

LIFTING MAGNET SELECTION

PUBLIC DOMAIN INFORMATION

DETAILED GUIDE

INTRODUCTION

Lifting magnets may be electro or permanent, and may be installed and used as single magnets or as arrangements of multiple magnets. In all of these cases, making an optimum selection of lifting magnet components to handle steel plate and shapes requires a thorough knowledge of the application.

The factors that dominate the lifting magnet selection for any specific application are:

1. Weight, shape, and contact area of the objects to be lifted.
2. Surface conditions of load and magnet.
3. Stiffness of load.
4. Range of sizes and shapes to be lifted.
5. Frequency of occurrence of the different sizes and shapes.
6. Adjustment of lifting power for less than full magnet face utilization.
7. Temperature of load material.
8. Ambient temperature.

Consideration of each of these factors will lead to identification of the magnet type, shape, number, and face contour best suited for economy, efficiency, and safety.

WEIGHT, SHAPE, AND AREA OF LOAD

Weight, shape and contact area must be considered at the very beginning in lifting magnet selection. The contact area of the load controls the required magnet number and size almost as much as the weight of the load. If a given load offers a relatively small surface area to the magnet face, then a magnet has to be selected that has a magnetic field that will "penetrate" the load thickness, so that holding power is sufficient for the load involved.

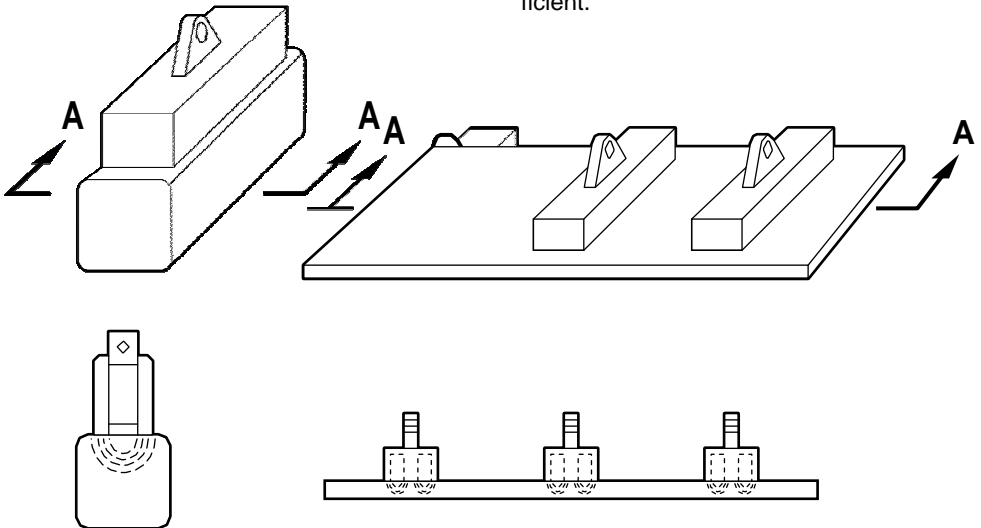
But if the same load offers a much larger contact area magnets of a different type, or smaller magnets of the same type, but more of them, can be used. These smaller magnets need not produce a field with such deep penetration into the load because the power of each magnet can be multiplied by the number used.

Generally speaking, as gaps between poles increase, the depth of field, or penetrating ability of the magnet, increases. For a given physical size,

magnets with two poles will have greater gaps than those with three poles and, accordingly are usually better suited for thicker loads. Conversely, three-pole magnets are normally the logical choice for thinner loads.

A billet and a flat plate are sketched, each with the same weight. The type of magnet arrangement used for efficient lifting in each case is shown. As indicated above, a two-pole magnet is used for the billet and three pole magnets for the plate.

The billet offers comparatively small contact area in relation to its weight. The plate of the same weight offers a considerable contact area. A magnet for handling the billet must penetrate the billet material to get adequate holding or lift power. But this same magnet would be inefficient for lifting the plate because the shape of its penetrating field would result in considerable fringing outside the relatively thin plate. For lifting the plate an arrangement of multiple smaller lifting magnets is more efficient.



