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POWDER ACUTATED TOOL
MANUFACTURERS' INSTITUTE INC

POWDER ACTUATED FASTENSING SYSTEMS BASIC TRAINING MANUAL

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BASIC TRAINING MANUAL

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CONTENTS

I. PURPOSE OF THIS TRAINING MANUAL

Experience and statistical studies have established that the most important factor in achieving safe and effective use of powder actuated fastening systems is operator training. Many local unions therefore include powder actuated fastening systems in their apprentice training programs. The labor regulations of many states as well as OSHA require that the operators of powder actuated fastening systems be thoroughly trained and certified for competence prior to operating the powder actuated tools. Since the fundamentals of using most powder actuated fastening systems are essentially the same, this Manual is designed to educate the user on those elements and applications common to most manufactured systems. It is made available to assist training courses including local union apprentice and training programs, federal, state and other regulatory bodies, trade schools and organizational safety departments. This Manual must be supplemented by specific training from the tool manufacturer on the operation, care and maintenance of that manufacturer's tool(s) and system(s), and upon completion of that manufacturer's required training (and compliance with any local regulations) the operator will be certified for use of that system.

II. INTRODUCTION

WHY USE POWDER ACTUATED FASTENING TECHNOLOGY

- **Portability** - no external power supply (one of the first cordless power tools).
- **Fast** - many systems are semi-automatic.
- **Small & lightweight** - ideal for fastening in locations that are difficult to access.

REQUIRED TRAINING & BASIC SYSTEM COMPONENTS

A powder actuated fastening system is a safe cost efficient method of making instantaneous forced entry fastenings into various construction materials. Although this system is relatively simple to use, there are important precautions and safeguards that must be observed. This manual provides only the basic information common to most powder actuated systems, and does not qualify or certify you to operate a powder actuated fastening tool or system. To become a certified operator), you must receive additional training covering operation, maintenance and recommended practices for each manufacturers' tool that you use. A certified operator should also read and be familiar with any applicable local, state, and federal regulations.

A powder actuated fastening system consists of the following components:

POWDER LOAD/BOOSTER

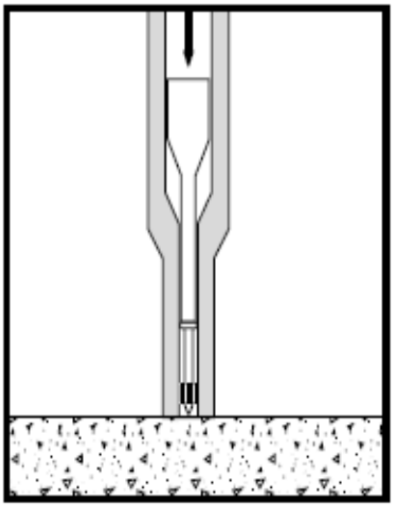
FASTENER

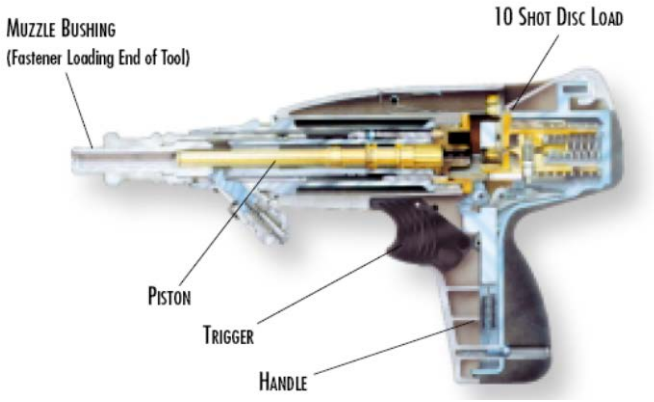
TOOLS

III. TOOLS - VELOCITY & ACTION

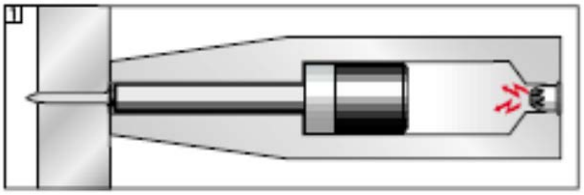
Tools have historically been classed by their velocity ("high", "medium" and "low")[1] and by type (direct or indirect acting).[2] Today's tools (i.e. all tools manufactured in the U.S.) are indirect-acting low velocity tools.[3] Which means that the expanding gas of the powder load/booster acts on a captive piston which in turn drives the fastener into the work surface. If you should encounter a high velocity direct-acting tool, you should promptly contact the manufacturer of that tool.

This training manual assumes that you are using a low velocity, indirect acting tool.





LOW VELOCITY TOOL/FASTENING DIAGRAMS



[1] The velocity class of a tool is determined by a ballistic test utilizing the lightest fastener and the strongest powder load/booster for which the same tool is designed.

[2] In an indirect-acting tool the expanding gas of a powder load/booster acts on a captive piston which in turn drives the fastener into the work surface. In a direct-acting type tool the expanding gas of a powder load/booster acts directly on the fastener to be driven into the work surface.

[3] A low velocity tool is one in which the average test velocity does not exceed 100 meters per second (328 feet per second).

IV. FASTENERS

Fasteners used in powder actuated tools are **NOT common nails**. They are manufactured from special steel and heat-treated to produce a very hard yet ductile fastener. These properties permit the fastener to penetrate concrete or steel without breaking. A powder actuated fastening results in a permanently installed fixture.

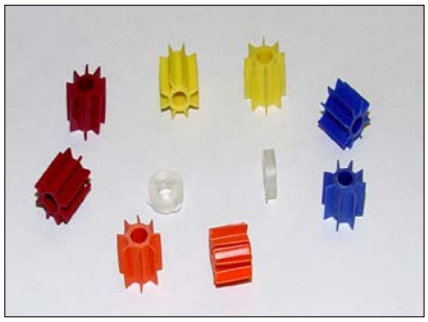
Every fastener must be equipped with some type of tip, washer, eyelet or other guide member. This guide member aligns the fastener in the tool as it is being driven and is commonly used to retain the fastener in the tool. Examples of these alignment tips are shown below.

Never attempt to use a common nail for powder actuated fastening.

TYPICAL ALIGNMENT TIPS

WASHER

PLASTIC



EYELET

COMMON FASTENERS

There are two common powder actuated fasteners: drive pins and threaded studs.

1. **Drive Pin** - A drive pin is a special nail-like fastener designed to permanently attach one material to another, such as wood to concrete or wood to steel. Head diameters vary in size from 1/4" to 3/8". However, for additional head bearing in conjunction with soft materials, washers, of larger diameters are either fastened through or made part of the drive pin assembly.

Fastening Wood Sill Plate to Concrete Floor

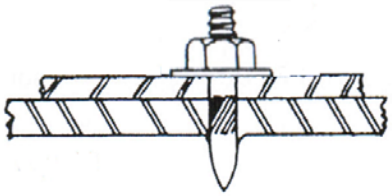
COMMON DRIVE PIN

Fastening Wood to Concrete Wall

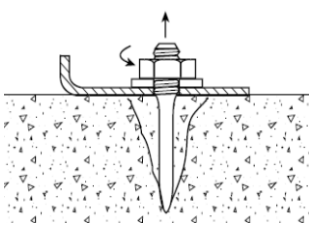
2. **Threaded Stud** - A threaded stud is a fastener comprised of a shank portion which is driven into the base material (and is therefore not visible after fastening) and a threaded portion (which remains visible after the fastening). An object is then attached to the threaded portion with a nut. The most common thread sizes are 1/4-20, and 3/8-16.

