

TRUNNIONS

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INTRODUCTION

In the following pages we will be discussing the recommended steps for setting up and adjusting trunnions. Over the years there have been many theories and designs, each having their own special requirements, advantages and/or shortcomings. In this revision I am going to try to address some of these issues more specifically than in past revisions. By reviewing the table of contents the reader will find sections specific to certain tasks, covering adjustment procedures for specific “categories” of drums, and sections covering specific problems. In many cases the information repeats. This is especially true of the section for “Double Barrels only,” this section details almost every step. However, not all the information contained herein applies to everyone. Where possible I have chosen to refer the reader to another section rather than repeat that section. I have tried to always use the title for the reference section just as it can be found in the table of contents. This way the reader can quickly find the appropriate pages. In other cases where a section may appear to repeat, the reader is cautioned to be aware of subtle design differences.

Other than for reasons of design difference, the component names and terminology used by the author may be different from those you are used to because terminology may vary between different manufacturers or different geographical areas. For this reason names and definitions of major components follow.

WARNING

This symbol is used throughout this text, and on safety signs, to call attention to safety instructions. These instructions are of great importance and should be followed.

COMPONENTS

DRUM. The rotating cylinder supported by the tires. The term is often associated with a parallel flow drum mixer. Dryer normally refers to a counter flow unit, usually part of a batch or continuous mix plant. However, for the purposes of this paper drum will also refer to dryers. The inner rotating cylinder (drum) of the Astec Double Barrel[®] drum mixer is a dryer.

FRAME. The structure that is the main building block of the drum (or dryer). It usually consists of two large “I” beams, parallel to the drum, with various crossing and support structures. It may also support the burner and burner blower or other equipment. The support platforms for the trunnions usually mount directly to the frame.

SADDLE. Used on many designs. Found on all Barber-Greene® and the smaller Astec® drums. A saddle is a piece, sometimes pieces, of metal used to support a tire. There will be multiple saddles between the tire and the drum. The burner end, or “hot end,” is sometimes left “floating” to allow for drum expansion. On this end the tire is held in place by “ears”, or sometimes “wedges” welded to the saddles but not the tire. The “cool end” (opposite the burner) is usually fixed. This means the tire is welded to the saddles. As a general rule, the weld should never run across a tire. The welds should run along the side of the tire (parallel to the face).

The floating tire and saddle method of mounting was used extensively by Barber-Greene. The design has the following important characteristic. First, on the expansion end (hot end) there is a gap between the saddles and the tire. This is to allow for expansion. This gap can be viewed (or measured) when the drum is **stopped while cold** by looking between the tire and the highest saddle (the one on top of the drum). When the drum is hot the gap is closed by expansion. Because the tire is not fixed to the drum, and the drum is not centered in the tire, when cold the drum will turn at a different speed than the tire. Thus, the tire and saddles will wear on each other. Over time this will cause the gap to increase in size. As the gap grows larger, wear will accelerate. This will eventually lead to the need to re-shim the saddles, and probably having to replace the ears also.

The Barber-Greene recommended gap between the saddles and tire is 1/16 of an inch when measured on top as described above. This works for almost all drums. There are naturally special situations where it may not. To determine exactly what it should be on your plant would require that you knew several factors and is simply not practical. Follow the manufacturer’s recommendations. But, just for the sake of information I would like to include the following.

Typically, the average steel used in drum manufacture has an expansion factor of about .0000065 per degree Fahrenheit.

For example: An 8 foot drum at 500° F would expand in diameter: $T \times .0000065 \times D$

Where:

T = Temperature difference (cold to hot) in degrees Fahrenheit. For example 500 - 60 = 440.

D = Diameter in whatever units are desired. (This same formula will also work for length).

Thus:

$440 \times .0000065 = .00286$ and $.00286 \times 8 \text{ ft.} = .02288 \text{ ft.}$ or $.026 \times 12 = .27456 \text{ inch.}$

In other words over 1/4 of an inch in diameter. Note that this is 4 times more than the recommended gap! However, we have not factored in the expansion of the tire or any of the other components. Remember too that we want it tight when hot. Also, metal if restrained in one direction will tend to expand in others, etc. etc....

SPOKE. Used on the Astec tire design. These are actually like spokes on a wheel except they lay flat and act like a spring also. The spring action allows the drum to expand without applying additional strain on the tire. This design never requires shimming, as there is no gap to preset. The design changes most of the load carrying points of the drum and tire from the bottom to the sides. Astec spokes are made of Core-Ten A to resist strain aging. They have a tensile strength of 50,000 pounds per square inch.

Note: Core-Ten B and A-588 are not substitutes for Core-Ten A.

THRUST ROLLERS. The rollers attached to the frame, which will ride against the side of a tire, to limit the movement of the drum. There is generally one thrust roller to limit up-hill movement and another to limit the downhill. The thrust rollers usually are on opposite sides of the same tire. Because of expansion they do not work well when against different tires, however, there are manufacturers that have placed them this way. There may even be two sets of thrust rollers (this is very rare). Whatever the design, their purpose is the same: **to limit the movement of the drum, not to control it.**

There is at least one trunnion design that may not use any thrust rollers. These are drums equipped with flanged trunnions, like a train wheel. With this design the flange is intended to ride against the tire and thus limit drum travel.