Section A-A

Section A-A

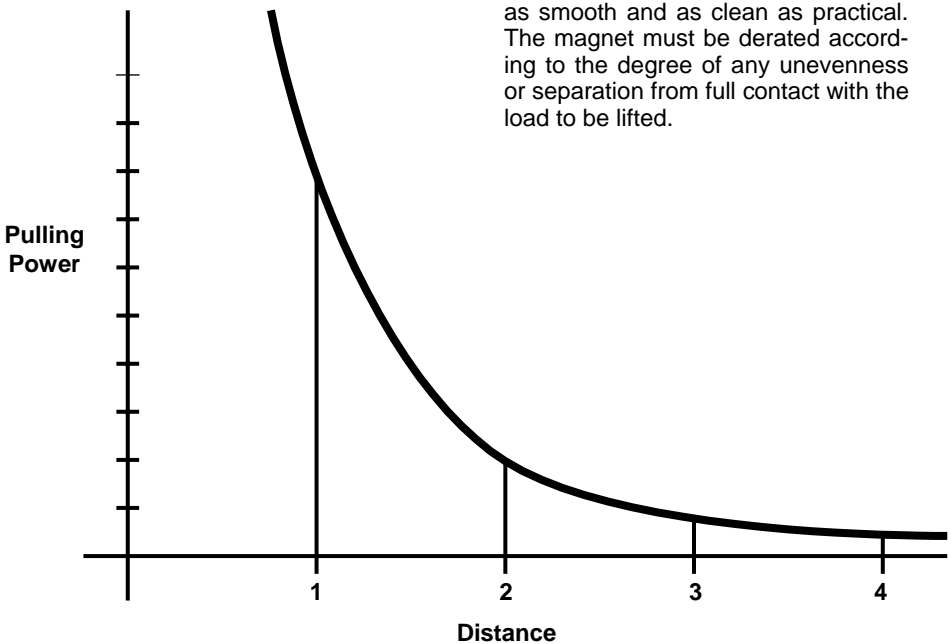
SURFACE CONDITION OF LOAD MAGNET

Only when there is no space between the mating surfaces of the magnet and load can the full lifting ability of the magnet be put to work. The familiar "inverse square law" tells us that the pulling power of a magnetic pole decreases rapidly as the distance between magnet face and load is increased. The graph illustrates this effect. We see that a magnetic pole with a given pulling power at 1 unit of distance will have only 1/4 that pull at 2 units of distance, 1/9 that pull at 3 units of distance, etc.

For holding or lifting magnet applications we are concerned with distances between magnet and load measured in fractions of inches (or only a few millimeters). These distances are very small in comparison to the dimensions

of the magnetic poles and loads themselves. Also, we are frequently concerned with magnetic field shapes more complex than those created by a single magnetic pole. Although the inverse square law will continue to apply in these cases, these "real world" effects may reduce its APPARENT significance. That is, the pulling power of a given real world magnet will not necessarily drop off as the square of the gap between the magnet face and the load as long as that gap is small. Nevertheless, there is a considerable loss of lifting power when surface separations as small as .1" (2.5mm) occur. These separation distances are caused by normal machining grooves on the magnet face or by normal irregularities such as scale, pitting, or paint on the load.

It follows then that for maximum efficiency from a lift magnet, both the magnet face and the load surface must be as smooth and as clean as practical. The magnet must be derated according to the degree of any unevenness or separation from full contact with the load to be lifted.

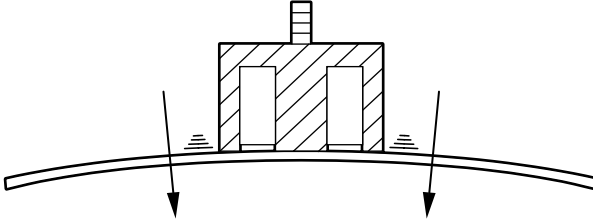


STIFFNESS OR FLEXIBILITY OF LOAD

If the load is balanced, and is stiff enough so that there is insignificant sag or droop of the portions of the load that overhang the lift magnet(s), then no consideration of load stiffness is required. But, if the overhanging portions of the load may sag, the magnets must

magnet face. The sketch shows how this force causes a peeling action opposing the holding force.

This peeling action tries to take the load off one pole of the magnet at a time. This is not resisted by the full rated magnet strength because the magnet



be positioned on the load to minimize peeling effects. Also, even if sag is not a factor, if the magnets cannot be placed on center the strength of the magnets must accommodate the resulting unbalanced load condition.

The holding or lift power of a magnet is rated with the pull of the load perpendicular to the face of the magnet, but droop of the load overhang causes a force that is not perpendicular to the

rating depends on contact and pull of load against all magnet poles at the same time. Normally, assuming the magnets are of sufficient strength to cover all other factors, the peeling effect is not detrimental if the overhang of a flexible load falls within the limits shown on the chart below. Outside those limits the magnets should be de-rated appropriately.