SAMPLE THREADED STUDS

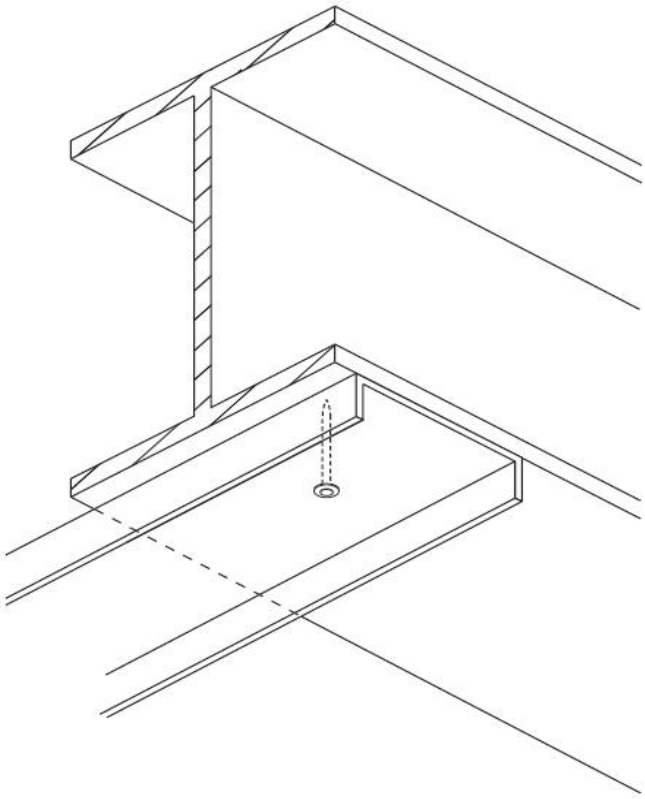
STEEL TO STEEL PENETRATION GRAPHIC
(w/nut & washer)



STEEL TO CONCRETE PENETRATION GRAPHIC
(w/nut & washer)



STEEL TO STEEL APPLICATIONS



Electrical Box to Steel Beam

Strut to Steel Beam

FASTENERS FOR SPECIAL APPLICATIONS:

There are also other types of fastener assemblies designed for specific applications.
Here are some examples:

BREAKAWAY FASTENERS
For temporary fastening of wood forming to concrete, designed to break away after forms are removed.

WASHERED FASTENERS
Typically used to attach lumber to steel or concrete.

MAGAZINE FASTENERS
These are collated fasteners for magazine fed tools

STEEL DECK FASTENERS
Used to attach corrugated metal deck to bar joist or I-beam

CABLE CLIP
Used to attach cable to concrete, masonry or steel

CONDUIT CLIPS
Used to attach EMT conduit to concrete, masonry or steel

CEILING CLIPS

Typically used by ceiling contractors

ROAD BASKET CLIPS

Used to secure re-bar baskets in highway construction and paving

V. POWDER LOADS/BOOSTERS

TYPES OF POWDER LOADS

Powder loads/boosters provide a unique, portable, self-contained energy source used in powder actuated tools. In the most commonly used form, the propellant is contained in a metallic case. Below is a description/display of different powder loads, their casings and disc/strip for multiple loads.

RIM FIRE

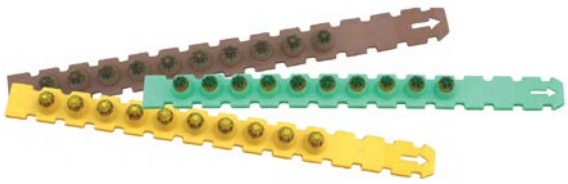
CENTER FIRE

CRIMPED NECKED

WADDED

DISC

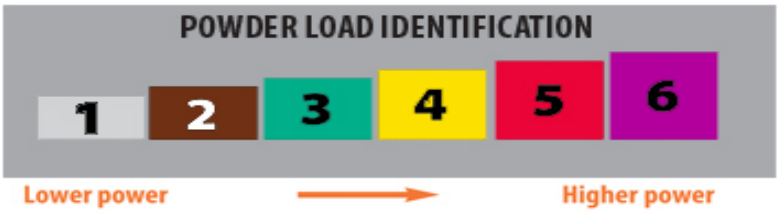
STRIP



Powder loads are available in various sizes from .22 through .27 calibers. Regardless of the type, caliber, size or shape, there is a standard number and color code used to identify the power level or strength of all powder loads. Although there are 12 power levels for powder loads, the most commonly used are 1 through 6, the lightest (i.e. lowest power) being #1 load and the heavier (i.e. the higher power) being #6 load.

The following chart shows this simple number and color identification code:

POWER LEVEL	COLOR IDENTIFICATION	
(lowest)	Case Color	Load Color
1	Brass	Gray
2	Brass	Brown/White
3	Brass	Green
4	Brass	Yellow
4.5	Brass	Blue
5	Brass	Red
6	Brass	Purple/Black
(highest)		

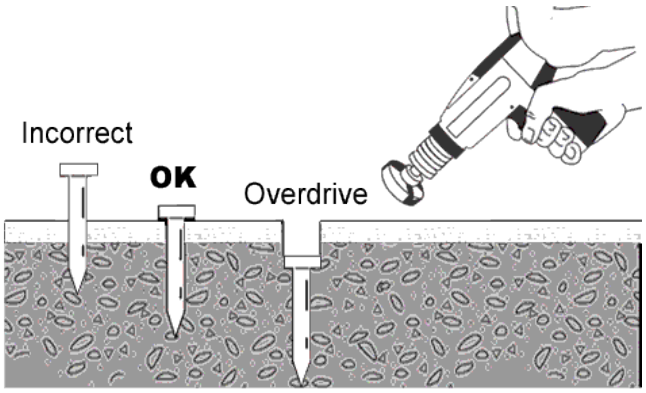


In some tools, now commonly called semi-automatic or automatic, the powder load/boosters are assembled in groups of ten in a strip or disc, which are usually made of plastic or metal. Even when so assembled, the powder load/boosters maintain the same color level as the single loads/boosters, to maintain control the power level. The plastic or metal carrier might or might not be color coded in the same scheme. In addition to the identification of the powder load, each package is color coded and shows the load level number.

SELCTING THE PROPER POWDER LOAD/BOOSTER

In selecting the proper power level to use for any application, it is important to start with the lowest power load level recommended for the tool being used. If the test fastener does not penetrate to the desired depth using the lowest powder load level, then the next powder load level should be used and so on, continuing to increase powder load levels by single steps until the proper penetration is obtained. For tools with a power regulator, start with the lowest power setting and the lowest powder load level, increasing the overall power level gradually until the proper penetration is obtained.

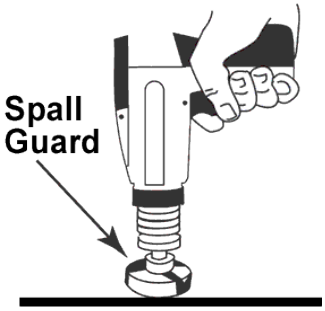
EXAMPLE
Assume the tool for your job uses power levels #1 through #4. Your first test fastening should be made with the 1 gray load (brass case) and if the fastener is not fully driven, your next test fastening should be with a #2 brown load, and so forth.



The type and range of powder loads/boosters used with any tool is printed on the inside lid of the tool carrying case and/or shown in the Operator's Manual included with the tool.

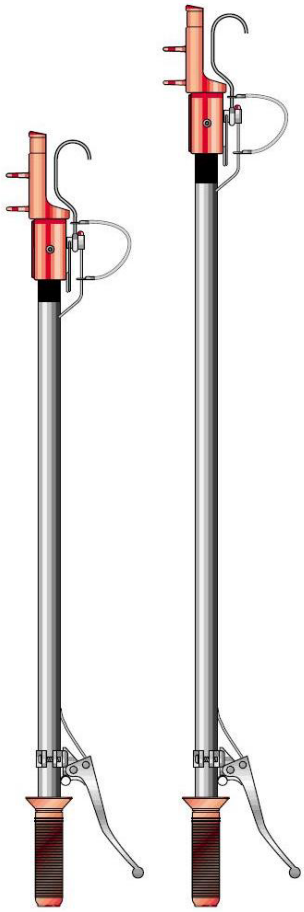
VI. SHIELDS AND SPECIAL FIXTURES

Shields and special fixtures are important for a safer and more reliable use of your powder actuated fastening system. All tools are supplied with a shield or stabilizer to confine flying particles and to help insure that the tool is perpendicular to the work surface. This shield should be used when fastening directly into a base material (such as driving threaded studs or eye pins into steel or concrete), and when fastening one material to another if the material being fastened does not confine flying particles.



