load capacities, that limit the strength of the connection. For sill plate applications, Powers publishes test data based on the use of 2x lumber to develop the capacities. The allowable bending load should be calculated by a design professional based on the material from which the fastener is manufactured. For threaded powder actuated fasteners and step shank pins, it is important to remember that the point of maximum stress is at the interface of the shank and the base material. For example, when calculating the bending load for a fastener such as a 1/4"-20 threaded stud, it is important to use the shank diameter of 0.145" in calculations, not the 0.211" root diameter of the threads.



DESIGN RECOMMENDATIONS FOR CONCRETE

Allowable Load Capacities

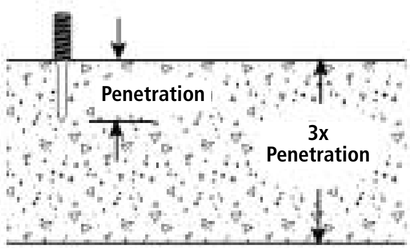
The allowable load capacity which may be applied to a powder actuated fastener is based on applying a safety factor to the average ultimate load capacity obtained from testing according to ASTM Standards E 488 and E 1190. One purpose of the safety factor is to allow for field variations which may differ from the testing conditions in the laboratory. An example is the type and strength of the base material. For proper performance, powder actuated fasteners must be installed by properly trained and licensed operators. In concrete and masonry materials, the values for allowable loads are based on applying a safety factor of 5:1 or greater to the ultimate loads. Loads are based on testing fasteners installed in base materials having the designated strength at the time of installation. Values are for the fastener only, connected parts must be investigated separately. Due to the variability of powder actuated fasteners installed in concrete or masonry materials, use of multiple fasteners is recommended to increase reliability. The design data listed in the tables are suggested allowable load capacities based on the safety factors noted below each table. These safety factors are based on industry experience and may need to be increased based on the application requirements or local codes as determined by the design professional responsible for the product installation. Proper spacing and edge distance guidelines must be followed.

DESIGN RECOMMENDATIONS FOR CONCRETE (Continued)

Base Material Strength

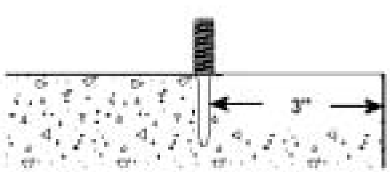
As discussed earlier in this manual, the strength of concrete and masonry base materials can vary widely. For installations in concrete, load capacities are published for powder actuated fasteners in normal-weight concrete in various compressive strength ranges. Linear interpolation of the data to calculate load capacities for fasteners installed in intermediate concrete strengths is permitted. Normally, the load capacities can be expected to increase as the compressive strength of the concrete base material increases. However, some types of high compressive strength concrete or concrete with a very hard aggregate may not be suitable for powder actuated fastenings. Job site installation tests are recommended to determine fastener suitability. For structural lightweight concrete, values are published for minimum 3000 psi concrete with and without steel deck. For masonry base materials, the published load capacities are based on testing in a wall constructed from ASTM C 90, Grade N, lightweight block. Since the consistency of masonry block can vary widely, especially within the mortar used, these values should be used solely as a guide. Job site tests are recommended to determine actual load capacities when used in masonry walls.

Base Material Thickness



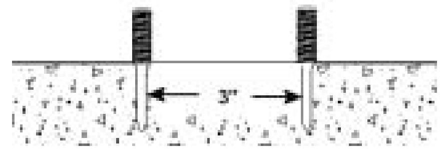
Concrete base material should be at least three (3) times as thick as the fastener embedment penetration. If the concrete is too thin, the compressive forces forming at the fasteners point can cause the free face of the concrete to break away. This can create a dangerous condition from flying concrete and/or the fastener and also results in a reduction of fastener holding power. For applications in the face shell of concrete masonry block, select a fastener length which will not exceed the thickness of the face shell.

Edge Distance



Do not fasten closer than 3" from the edge of concrete. If the concrete cracks, the fastener may not hold. Closer edge distances for applications such as sill plates may be permitted if specific fastener testing has been conducted.

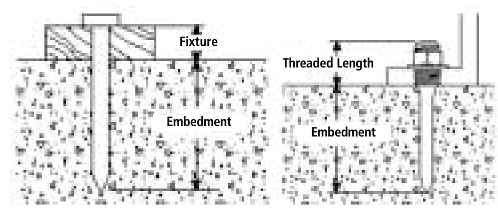
Spacing



Setting fasteners too close together in concrete or masonry can cause cracking. The recommended minimum distance between fasteners is 3" center to center.