In cases where there may be large

SHEET OR PLATE SAG CAUSED FROM OVERHANG WHEN USING LIFT MAGNETS

UNSUPPORTED OVERHANG	12" (305)	18" (457)	24" (610)	30" (762)	36" (914)	48" (1219)	60" (1524)	72" (1829)
MATERIAL THICKNESS	AMOUNT OF SAG IN MATERIAL CAUSED BY ITS OWN WEIGHT							
(.75)	(9)	(43)	(135)	(334)	...	UNSAFE	UNSAFE	UNSAFE
22 Ga. (.0299")	11/32	1-11/16	5-5/16	13-5/32	...	...	...	...
18 Ga. (.0478")	1/8 (3)	11/16 (17.5)	2-3/32 (53)	5-5/32 (131)	10-5/8 (270)	...	...	...
16 Ga. (.0598")	3/32 (2.5)	7/16 (11)	1-11/32 (34)	2-9/32 (58)	6-3/4 (171)	21-9/16 (548)	...	...
14 Ga. (.0747")	1/16 (1.9)	9/32 (7)	7/8 (22)	2-1/8 (54)	4-3/8 (111)	13-13/16	...	...
11 Ga. (.120")	...	3/32 (2.5)	11/32 (9)	13/16 (21)	1-11/16 (43)	5-11/32 (136)	13-1/32 (331)	...
3/16 (4.7)	...	1/16 (1.5)	1/8 (3)	5/16 (8)	11/16 (17.5)	2-3/32 (53)	5-1/8 (136)	10-5/8 (270)
1/4 (6.5)	...	1/32 (1)	3/32 (2.5)	3/16 (4.5)	3/8 (9.5)	1-7/32 (31)	2-15/16 (75)	6-3/32 (155)
5/16 (8)	...	...	1/16 (1.5)	1/8 (3)	1/4 (6.5)	25/32 (20)	1-7/8 (48)	3-29/32 (99)
3/8 (9.5)	...	...	1/32 (1)	3/32 (2.5)	5/32 (4)	17/32 (13.5)	1-15/16 (49)	2-23/32 (69)
1/2 (12.7)	...	...	...	1/16 (1.5)	3/32 (2.5)	5/16 (8)	3/4 (19)	1-17/32 (39)
3/4 (19.1)	...	...	...	...	1/16 (1.5)	1/8 (3)	5/16 (8)	11/16 (17.5)

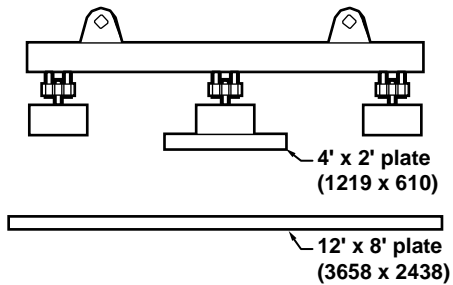
amounts of load droop, two other factors must be considered by the system designer and operators. These are: (1) the possibility that the load may assume an overall "arc" shape that does not match the linear arrangement of magnets on the lifting beam - the load effectively lifting any central magnet(s) at the expense of increased forces on the end magnets, and (2) the possibility of load "bounce" during transition portions of the lift - where the effective peeling load may be multi-

plied by large factors due to the transient acceleration of the unsupported portions. Both of these effects must be minimized by careful lifting beam design, where the lifting loads at each magnet position are calculated by taking account of the flexibility and possible transient behavior of the load, and by appropriate operating restrictions. In some cases, the magnets may be attached to the lifting beam using springs to help equalize the forces where there is extreme load droop.

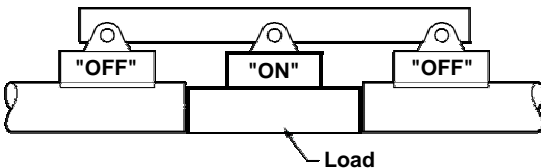
SIZES AND SHAPES TO BE LIFTED

For practical reasons most lift-beam and magnet assemblies are used on a wide range of load sizes. This is particularly true when the assembly is used to unload or load flatcars or trucks where the load can be plates of varying sizes at one time and bars or beams or other structural shapes at another. The assembly must be designed with the proper selection and arrangement of magnets so that it is efficient on the full-range of items handled. If, for example, a magnet and lift-beam assembly is used to unload plates that vary in size from 12' x 8' (3658mm x 2438mm) down to 4' x 2' (1219mm x 610mm) the magnet layout to handle the smaller plates will not handle 12' x 8' (3658mm x 2438mm) plates efficiently. Even if there is adequate lift power in the layout for the larger plates,

overhang would be excessive. Obviously, we have to arrive at a magnet layout dictated by the larger plates. This layout will then result in magnets overhanging the smaller loads as shown in the sketch.



Whenever the magnets overhanging the load cannot be energized because of some limiting factor of the operation, the control can be arranged so the overhanging magnets are "off" when they are not in contact with a load. An example of this might be when we want to lift only one beam or bar from a storage rack where the beams or bars - of varying lengths - are lying end to end. The sketch shows the way a short piece could be lifted from a storage rack in this situation.



VARYING LOAD SIZES AND SHAPES

It is obvious that if an assembly of lift magnets is to handle loads with relatively consistent size, weight and shape 95% of the time, and some much larger and heavier loads about 5% of the time, we would have to select and space the magnets for an efficient lift on the larger load.

But when this difference between the largest, seldom-encountered load and the smaller, commonly encountered load is vastly different, we should examine the costs involved to see if the system is truly economical. Such an analysis can lead us to a compromise as to amount of magnet to be used.

EXAMPLE: 4' x 8' x 1" (1219mm x 2438mm x 25mm) plate is to be handled almost all the time with a lift magnet assembly. Occasionally, much heavier, larger, and thicker plates are to be encountered. Rather than sizing the magnetic system for the heavier plates, consider sizing the magnet lift assembly to the common lightweight plates and plan to use other approaches on the rare heavier and larger plates.

You could (a) use a sling and hook arrangement to lift the heavier plates by welding temporary lift eyes on the heavier plates, or (b) perform any burning or cutting that would normally be done on the larger plates before you unload them.

Often a very large load variation as described would dictate a high initial magnet cost for total magnetic handling. With the approach described the user gets the laborsaving and speed advantages of magnetic handling on 95% of the material handled. Further, the lift beam can be designed for future possible magnet additions that would make the system completely automatic.