VII. SPECIALITY TOOLS

Overhead fastenings which are difficult to reach (e.g. acoustical ceilings) can be made with an extension for your powder actuated tool or with a special ceiling tool. Use of either the extension or the ceiling tool helps eliminate the need for scaffolding since you can make overhead fastenings from the floor. You must follow the powder tool manufacturer's instruction manual for safe use of the extension. Only the powder tool manufacturer's recommended extension should be used with a hand-held powder tool. Similarly, you must follow the ceiling tool manufacturer's instruction manual to operate it safely.



VIII. BASE MATERIALS

The material into which the fastener shank is driven and from which holding power is obtained is known as the base material. In general, base materials are metal, concrete and masonry of various types and hardness.

For specific application recommendations, contact your tool manufacturer. It is very important that the certified operator should determine the suitability of any material into which the fastener is to be driven.

Suitable Base Materials have sufficient hardness and thickness to prevent the entire fastener from passing completely through. Suitable base materials will expand to compress the fastener shank and produce holding power.

Unsuitable Base Materials can be put into three categories:

Too Hard—fastener will not be able to penetrate and could possibly deflect or break. Examples: hardened steel, welds, cast iron, marble, spring steel, natural rock, etc.

Too Brittle—material will crack or shatter and the fastener could deflect or pass completely through. Examples: glass, glazed tile, brick, slate, etc.

Too soft—material does not have the characteristics to produce holding power and fastener could pass completely through. Examples: wood, plaster, drywall, composition board, plywood, gypsum, etc.

CENTER PUNCH TEST
A very simple quick test can be made to determine base material suitability.

Caution: To prevent personal injury, always wear ANSI approved eye protection when performing center punch test. Be certain that your eye wear is labeled "Z87.1**+**" and not just "Z87.1". The "**+**" sign/symbol means that the eye protection meets a high impact standard.

Procedure: Use a fastener as a punch on the actual base material (see diagram below).

Using an average hammer blow, strike the head of a powder actuated fastener on the base material into which you intend to make the fastening.

1. If the material shows a clear fastener point impression and the fastener point is not blunted - proceed with the first test fastening.

2. If fastener point is blunted - material is too hard.

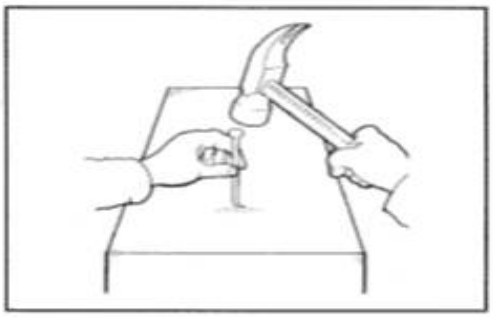
3. If material cracks or shatters - material is too brittle.

4. If fastener sinks into material with an average hammer blow - the material is too soft.

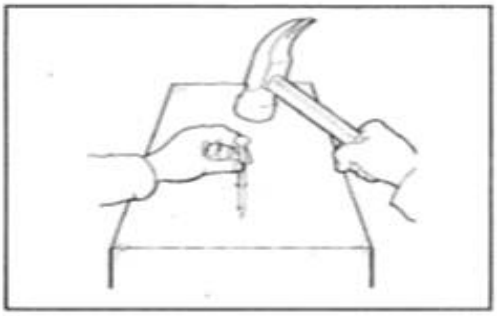
The same procedure to test for hardness or brittleness should be made on questionable material to be driven through and attached to the base material. Soft materials to be attached need not be tested.

UNKNOWN OR QUESTIONABLE BASE MATERIAL

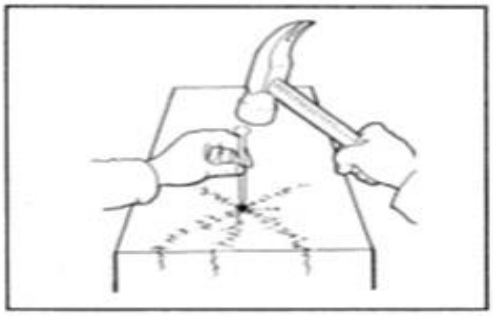
CENTER PUNCH MATERIAL WITH FASTENER



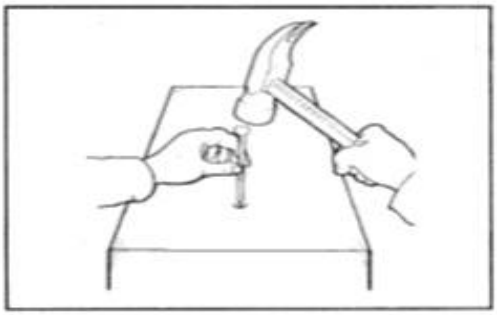
If the fastener point is flattened, the material is too hard for powder actuated fastening.



If the fastener penetrates the material easily, the material is too soft.**



If the material cracks or shatters, the material is too brittle.



If the fastener makes a small indentation into the material, the material is suitable for fastening.

****DO NOT GUESS****

IF IN DOUBT CENTER PUNCH TEST THE MATERIAL

OR

CONSULT TOOL MANUFACTURER'S REPRESENTATIVE
BEFORE ATTEMPTING TO FASTEN

IX. FASTENING INTO CONCRETE AND MASONRY MATERIALS

Concrete & Masonry Materials Generally Suitable for Powder Actuated Fastentings

The following concrete and masonry materials are suitable for powder actuated fastening:

1. Poured concrete
2. Precast concrete
3. Concrete masonry unit (CMU) depending on the application

To determine if other concrete or masonry materials are suitable, contact your tool manufacturer.

Why A Fastener Holds

It is important to understand what happens when a fastener is driven into any concrete/masonry material and why the fastener holds. The holding power of the fastener results principally from a compression bond of the concrete/masonry to the fastener shank. As the fastener penetrates it displaces the concrete/masonry (i.e. it pushes the concrete/masonry aside to make room for the fastener). Because the concrete/masonry material wants to return to its original form (i.e. fill the space taken by the fastener) it squeezes or compresses around the fastener (thus creating a compressive bond).

In addition to the compressive bond, the heat generated by driving the fastener causes an additional bond between the fastener and the concrete/masonry, commonly referred to as a centering bond or weld.

Fig. 1 (below) illustrates the bond of a fastener driven into concrete/masonry material.

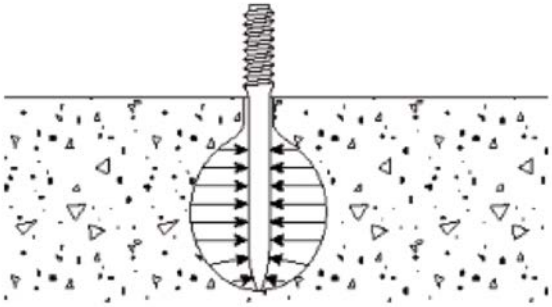


Fig. 1

Soft Concrete/Masonry vs. Hard Concrete/Masonry

It is important to understand that concrete/masonry can have different compressive strengths. Higher compressive strength concrete/masonry has greater material compression which generally results in a higher bond and therefore a greater holding power at the same fastener penetration.

Relationship Between Concrete/masonry Strength, Fastener Bonding & Fastener Penetration

If an excessive direct tension (pullout) load is applied to the fastener, failure will occur in either of two ways:

1. The fastener may pull out of the concrete/masonry (see **Fig. 2**), **OR**

2. The concrete/masonry itself may fail. (see **Fig. 3**).

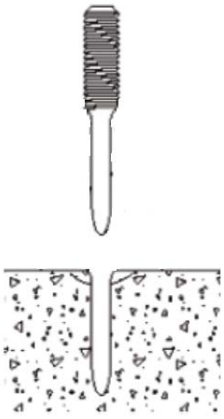


Fig. 2

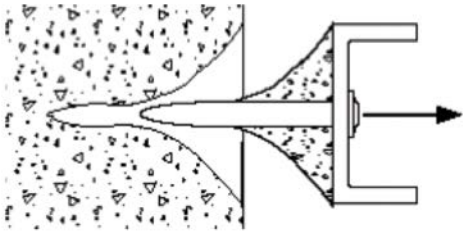


Fig. 3

This illustrates an important relationship between the depth of fastener penetration, the bonding of the fastener shank, and the strength of the concrete/masonry itself. When the depth of penetration produces a bond on the fastener shank equal to the strength of the concrete/masonry, you achieve the optimum holding power.