Length Selection

For permanent applications using pins in concrete, first determine the thickness of the fixture to be fastened. To this, add the required embedment or penetration into the base material. This will be the fastener shank length required. For applications in the face shell of masonry block, select a fastener length which will not exceed the thickness of the face shell.



For removable applications with threaded studs, the shank length required is equal to the embedment depth required. To determine the minimum threaded length, add the thickness of the fixture and the nut / washer thickness. The nut and washer thickness is equal to the nominal thread diameter. For applications where 3/8" threaded studs are used at an embedment depth of 1-3/8", the fasteners were driven up to the threaded portion of the part. Do not over tighten threaded parts. Maximum tightening torque values are listed in the table below. Use of a nut setter is recommended to reduce the possibility of over tightening the fasteners. For critical applications, perform a job site test.

Maximum Torque for 1/4" Stud (ft.-lbs.)	Maximum Torque for 3/8" Stud (ft.-lbs.)
2	4

DESIGN RECOMMENDATIONS FOR STEEL

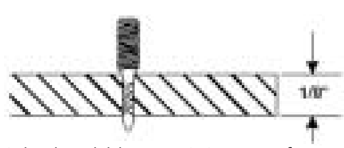
Allowable Load Capacities

The allowable load capacity which may be applied to a powder actuated fastener is based on applying a safety factor to the average ultimate load capacity obtained from testing according to ASTM Standards E 488 and E 1190. One purpose of the safety factor is to allow for field variations which may differ from the testing conditions in the laboratory. An example is the type and strength of the base material. For proper performance, powder actuated fasteners must be installed by properly trained and licensed operators. In steel materials, the values listed are based on a safety factor of 5:1 or greater to the ultimate loads. Values are for the fastener only, connected parts must be investigated separately. Use of multiple fasteners is recommended to increase reliability. The design data listed in the tables are suggested allowable load capacities based on the safety factors noted below each table. This safety factor is based on industry experience and may need to be increased based on the application or local code requirements as determined by the design professional responsible for the product installation. Proper spacing and edge distance guidelines must be followed.

Base Material Strength

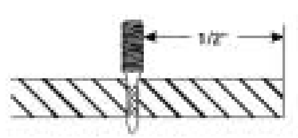
The published allowable load capacities are based on testing conducted in ASTM A 36 structural steel with the fastener point fully penetrating the steel member. For use in higher strength steel, applications where the point of the fastener will not penetrate a thickness of steel greater than those listed in the tables, job site tests are recommended to determine the suitability of the application and the actual load capacities.

Base Material Thickness



Steel base materials should be a minimum of 1/8” in thickness.

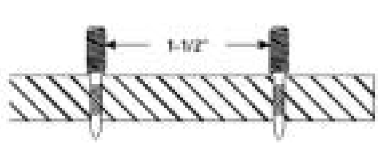
Edge Distance



For installations in steel, 1/2" is the recommended minimum edge distance.

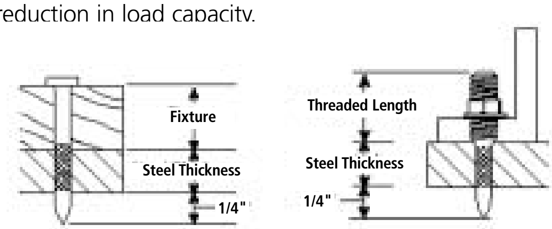
Spacing

The recommended minimum distance between fastenings is 1-1/2" center to center for installations in steel.



Length Selection

For permanent applications when using pins in steel, first determine the thickness of the fixture to be fastened. To this, add the thickness of the steel base material plus a minimum of 1/4" to allow for proper point penetration. This will be the minimum fastener shank length required. Do not select a fastener length longer than that required for the application. An excessively long shank can burnish or polish the hole created in the steel resulting in a reduction in load capacity.



For removable applications with threaded studs, the shank length required is equal to the thickness of the steel base material plus a minimum of 1/4" to allow for point penetration. This will be the minimum fastener shank length required. Do not select a shank length longer than that required for the application. An excessively long shank can burnish or polish the hole created in the steel resulting in a reduction in load capacity. To determine the minimum threaded length, add the thickness of the fixture and the nut / washer thickness. The nut and washer thickness is equal to the nominal thread diameter.

Do not over tighten threaded studs, the maximum tightening torque is listed in the table below. Use of a nut setter is recommended to reduce the possibility of over tightening the fasteners. For critical applications, perform a job site test.

Base Material Thickness (in.)	Maximum Torque for 1/4" Stud (ft.-lbs.)	Maximum Torque for 3/8" Stud (ft.-lbs.)
1/8"	2	4
3/16"	4	6
1/4"	6	10
3/8"	8	12