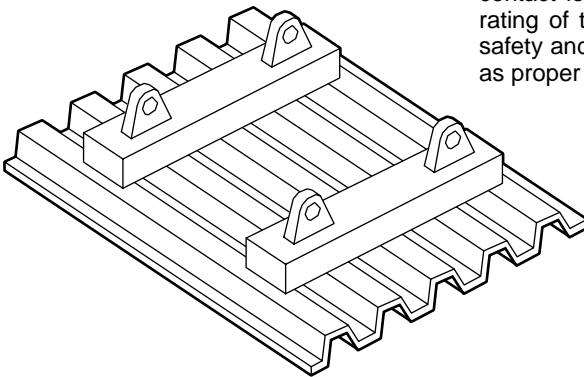
The point is that a study of all factors of economy, cycle time, manpower available, and a clear definition of the actual number of times an outsized load is encountered can result in a significantly reduced initial magnet system cost.

PARTIAL MAGNET FACE USE FOR LIFT

Whenever the load surface is not uniform over the magnet face, flat lifting magnets can be used but must be de-rated in proportion to the load area actually contacting the magnet face.

When lifting a sheet of expanded metal there will be poor contact on the magnet face because of the high points on the expanded sheet. Further, the openings in the sheet will not offer a solid path for the magnetic circuit. Almost the same consideration is required when handling flat perforated sheet. Although these sheets are flat, with no high points that prevent flush load and magnet contact, the holes in the sheet also prevent a solid path for the magnetic circuit. With both applications the effective lifting power of the magnet will be a function of:

- (1) Percentage of sheet area actually contacting flush with the magnet face.
- (2) Quality of the path the sheet offers to the magnetic circuit from pole to pole.



When a load is flat for a definable portion of its overall area, a simple calculation of the proportion of the magnet face that is covered will allow us to estimate magnet holding power. For example, corrugated sheet is to be handled as illustrated. In this case half of the magnet face is covered, so the lifting power on this corrugated sheet is estimated to be about one half what it would be on a solid sheet of the same thickness.

The situation is more complex when considering loads that offer little flat contact surface to the magnet. There are so many varied-shaped loads possible that they cannot be classified easily. In many cases, comparing the contact area with the contact area of a flat solid load will allow an approximation of the lifting power of a magnet on the irregular load. In other cases, particularly when more accurate estimates are required, a 3D finite element magnetic field analysis may be carried out by a magnet supplier, and/or actual comparative pull tests - using physical specimens - may be required.

The important point is that a partial contact load requires appropriate de-rating of the magnet - for reasons of safety and efficient operation - as well as proper design.

LIFTING MAGNETS WITH SPECIAL SAFETY FEATURES

If a load is lifted with one or more electromagnets, a failure of electric power to the magnet(s) during lift or transfer would cause the load to drop. Depending on the load and location of lift and transfer, the results of dropping the load could be:

1. Of no consequence, as in the case of scrap yard magnet handling scrap between pile and railroad car.
2. Damage to the load, if finished items or loads subject to bending or breaking are being handled.
3. Damage to structures below.
4. Disastrous, if the lift and transfer is made in an area where personnel might inadvertently be located.

When protection against failure of the lifting capability of the magnet is required, consider the use of magnets with special safety features.

Permanent magnets are now available that use electricity only to negate the field and that require deliberate action by an operator to release a load. The lifting power is generated by the permanent magnet component. When the electromagnetic coils are activated, load holding flux lines from the permanent magnet are temporarily diverted so that the holding power at the pole face is zero. Since there are no moving parts, there is no need for concern about a mechanical malfunction.

Similar protection can be obtained from permanent turn-off type magnets. These permanent lifting magnets use additional permanent elements that can be rotated into position to negate the lifting field. Electricity is used only to activate the turn-off cycle. The turn-off cycle also can be manually activated, thereby making the holding and releasing function completely independent of an electrical power source.

The magnetic holding power is never lost with either type of switchable permanent magnet. A failure of the electric power supply, while it would render the crane inoperable, would not cause loss of load.

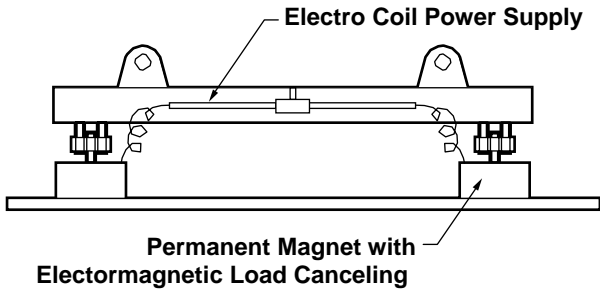
Electromagnets can be used in conjunction with an auxiliary power source (battery) that cuts in instantaneously if the main power source fails. The battery capacity can be sized to provide power for a reasonable time (usually 15-20 minutes) so that temporary slings can be rigged to secure the load and other precautionary measures taken.