How Fastener Diameter relates to Fastener Penetration

The fastener shank diameter is related to the fastener shank penetration in two ways:

1. For a particular hardness of concrete/masonry there is one diameter and penetration combination that produces the maximum holding power.

2. The fastener diameter must have a definite relationship to the shank length in order to satisfactorily resist bending during penetration.

Good holding power can be obtained using the following recommended penetration depths:

1. For soft concrete/masonry (approximately 2,000 to 2,500 psi) penetration should be equal to approximately 9 to 10 times the fastener shank diameter.

2. For average concrete/masonry (approximately 3,500 to 4,000 psi) penetration should be equal to approximately 7 to 8 times the fastener shank diameter.

3. For hard concrete/masonry (approximately 5,000 to 6,000 psi) penetration should be equal to approximately 5 to 6 times the fastener shank diameter.

The concrete/masonry's compression bond around the fastener increases with the depth of fastener penetration and with the strength of the concrete/masonry itself.

Spacing Fasteners

When fastening to concrete/masonry, it is important to remember a few basic facts for safe and proper fastenings:

1. Do NOT Fasten closer than 3” from the edge of concrete/masonry (see Figs. 4A & 4B). If concrete/masonry cracks, the fastener won’t hold and there’s a chance a piece of concrete/masonry or the fastener could escape in an unsafe way (see Fig. 4C).

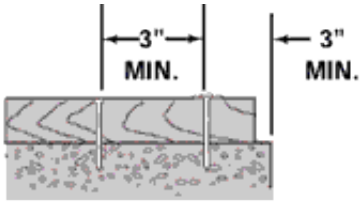


Fig. 4A

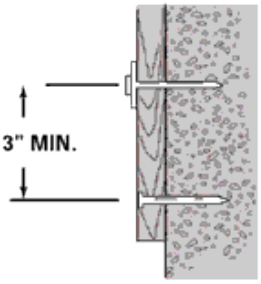


Fig. 4B

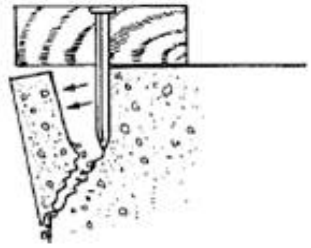


Fig. 4C

2. Setting fasteners too close together can also cause concrete/masonry to crack. Recommended minimum fastener spacing based on shank diameter is as follows:

Fastener Spacing and Edge Distance to Preclude Influences on Fastener Performance*

Shank Diameter mm (in.)	Minimum Fastener Spacing mm (in.)		Minimum Edge Distance mm (in.)	
	Steel	Concrete	Steel	Concrete
2.5 to 4.0 (0.100 to 0.156)	25 (1.0)	100 (4.0)	12 (0.5)	80 (3.2)
4.1 to 5.0 (0.157 to 0.199)	25 (1.0)	130 (5.1)	12 (0.5)	90 (3.5)
5.1 to 6.5 (0.200 to 0.250)	40 (1.6)	150 (5.9)	25 (1.0)	100 (4.0)

*Source ASTM E1190

3. It is important that the concrete/masonry be at least three times as thick as the fastener penetration. If concrete/masonry is too thin, the compressive forces forming at the point of the fastener may cause a portion of the concrete/masonry to break away (See Fig. 5 below). As a result, the fastener may not hold and there is a danger that pieces or chunks of the concrete/masonry will fly off.

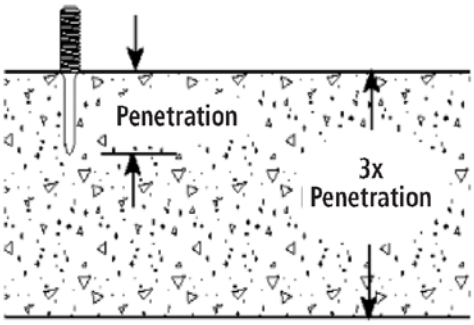


Fig. 5

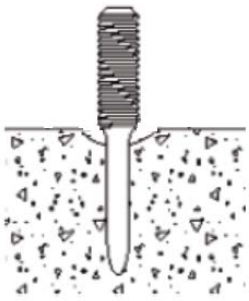


Fig. 6

4. **Fastening into mortar joints should only be attempted in the horizontal joint.** A vertical joint is typically NOT solid mortar and is therefore not thick enough to support powder actuated fastening. Fasten in horizontal joints only. You must also be certain that the shank diameter of the fastener is not so large that it reaches outside the mortar joint (into the concrete/masonry). A fastener that is too large may cause cracking in the joint and reduce its holding power.

5. **Chipping in the concrete/masonry surface around the fastener shank is called spall.** There are several factors about spall to remember:

   - It is caused by the fastener's compression of the concrete/masonry and the initial impact. (See **Fig. 6** above).
   - Minimal spalling does not significantly reduce holding power.
   - If spall is an appearance problem, the appearance can be improved by fastening using a spall reducing adapter (see **Fig. 7A & 7B**).

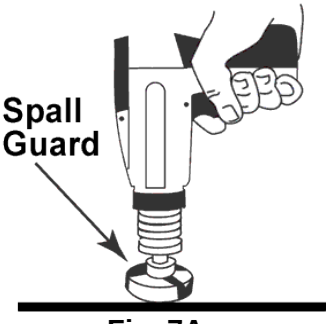


Fig. 7A

Fig. 7B

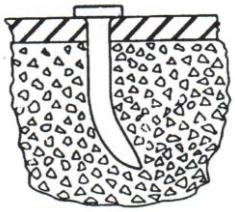
Spalling may be reduced or eliminated as follows:

- Use a fastener with a smaller shank diameter which may also allow you to use a fastener with a shorter shank length (resulting in less penetration). Be aware that performance values may be reduced.

- Since over penetration often causes excess spall, try a shorter shank length, lower power level, or both. Be aware that performance values may be reduced.

- Be sure your powder actuated tool is perpendicular to the concrete/masonry surface. Any angular forces may cause spall. Utilize tool shield for stability.

6. **If you drive a fastener into large, hard and excessive amounts of aggregate, reinforcing rod it may cause fish-hooking. Fish-hooking typically occurs when a partially driven fastener hits a hard object, and that object bends and deflects the fastener.**



Fish-hooking may reduce holding power (i.e. your fastening may not be effective) and usually increases spalling. Fish-hooking can also be hazardous because is causes chipping and flying of concrete/masonry particles. Unless the fastening application itself provides equal or greater protection, always use a shield or fixture on the tool, **especially when** driving threaded studs or eye pins directly into concrete/masonry.

Ways to eliminate or minimize fish-hooking:

- Reduce shank penetration
- Increase shank diameter
- Check power level to be sure that fastener is not being overdriven.
- Use a spall guard or stabilizer

7. **If you modify the length or diameter of the fastener to minimize spall or eliminate fish-hooking you must recheck the fastener's holding power.** If there is any doubt about the effectiveness of your fastening you must re-test (see Section VIII).

X. FASTENING INTO STEEL

A fastener driven into steel holds in the steel because of the steel's natural tendency to return to its original undisturbed condition after the fastener penetrates. As the fastener is driven into steel it pushes the steel aside, compressing and displacing the steel. The tendency of the steel to flow back to its original position exerts a gripping or clamping force on the fastener shank as shown in **Fig. 8** (below).

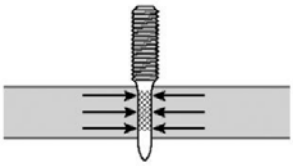


Fig. 8

Holding power of a powder actuated fastener set in steel is directly affected by the total contact area between the fastener shank and the steel base material.

An increase in either the fastener's shank diameter or steel base material thickness will generally increase holding power. For effective holding power, the fastener's shank diameter should not exceed the thickness of the steel base material.

In order to get maximum gripping force, the fastener point should completely penetrate the opposite side of the steel into which the fastener is set. If the point of the fastener shank does not extend through the steel base material, a part of the compressive force in the area of the point will act to force the fastener back out as shown in **Fig. 9** (below).