In summary, special safety can be attained by three different avenues, and the one selected will depend on the load involved. These three approaches are:

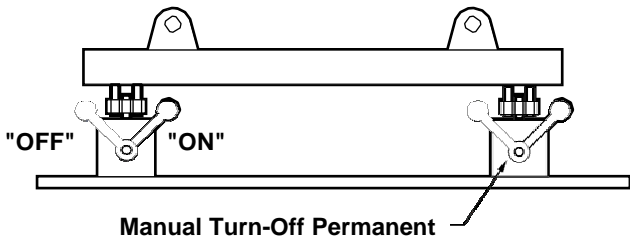
1. Permanent magnets with electromagnetic load canceling.
2. Permanent turn-off magnets with automatic or manually activated turn-off cycle.
3. Electromagnets with auxiliary, automatic cut-in power supply.

The sketches on page 11 outline these three installations.

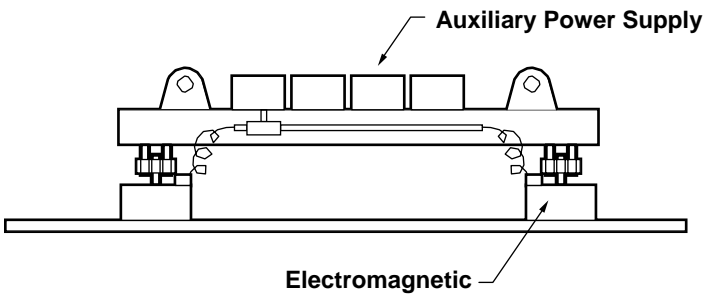
1



2



3



SAFETY FACTOR

Published lifting magnet capacities represent ultimate lift strength - the lifting capacity of the magnet on different loads UNDER IDEAL CONDITIONS - unless clearly specified otherwise.

It would be impossible to foresee all varying conditions of operation from one installation to another and to try to rate the magnet for each and every possible condition of operation. Instead, the magnet specifier must do this by applying a Safety Factor to the ultimate lift strength of the magnet, making sure that the safety factor applied represents actual conditions as much as practical.

Some of the operating conditions that dictate the applicable safety factor are:

1. Surface condition of load
2. Surface condition of magnet
3. Smoothness of lift
4. Flatness and stiffness of load
5. Centering of load on magnet
6. Environment
7. Voltage fluctuations (for electromagnets)
8. Unknowns

When any of these conditions are anything but ideal the specifier must apply a safety factor that will account for corresponding adverse effects on the ultimate lift strength of the magnets.

As an example, a safety factor can be arrived at by assigning a value to each adverse condition and adding the results, as follows:

$$\text{Safety Factor} = A + B + C + D + E$$

A - the load itself = 2 to 4

B - a surface condition of the load that is not perfect = 1

C - possible non-centered load = 1

D - undesirable conditions of environment = 1

E - all other unknowns = 3

$$\text{Safety Factor} = (2 \text{ to } 4) + 1 + 1 + 1 + 3 \\ = (8 \text{ to } 10)$$

In this case the specifier would select magnets that theoretically will lift 8 to 10 times the maximum load involved and will have the capacity to account for actual conditions expected.

The above is an example only. The particular way of defining and applying a safety factor, as well as assigning values to the effects covered by the safety factor, must be the responsibility of the specifying engineer for the lifting magnet application.

If a magnet is applied to a vertical load surface the load will tend to slide or shear from the pole face. In this case, the ultimate lift strength is typically reduced to 1/4 its normal value. Safety factors as previously outlined must then be applied to the reduced shear rating.

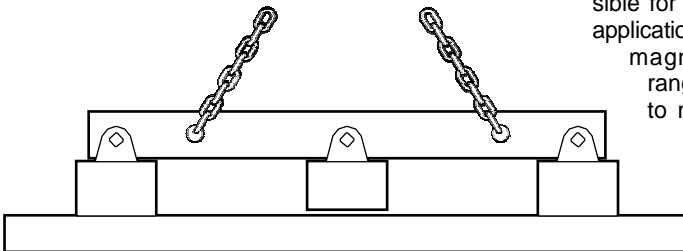
NUMBER OF LIFT MAGNETS FOR MAXIMUM EFFICIENCY

The most economical number of lift magnets for any particular application is one: a single magnet with a capacity rated for the load. The expense of attachment to a crane and wiring is minimized when a single magnet can be used.

However, using a single large magnet to lift large plates and sheets is not efficient. We must distribute the load-carrying capacity of the magnet over the entire plate area. A single magnet properly sized to distribute the lift capacity over a large area would be prohibitive in cost, and, because of its size, would produce a field too deep for anything but very thick plates.

To lift large plates and sheets, then, more than one magnet is required. From the wide range of magnet sizes, shapes, and capacities available we will generally have to consider multiple variations to be able to select the best size and smallest number of magnets to do an efficient lift job on the load involved.

Magnet weight, linkage weight, lift beam weight, and the load itself all add up to dictate the crane size required. So any way that this weight of magnets and attachments can be minimized will yield savings in crane and crane support costs.



When more than two lift magnets are used on a beam assembly, attachment to the beam must be arranged so that

all magnets can reach the load and none can be stripped off the load when the lift is made. This is most important when the magnet faces may not be perfectly aligned and a stiff load is handled - one that will not deflect to match the magnet faces. The sketch shows how one of the magnets is prevented from maintaining contact on the load during lift. The unevenness of the magnet face elevations is exaggerated in the sketch, but in effect this is the result when multiple magnet assemblies are not mounted correctly. The same end result occurs if the lift beam has excessive deflection under load.

Conversely, when several lift magnets are mounted loosely on a single beam assembly, while the magnet faces may be able to align easily with the load, it is possible for the load flexibility and overhang to combine in such a way that one or more of the magnets is actually lifted by the load. This not only eliminates those magnets as effective lifting components, but it adds their weight to the load which must be carried by the remaining magnets. This is a particularly deceptive variation of the "peeling" phenomenon discussed earlier. Springs in the magnet linkage can be used to counteract this effect.

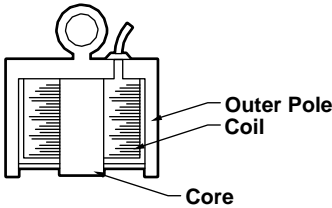
Summary: Use the fewest magnets possible for any particular lift application, engineer the magnet support arrangement carefully to maintain alignment of magnets and load, avoid arrangements that require the load to "push" the magnets

into position, and consult with the magnet supplier when setting up a beam assembly to lift flexible loads.

CONSTRUCTION OF LIFTING MAGNETS

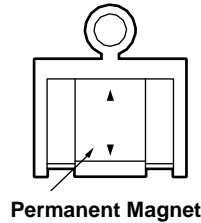
Lifting magnets fall into two general shape classifications: round and rectangular.

The round lifting magnet is built with a center pole (or core) and a round outer pole concentric with the center pole. This magnet can be either permanent or electro.



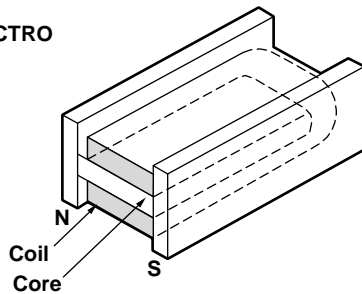
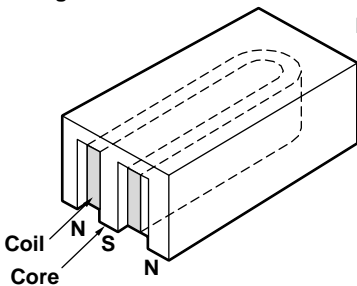
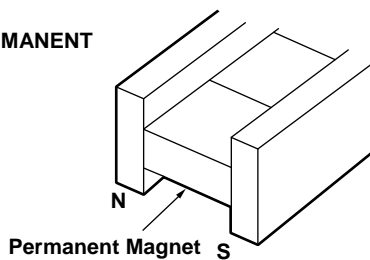
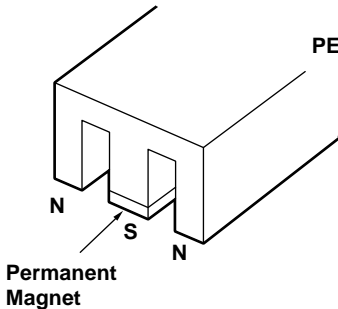
round lifting magnets, and hot rolled steel round bar stock is used for the center core of round electro magnets.

The rectangular lifting magnet is built with either of two basic magnetic circuits, the two-pole or three-pole circuit, and it also can be permanent or electro.



The round electro lifting magnet is most efficient when considering its face area as related to lift power. Because the outer pole is a consistent distance from the core or center pole, the result is a uniform magnetic strength over the magnet face area. Black iron pipe or steel tubing is used for outer poles of

Pole plate and core material will be hot rolled steel or low carbon steel. For the plates of rectangular lift magnets hot rolled steel plate is welded and joined into the required box shape. Using these stock materials, there is no limitation to lift magnet geometry, but round and rectangular lift magnets will usually prove adaptable to almost any lifting application.

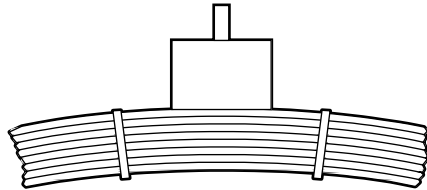
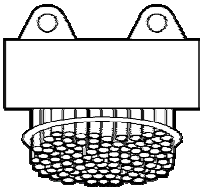


LIFTING LOADS WITH UNDEFINED SHAPES

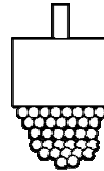
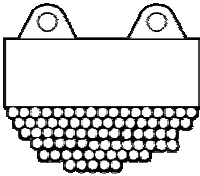
Generally, lift magnets are designed to handle loads that can be classified into plate, bars, structural shapes, and round stock. These configurations all offer a consistent and predictable surface to the magnet face. Therefore the magnet face can be matched to the shape of the load.