Light Gage Steel Fastened to Steel

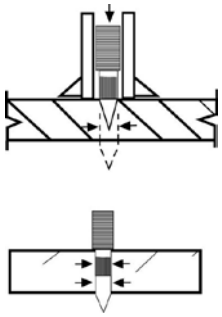


Fig. 9

An example of this effect is demonstrated when an ice pick is thrust through a slab of rubber a 1/2 inch thick. If the point does not completely penetrate the rubber, withdrawal is relatively easy. When the point fully penetrates and the rubber compresses around the shank, withdrawal is more difficult. If the ice pick is removed, the hole in the rubber tends to close.

Where fasteners are set in thick steel members in which the point does not completely penetrate, fastenings can still be made. However, the fastener holding power will be reduced due to the compressive force acting on the fastener point. Remember, the total effective holding power is that supplied by the straight section less the negative effect of the embedded point. To increase the effectiveness of the straight portion, knurls of various types are used.

Generally, fasteners made for use in steel have knurled shanks. The rough surface provided by the knurling

gives an interlocking action between the fastener and the steel. Generally, knurled shanks give greater resistance to pullout than smooth shanks and increase the resistance to turning when tightening nuts on threaded studs. See typical forms of knurled shanks shown in **Figs. 10A & 10B** (below).

Fig. 10A
(photo spiral/diagonal knurl fastener)

Fig. 10B knurl types
Knurl types, range from (left to right above), Straight, Diamond, Spiral (shown, aka Diagonal), and Chevron.

For best fastening, specific knurled shanks and powder load selection for specific applications, consult the recommendations of the tool manufacturer. When any doubt remains, make actual tests on the job.

Where fasteners are to be driven into unknown metal materials it will be necessary to determine the acceptability of that material for powder actuated fastenings either by consulting the tool manufacturer or by center punch testing for hardness (see base material suitability punch test in Section VIII).

When fastening into steel it is important to remember a few basic facts to help assure safe and proper fastenings:

Do NOT fasten too close to the edge of a steel member. The steel between the fastener and the edge can stretch so that it will not grip the fastener shank. It may fracture and allow the fastener to escape in an unsafe manner (see Fig. 11). In neither case can maximum holding power be obtained.

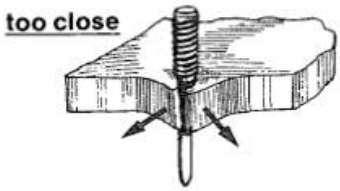


Fig. 11

Do NOT set fasteners too close together. Setting fasteners too close together can disturb the compressive force holding the adjacent fastener and reduce its holding power. Below are the minimum spacing and edge distance requirements for effective fastenings.

Fastener Spacing and Edge Distance to Preclude Influences on Fastener Performance*

Shank Diameter mm (in.)	Minimum Fastener Spacing mm (in.)		Minimum Edge Distance mm (in.)	
	Steel	Concrete	Steel	Concrete
2.5 to 4.0 (0.100 to 0.156) 25 (1.0)	100	(4.0)	12 (0.5)	80 (3.2)
4.1 to 5.0 (0.157 to 0.199) 25 (1.0)	130	(5.1)	12 (0.5)	90 (3.5)
5.1 to 6.5 (0.200 to 0.250) 40 (1.6)	150	(5.9)	25 (1.0)	100 (4.0)

*Source ASTM E1190

Do NOT fasten into steel base material thinner than the fastener shank diameter. Holding power will be reduced and the fastener may be overdriven.

Recommended Minimum Steel Thickness

Fastener Shank Diameter	Minimum Thickness
0.125	1/8”
0.145 through 0.187	3/16”
0.21875 through	1/4”

Do NOT use fasteners with a shank longer than required for the application. The burnishing effect of a long shank passing through the steel enlarges the hole in the steel, reducing holding power (generally no greater than 1/4" of the tip penetrating through the backside of the base material).

Avoid over driving the fastener. A fastener driven with excessive force can be damaged or break. Rebound (bounce back) of an overdrive fastener will reduce holding power of the fastener. (**Fig. 12**). The useful thread length is also reduced by over driving (**Fig. 13**).

Fig. 12

Fig. 13

Do NOT drive a fastener in areas that have been welded or torch cut. Welding or torch cutting can produce hard areas. These areas may be too hard for powder actuated fastening.

Use the proper tool spall guard when fastening into steel which is heavily rusted, scaled or galvanized. Dislodged surface particles can be hazardous.

Do NOT fasten through existing holes unless a positive guide to center the bore of the tool over the hole is used. Unless the fastener is centered over the hole, it can be deflected by the edge of the hole.

When fastening into long unsupported steel members, to assure uniform penetration and proper holding power, support the steel in the area of the drive to avoid any *springing* action.

XI. BASIC APPLICATIONS

Most applications for powder actuated fastening systems fall into one of six general classifications. Let's examine them one at a time:

A. Fastening relatively soft material (wood, insulation, etc.) permanently to concrete (Figs. 14A, 14B, 15).

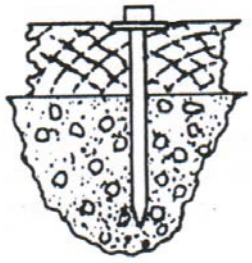


Fig. 14A
Pin with Washer
Fastening Wood to Concrete

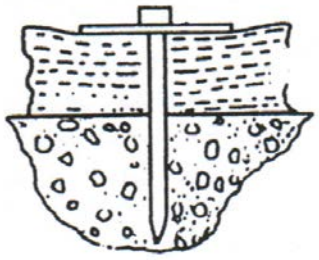


Fig. 14B
Pin with Large Washer For
Insulation to Concrete

Fig. 15
Looking Down on Fastener (with washer)
Wood Fastened to Concrete

An important consideration is the amount of bearing surface needed to assure proper holding of the material being fastened, without over driving. Head diameters of the drive pins used for permanent fastenings are relatively small. Soft materials may be split, damaged, or the softness of the material may permit the fastener head to pull through the material, destroying the fastening even though the drive pin may remain firmly in the base material. This can be overcome by driving the fastener through a larger diameter washer to provide the necessary increased bearing surface for good retention of the soft material, and at the same time, prevent over driving. The size of the additional washer needed will depend on the softness of the material. Very soft material such as foam insulation may require a washer (disc) of two inches diameter or more. (see **Figs. 14B, 15 & 18**).

B. Fastening relatively soft material (wood, insulation, etc.) permanently to steel (Figs. 16 , 17, 18).

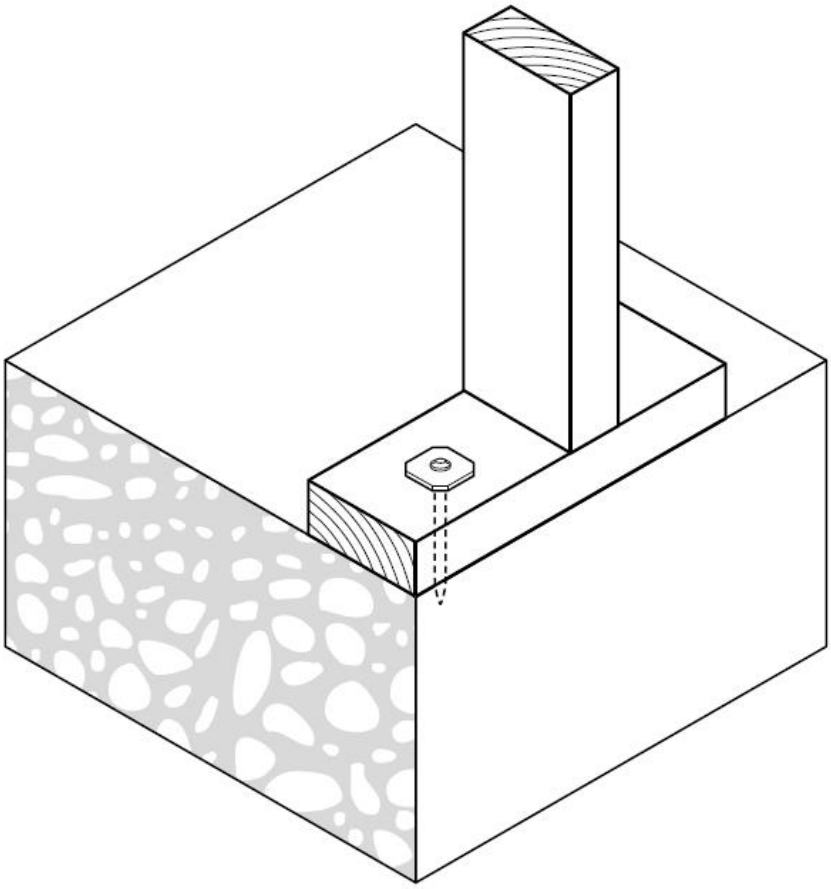


Fig. 16
wood sill plate to concrete

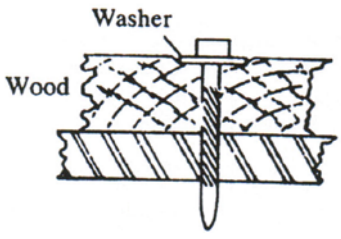


Fig. 17

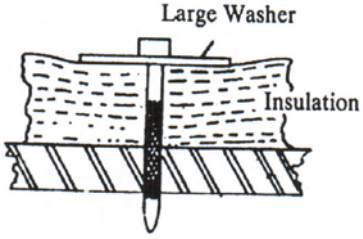


Fig. 18

In these applications, exactly the same considerations apply as in Paragraph A above. Remember that knurled shank fasteners generally provide better holding power in steel than smooth shank fasteners.

C. Fastening metal permanently to concrete (Figs. 18A, 18B, 19 &19A).

Fig. 18A
(viewing down on fastener)

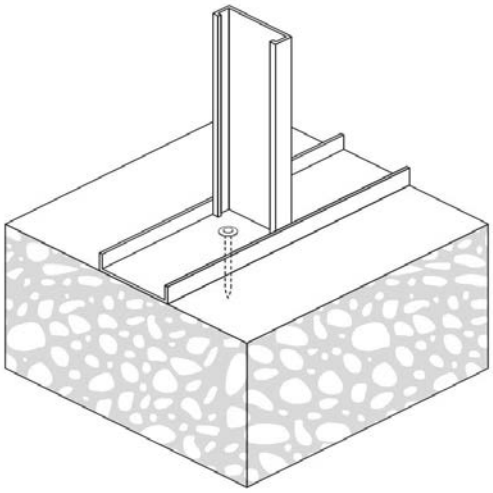


Fig. 18B
(viewing down on drywall track to concrete)

Many kinds of metal items are regularly fastened to concrete, including plates, angles, channels, clips, brackets, as well as sheet siding and roofing. Since the material being fastened is quite hard, the relatively small head bearing surface of the drive pin utilized for permanent fastening is usually sufficiently large in diameter for good retention and holding power (**Fig. 19**). Use of a washered fastener may increase the pullover resistance of the fastener (**Fig. 19A**).

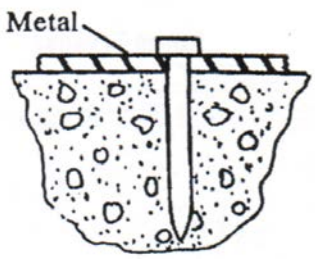


Fig. 19

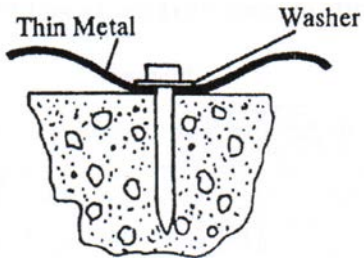


Fig. 19A

D. Fastening metal permanently to steel (**Figs. 20 & 21**).

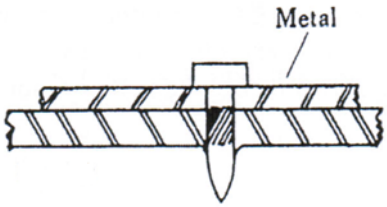


Fig. 20

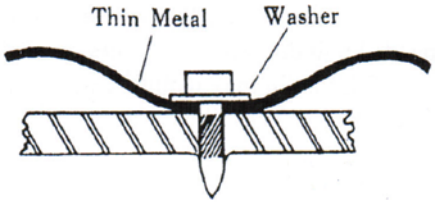


Fig. 21

In this group of applications, the same fundamental considerations as in Section C (above) apply.

E. Fastening removable items or materials to concrete. (see **Fig. 22**).

The most common applications in this group involve items with existing or pre-drilled holes. The fastener location is first carefully predetermined and laid out on the work surface at the exact point that the hole in the material to be fastened will be located. The fastener is then driven at the intersection of the layout lines. The material being attached is then placed over the driven stud and secured with a washer and nut. The selection of the washer to be used under the nut will depend on the softness of the material being fastened. The softer the material being fastened, the larger the washer should be to provide good retention and bearing surface.

CAUTION: Over tightening a nut on a threaded stud will pull out the stud. Consult fastener manufacturer for proper tightening torque.

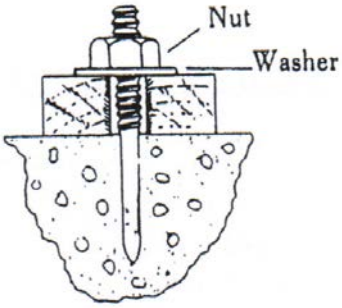


Fig. 22

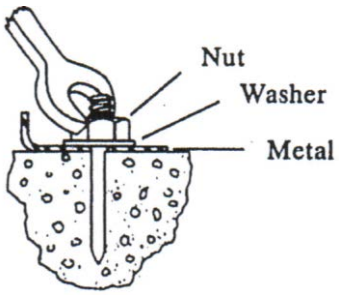


Fig. 23

Occasionally, it is necessary or desirable to provide a method to remove either the fastener or the fastened material where there is no preexisting hole. In these cases, a threaded stud may be used, just as if it were a drive pin and driven directly through both the material being fastened and into the base material, just as in Paragraphs A through D, Section XII. To remove the stud, apply torque with a wrench. As the nut is deliberately over-tightened, it exerts a jacking or pulling force through the washer and fastened material, resulting in withdrawal of the fastener (see **Fig. 23** above).

F. Fastening removable items or material to steel (Fig. 24).

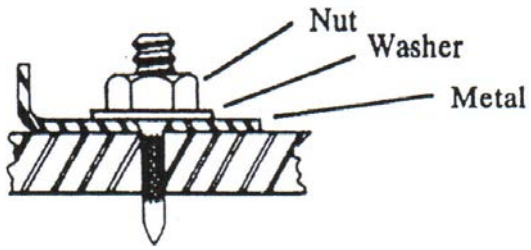


Fig. 24

The same general considerations apply as when fastening removable items or materials to concrete (**Fig. 22**). It is best to use a stud with a knurled shank and to be sure that the fastener point fully penetrates through the back side of the steel base material for greatest holding power.

REMEMBER
Do not overtighten the nut. Consult fastener manufacturer for proper tightening torque.

XII. SELECTING THE PROPER FASTENER

The selection of the proper fastener depends upon the application and the material into which the fastener is to be driven. If a permanent, non-removable fastening is desired, a drive pin should be used. If a removable installation is desired, use a threaded stud. If in doubt as to which fastener type should be used for your special applications, consult the tool manufacturer's representative. Various diameters for each shank length are available. For a light duty application, select a small shank diameter is generally sufficient. For a heavy duty application, select a large shank diameter may be needed. In additional to pin diameter, pin embedment and spacing will influence the holding capacity of the pin into the base material. Generally, most specifier's have a calculated load demand for their particular application, and most pin manufactures offer published performance data, and many have code reports with pin performance data. Check each manufacturer's published pin performance data per embedment depth and pin diameter.

FASTENING INTO STEEL

Remember, as a general rule, when fastening into steel the point of the fastener should fully penetrate the opposite side. This factor should be considered when selecting shank lengths. Also remember, knurled shank fasteners generally hold better in steel compared to smooth shank fasteners,

Drive Pins - To select the proper shank length, determine the total thickness of the material to be fastened (X), the thickness of the steel into which the pin will be driven (Y) plus the point length. A total of X, Y and the point length is the proper shank length (Fig. 25).