But there are unusual shapes and loads that can also be handled as long as we realize that because these shapes do

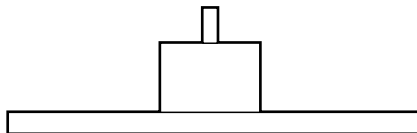
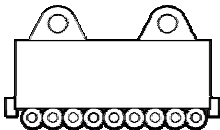
not match the magnet lifting surface we have to derate the lift magnets. Some of these shapes are shown, each being handled by flat-face lift magnets. It can be seen that it would be impossible to match the face of a practical magnet to all such varying loads, but it is possible to design the internal circuit of the magnet to achieve maximum efficiency on any of these loads.



Reinforcing Rods



Steel Balls



Pipe and Tubing

AUXILIARY POLE PLATES

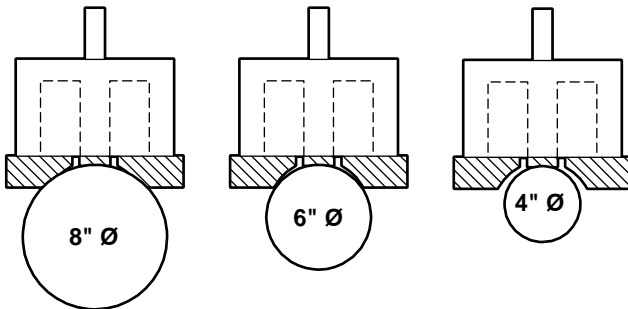
Auxiliary pole plates are added to the "integral" poles of a magnet on its working face when the integral magnet poles do not match a load shape closely enough for efficient handling. Auxiliary poles can be interchanged on a magnet at different times to match different loads.

Usually such poles will not reduce the holding power of a magnet from that produced if its integral poles had the same configuration as the auxiliary poles. However, the mating surfaces where the integral poles join the auxiliary poles must not introduce an air gap into the magnetic circuit or holding power will be diminished. To avoid this, the contact surfaces of both poles must be machined smooth.

When there is necessary relative movement (sliding) between a magnet and load, sacrificial auxiliary poles can be used to take the resulting wear. These auxiliary poles can be hardened or plated much more economically than could the integral poles.

Because holding and lifting efficiency of a magnet are based on maximum contact between magnet and load, the shape of auxiliary pole faces should match the load as closely as possible. However, the pole shape can be "compromised" or averaged over the range of shapes handled so that it is not necessary to change poles every time load size changes.

For example: To lift 4", 6" and 8" (100, 150, and 200mm) diameter steel bars, as well as flat loads, auxiliary poles with a single shape can be designed for handling the full range of round bar sizes. When flat loads are handled the auxiliary poles are removed. The operator must recognize that the lifting ability of the magnet will not be the same on each of these round shapes as it would be if each round shape had exactly matching poles. The sketch shows these "average" auxiliary poles. The auxiliary poles most closely match the configuration of the 8" (200mm) bar because this bar is the heaviest. Less contact is required on the lighter, smaller bars.

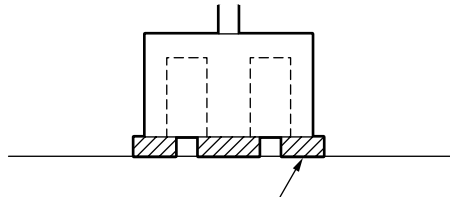


Even if load shape is constant and wear is not experienced, it can be more economical to do any machining of pole plates required to match load shapes on small auxiliary poles than on the main magnet face. After the machining is completed these poles can be permanently attached to the magnet. Using auxiliary poles can readily convert standard or stock magnets to specials with maximum

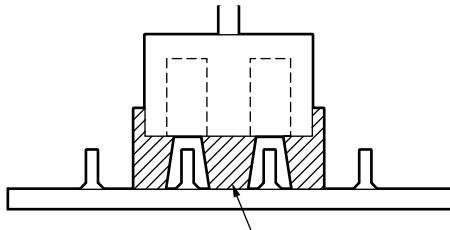
economy and minimum fabrication time.

Auxiliary poles are beneficial for handling hot material. They space the coil further from the source of heat and increase space for passage of circulating air.

Some auxiliary pole plate applications are shown below.



Chrome - faced auxiliary poles handle polished sheets without damage



Auxiliary poles allow magnet to reach flat surface of special shaped load.

DROP CONTROLLERS

Electromagnets hold a load by means of magnetic lines of force that are generated by the magnetomotive force of the energized magnet. When the magnet is de-energized, residual lines of force may remain if there is close con-