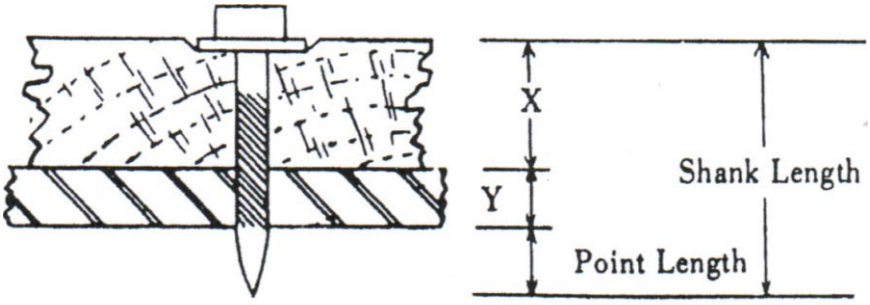


Fig. 25

Threaded Studs - The proper shank length for threaded studs depends on the thickness of the steel (Y) plus the point length on of the threaded stud. Depending upon the thickness of the material to be fastened, different thread lengths are available. Generally, if the item to be fastened is sheet metal, a short thread length would be selected. If the item to be fastened is thick, a correspondingly long thread length should be chosen so that a nut and washer can be applied. (**Fig. 26**).

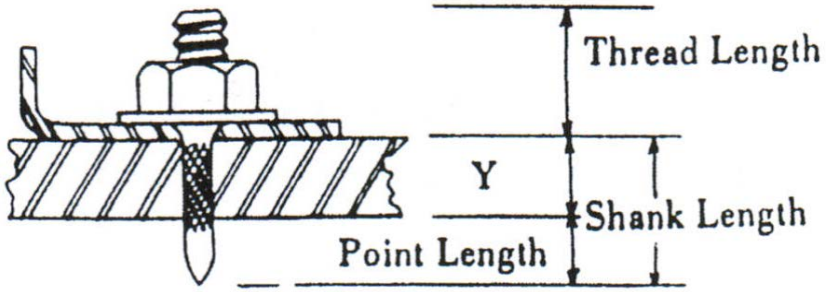


Fig. 26

FASTENING INTO CONCRETE/MASONRY

As a general rule, when fastening into average concrete, the fastener should penetrate 7 to 8 times the shank diameter. In hard concrete, 5 to 6 times the shank diameters penetration would normally be sufficient for proper holding power. In softer (low compressive strength) concrete, 9 to 10 times the shank diameter is generally sufficient.

Drive Pins - In selecting the proper drive pin for concrete or masonry, you must determine the correct shank length by allowing for the thickness of the material to be fastened (X), plus the depth of penetration required (Y) utilizing the following shank diameter-penetration rules. (**Fig. 27**).

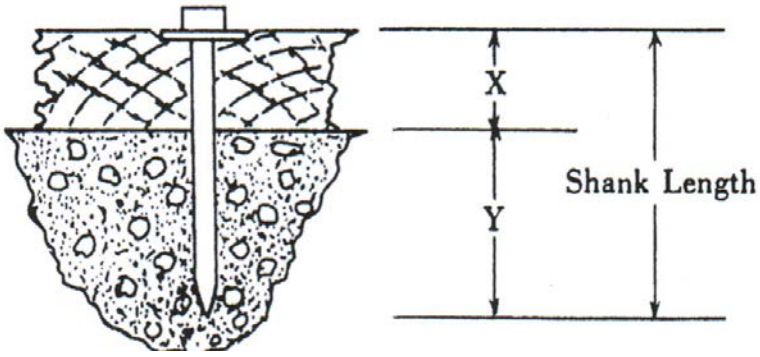


Fig. 27

Threaded Studs The selection of the proper threaded stud shank length is determined by using the preceding shank diameter-penetration rules. Select a thread length that allows for the thickness of the material to be attached as well as a nut and washer (**Fig. 28**).

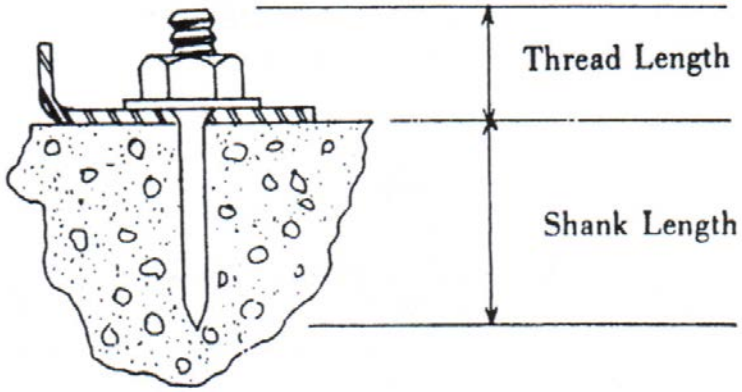


Fig. 28

Fastening Accessories - In selecting the proper shank lengths for fastening accessories such as eye pins and utility studs conduit clips and ceiling clips, allow for the thickness of the accessory (X), plus the depth of penetration required by utilizing the preceding shank diameter- penetration rules.

XIII. GENERAL SAFETY PRECAUTIONS

SERIOUS PERSONAL INJURY OR PROPERTY DAMAGE MAY OCCUR IF PROPER SAFETY PRECAUTIONS ARE NOT FOLLOWED.

Powder actuated tools are designed to operate safely. Unfortunately, they do not think for you, the operator of the tool.

THINKING IS YOUR RESPONSIBILITY!
Safe operation of powder actuated tools requires knowledge and constant alertness by you the tool operator.

A. To use powder actuated fastening systems safely:

1. Use common sense and good judgment.
2. Use the tool for its intended purpose only.
3. Know the material being fastened and the base material being fastened into.
4. Follow Your Tool Manufacturer's instructions.

B. Specific precautions to be remembered and practiced are:

1. Tool Operators and Assistants:

(a) Eye protection complying with ANSI/SEA Z87.1+ must be worn by the tool operator, assistants and adjacent personnel at all times when the tool is being used. Face protection must be used as working conditions otherwise require.

(b) Use of hearing protection is recommended.

(c) Never let bystanders gather around when you are using a tool.

(d) When working on ladders and scaffolds, maintain good balance and properly brace yourself at all times.

(e) Never load the tool until ready to make a fastening.

(f) Always keep tool pointed in a safe direction.

(g) Never carry a loaded tool from job to job. Only load a tool for immediate use in each fastening.

(h) Post a sign at least 8" x 10" in size, with at least 1" font height letters, stating "WARNING: POWDER ACTUATED TOOL IN USE" in plain sight of where powder actuated tools are in use, and in adjacent areas to where powder actuated tools are in use.

2. Tools - Care and Servicing:

(a) All tools should be cleaned and maintained in accordance with the tool manufacturers specific instructions.

(b) Always check all tools prior to each day's use to be sure they are in proper working condition.

(c) Tools not operating properly must be removed from service until they are repaired.

(d) Tools must be stored, operated and maintained in strict accordance with the manufacturer's instructions. Powder actuated tools must be serviced and inspected for worn or damaged parts at regular intervals as recommended by the tool manufacturer.

(e) Do not alter any powder actuated tool. Only use replacement parts specified by the tool manufacturer. Altering the tool, or using components other than those specified by the manufacturer could disable the tool's protective safety mechanisms.

(f) Tools and loads should be stored in a locked container when not in use. Be sure to unload the tool before storing. A loaded tool should never be stored or otherwise left unattended.

3. Tools - Use and Limitations

(a) The proper shield, fixture, adapter or accessory suited for the application, as recommended and supplied by the manufacturer, shall be used.

(b) Only use the off-center positions of adjustable shields when fastening near obstructions, such as a wall, when the obstruction provides the same protection as the shield.

(c) Always operate a tool at right angles to the work surface, except for specific applications recommended by the tool manufacturer.

(d) Always check the chamber for foreign matter before loading.

(e) Do not use the tool in an explosive or flammable atmosphere.

(f) Never place your hand over the front (muzzle) end of a tool.

(g) Always load the fastener first, then the powder load/booster.

(i) Never put your fingers near the trigger until you intend to fire the tool.

(j) Never point a tool - loaded or unloaded - at anyone.

4. Powder Loads

(a) Always check the color and caliber of each powder load/booster before inserting it into the tool chamber.

(b) Always make your first test fastening with the lowest power level (or power setting) recommended for the tool.

(c) Never attempt to force a powder load into a tool chamber or pry a load out of a chamber.