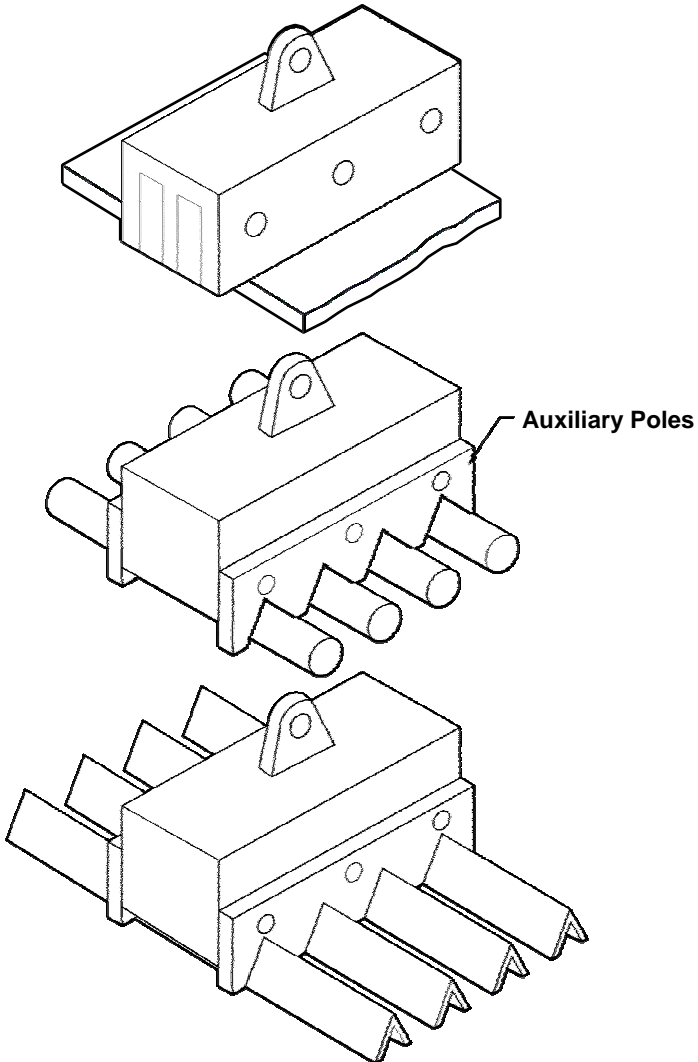
tact between the magnet and load. Reverse current drop controllers are used to apply reverse current to the magnet for cancellation of these residual lines. This cancellation results in faster release of the load.

TYPICAL APPLICATION EXAMPLES

Auxiliary Poles

The requirement is to lift and transfer plates, flat and round bars, and angles to a shot blast table. The bars and angles must be deposited on the shot blast table at the same spacing and in the same orientation at which they are used. Because the majority of lifts are

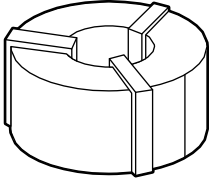
on flat plate and flat bars, the occasional handling of angles and round bars is done by adding auxiliary poles to the magnets. These are engaged only when the angles or round bars are handled, and provide the required spacing and the required magnet face contact on the angles and bars to make the lift.



TYPICAL APPLICATION EXAMPLES

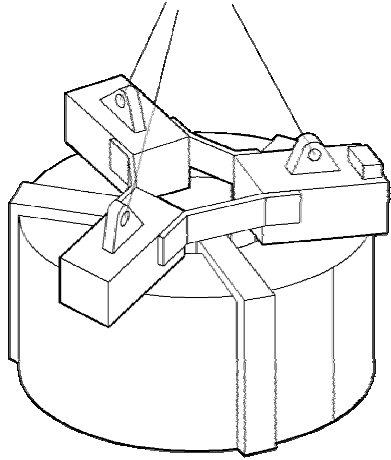
Lifting A Circular Coil

Coils of steel strip are to be lifted and moved using electro lift magnets. The coils vary in inner diameter (ID) and outer diameter (OD) and all have three banding straps as shown.



Rectangular lift magnets with a length dictated by the smallest ID and largest OD of the coil range are selected. The magnets will overhang the load on the ID or OD when any but a load with a minimum ID or maximum OD is handled. The number of magnets se-

lected is determined by the clear spaces between the three straps. If a lift magnet were allowed to rest on one of the bands, its lift capacity would be greatly reduced because the magnet face would not have full contact on the load.

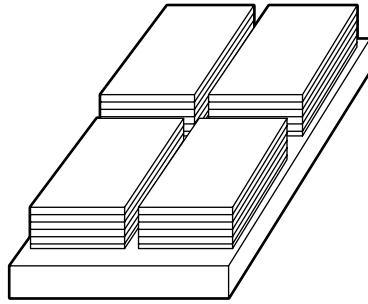
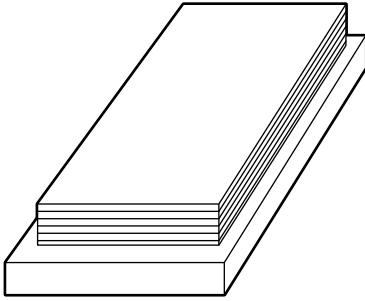


TYPICAL APPLICATION EXAMPLES

Lifting Plate of Various Sizes

Plates from one foot to four feet (300mm to 1200mm) wide and from four feet to eight feet (1200mm to

2400mm) long are handled. The plates arrive at the unstacking location in any of the arrangements shown depending on their width and length.



When more than one stack is on a common skid, only one stack is to be un-piled at a time. Here is a case where numerous small magnets, rather than a few large magnets, will be the best selection. The magnets are electro type or permanent turn-off type arranged in banks so only the magnets directly in

contact with the load to be lifted are energized.

The layout of magnets will be as shown, and the electrical controls designed so that all or any combination of magnets can be energized in order to selectively lift only one small plate at a time.