(d) In the case of a misfire hold the tool firmly against the work surface for a period of thirty seconds, and trigger the tool again. If the tool does not discharge, then and then follow the explicit instructions set forth in the manufacturer's instructions. Tag and remove the tool from service. If a load has been chambered but failed to fire, do not throw it into a trash container or leave on the job site. Such unspent loads must be collected and safely disposed according to manufacturers' instructions.

(e) Never carry fasteners or other metal objects in the same container, compartment, apron pocket or pants pocket with powder loads/boosters.

(f) You must store powder-actuated tools and powder loads/boosters in a secure, safe location which is accessible only to authorized personnel.

(g) Always keep powder loads separated by power level, color and type, i.e. do not mix powder loads of different power levels, colors or types, in the same container or compartment.

5. Base Materials and Materials to be Fastened.

(a) Before fastening into any unidentified material, check it by using the center punch test.

(b) Always follow the rules for edge distance, fastener spacing and material thickness.

(c) Do not attempt to install a fastener through an existing hole in steel or any other material unless a positive guide is used to assure accurate location. Doing so could cause the fastener to hit the edge of the hole and fish-hook or ricochet.

(d) Never attempt to fasten into a spalled or cracked area in concrete/masonry or into any area where a previous fastener has failed. Doing so could cause the fastener to fish-hook or ricochet.

(e) Never overdrive a fastener.

(f) Do not use a fastener to draw down a steel member. This could cause a springing action and over a period of time the fastener could be pulled loose.

(g) Never over-tighten a nut on a threaded stud. Over tightening a stud creates a pulling tension on the stud which could weaken the fastening.

(h) Do not attempt to install fasteners into very hard or brittle materials such as: cast iron, tool steel, spring steel, glazed tile, hollow tile, glass block, most brick and most natural rock.

(i) **NEVER FASTEN WOOD, FIBERBOARD, PLASTER OR OTHER SOFT MATERIALS UNLESS BACKED BY A MATERIAL THAT WILL PREVENT THE FASTENER FROM PASSING COMPLETELY THROUGH.**

(j) Always know the material into which you are fastening, especially in older buildings where the base material may be concealed. Check continually to avoid fastening into unsuitable material.

XIV. QUALIFIED OPERATOR

You may NOT use/operate a powder actuated tool until you:

- Read and understand the tool manufacturer's instruction manual.[4]
- Receive appropriate training as required by OSHA (which may include hands-on training from an authorized instructor and successfully completing a written examination provided by the tool manufacturer).[5]
- Receive special instruction if you are unable to distinguish colors used in the color code system to identify proper power levels.

Following your training and instruction you MUST be capable of:

- Reading and understanding the tool manufacturer's instruction manual.
- Cleaning the tool correctly.
- Recognizing any worn or damaged parts or defective operation.
- Recognizing the number-color code system used to identify proper power levels; and
- Using the tool correctly within the limitations of its use and correctly operating the tool in the presence of the instructor.

Reading this training manual and successfully completing the exam at the back of this training manual does NOT qualify, certify, or license you to operate a powder-actuated fastening tool or system. You must obtain training and instructions from your powder-actuated tool manufacturer or (where applicable) other authorized instructor before using any powder-actuated fastening system.

But receiving training and instruction on one tool does not qualify you to operate any other powder-actuated tool. Failure to get and follow OSHA-required training, and instruction from the manufacturer of each powder-actuated tool could result in serious injury to the operator or others nearby.

Laws, regulations (such as state and federal OSHA regulations) and standards (such as ANSI A10.3 - 2013) governing the safe use of powder actuated tools may periodically be revised. Any such revisions may change the safe operating methods described in this booklet and/or the training required to become a safe and qualified operator of powder-actuated tools. PATMI is not responsible for any such revisions that occur after this training manual is published. It is your responsibility to maintain familiarity with current laws, regulations, and standards that apply to the tool you are using.

4 See the Appendix for links to manufacturer's instruction manuals.

5 See Appendix for links to manufactures that offer on-line instruction/training.

EXAM

After studying this manual, you should be able to answer the following questions.
The exam is only a study guide and does not qualify you to operate specific tools.

1. You must have a certified tool operator's card to operate the tool. T F

2. The operator should never place his hand over the muzzle of the tool to cock or close the tool. T F

3. Tools should never be used where flammable or explosive vapors are present. T F

4. Use the tool for its intended application only. Horseplay or clowning around is not permissible. T F

5. Malfunctioning tools can be used and do not have to be removed from service immediately. T F

6. It is not necessary for operators, assistants, or adjacent personnel to wear eye protection when operating the tool. T F

7. Before fastening into any questionable material, the operator should determine its suitability by conducting a center punch test. T F

8. Never fasten into material that will permit the fastener to penetrate and escape. T F

9. The operator should make sure that the tool is perpendicular to the work surface when firing. T F

10. Test fastenings should always be made with the highest powder load level. T F

11. Never place your finger on the trigger until you are ready to make the fastening. T F

12. In the event of a misfire, you should extract the powder load/booster immediately. T F

13. Powder loads of different power levels and types should be kept in separate compartments or containers. T F

14. Hearing protection shall be used when making fastenings. T F

15. Safety shields or spall guards supplied with the tool by the manufacturer should be used on the tool whenever possible. T F

16. It is not important to read the operators instruction manual before operating the tool. T F

17. Powder loads should never be pried out of a tool. T F

18. The fastener should always be placed in the tool before the powder load. T F

19. Only fasteners designed and manufactured to function compatibly with powder actuated tools should be used. T F

20. Never fasten into cracked or spalled concrete. T F

EXAM - ANSWER KEY

1. True	Page 37, Section XIV
2. True	Page 35, Section XIII
3. True	Page 35, Section XIII
4. True	Page 34, Section XIII
5. False	Page 35, Section XIII
6. False	Page 34, Section XIII
7. True	Pages 17-18, Section VIII
8. True	Pages 17-18, Section VIII
9. True	Page 35, Section XIII
10. False	Page 35, Section XIII Page 14, Section V
11. True	Page 35, Section XIII
12. False	Page 36, Section XIII
13. True	Page 36, Section XIII
14. True	Page 34, Section XIII
15. True	Page 35, Section XIII Page 15, Section VI
16. False	Page 37, Section XIV
17. True	Page 35, Section XIII
18. True	Page 35, Section VIII
19. True	Page 7, Section IV
20. True	Page 36, Section XIII

CAUTION

IMPORTANT

This training manual is designed only to expose you to the general nature of powder-actuated fastening systems and their use. Reading this training manual and successfully completing the exam does NOT qualify, certify, or license you to operate a powder-actuated fastening tool or system. You must obtain training and instructions from your powder-actuated tool manufacturer, manufacturers authorized instructor, or (where applicable) state authorized instructor before using any powder-actuated fastening system. However, receiving training and instruction on one tool does not qualify you to operate any other powder-actuated tool. Failure to get and follow OSHA required training, and instruction from the manufacturer of each powder-actuated tool could result in serious injury to the operator or others nearby. Laws, regulations (such as state and federal OSHA regulations) and standards (such as ANSI A10.3-2013) governing the safe use of powder-actuated tools may periodically be revised. Any such revisions may change the safe operating methods described in this training manual and/or the training required to become a safe and qualified operator of powder-actuated tools. PATMI is not responsible for any such revisions that occur after this training manual is published. It is your responsibility to maintain familiarity with current laws, regulations, and standards that apply to the tool you are using. The information and recommendations contained in this document have been obtained from sources believed to be reliable. The Powder Actuated Tool Manufacturers Institute, Inc. makes no warranty, guarantee, or representation whatsoever as to the absolute validity or sufficiency of any representation contained in this document and the Institute assumes no responsibility for the use or misuse of the material contained herein. It should not be assumed that all acceptable safe operating methods are contained in this document or that other or additional measures may not be required under certain circumstances or conditions.

Facts About PATMI

PATMI provides a common industry voice for manufacturers of power actuated fastening systems. With operator safety as its primary goal, PATMI stresses training, certification, and safety awareness. PATMI associate members include suppliers of expendable good related to the industry, who are not directly involved in the manufacture of powder actuated tools. Membership and associate membership in PATMI is a statement of concern for the welfare of the powder actuated tool industry and the safety of industry customers.

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