Astec thrust rollers are surface hardened in the same manner as the trunnions.

TIRE. The large steel ring(s) that go around the drum. Sometimes spelled tyre. Some manufacturers use, or have used, cast tires and others “roll” their tires requiring they be welded.

Astec tires start life as a solid cylinder of steel, its size and weight is determined by what size tire it is to become. Typical tire materials are 1030 or 4130 steel, although this is not always the case. The billet is placed in an oven and brought to malleable temperature (red hot). A hole is punched through the billet, and it is placed on a set of special rollers. It is then “rolled” to near finished dimensions. During the punching and rolling process the future tire is kept at malleable temperature. After cooling the tire is taken to a large turntable where it is machined to final dimensions. **At no point in the process is the tire hardened.** Tires usually have a hardness between 180 and 200 BNH (Brinell Hardness). Tires do gain linear strength from the rolling process as the grains in the steel are aligned. Tires typically have a tensile strength of about 90,000 pounds per square inch.

Modern Astec tires are forged using the same technique described above. However, prior to machining they are austenitized, water quenched and then tempered. The austenitizing cycle involves heating the rings to 1600° F and holding them for a prescribed amount of time. Immediately following the austenitizing cycle the rings are water quenched. Then the rings are tempered at 700° F for 4 hours.

Astec tires are machined to a finish of 125 RMS (Root Means Square, the smaller the number the smoother the surface) and surfaces are held true to within 10 thousandths. Most tires are finished to 250 RMS, and surface specifications are usually plus or minus 1/64 inch. Surface specifications refer to sides being parallel and the surface perpendicular to the sides, as well as flat.

TRUNNION. The steel rollers that support the drum by way of the tires. Over the years there have been trunnions made of steel, cast, rubber, and who knows what else. This paper will reference only steel trunnions, which are by far the most popular. Drums used in the asphalt industry generally have four trunnion rollers. Very long drums, used in other industries, may require more.

Steel trunnions start as a forging or billet, slightly larger in diameter than the trunnion it is to become and several inches longer (the extra length allows it to be held while being machined). A common type of steel used is 4142. First a hole slightly smaller than the final ID is bored through the billet. Then it is turned to the final OD (or rough turned to just over). It is then flame hardened to **45 - 52 Rockwell C, at least 1/8 inch deep**. To prevent the edges from cracking, the last 3/8 of an inch in from each edge is not hardened. The trunnion then is “finished”, the keyway is cut and all dimensions brought to final specs. NOTE: Sometimes the trunnion is final finished and then hardened, in either case the outcome is this: **TRUNNIONS ARE HARDER THAN TIRES**.

For comparison purposes only. If trunnions and tires were put on the same hardness scale, trunnions would be two to three times harder than tires. A Rockwell C value of 52 equals a BNH of about 512.

There are several reasons for hardening the trunnions and not the tires. Similar metals, when run against each other, have a higher coefficient of friction than dissimilar metals. Thus, by simply making the trunnions and tires out of different steels we can lower friction and reduce wear. Even if the trunnions and tires were made of the same type of steel, we can reduce friction by changing the physical characteristics (hardness) of one component. Hardening the trunnions only accomplishes this. Thus, we have the best of both, dissimilar metals with different physical characteristics.

Hardening only the trunnions also helps promote uniform wear between the trunnions and tire. Even though there are two trunnions working against the surface of each tire, the tire still has a much greater surface area. This greater wear area alone is enough to outlast several trunnions when properly maintained.

TRUNNION DESIGNS

There have been many trunnion designs over the years and even more ways of mounting them. There are flanged trunnions, rubber tired trunnions, “flat” trunnions, “sloped” trunnions and more. On some designs the trunnion platforms are completely separate from the drum frame. Trunnions may be mounted on bearings and turn on a fixed shaft. Or the trunnion may be fixed to the shaft while the shaft turns in bearings. The trunnions may be idlers or actually drive the drum (trunnion drive). Some drums tie two drive trunnions to one motor. There are many possible combinations.

It is simply not possible to address all designs here. However, there are two basic designs that are by far the most prevalent. They are the “flat” and “sloped” designs. Both of these designs have been and are used by Astec and Barber-Greene. As an example of the “sloped” design the current Astec trunnion design (as described in **The Astec Trunnion Design section**) will be used. “Flat” trunnions will mean those designs that differ from the Astec design as described in the following explanation.

On “sloped” trunnions the face contact angle does not change when the trunnions are skewed. Because of the triangular-shaped frame section, the pivot plate turns in the same plane as the tire face (**Figure 1-b**). On trunnion designs where the trunnion pivot plate sits flat and level with the frame (**Figure 1-a**), the face contact angle changes as you skew a trunnion. With the “flat” trunnion design you cannot preset face contact.

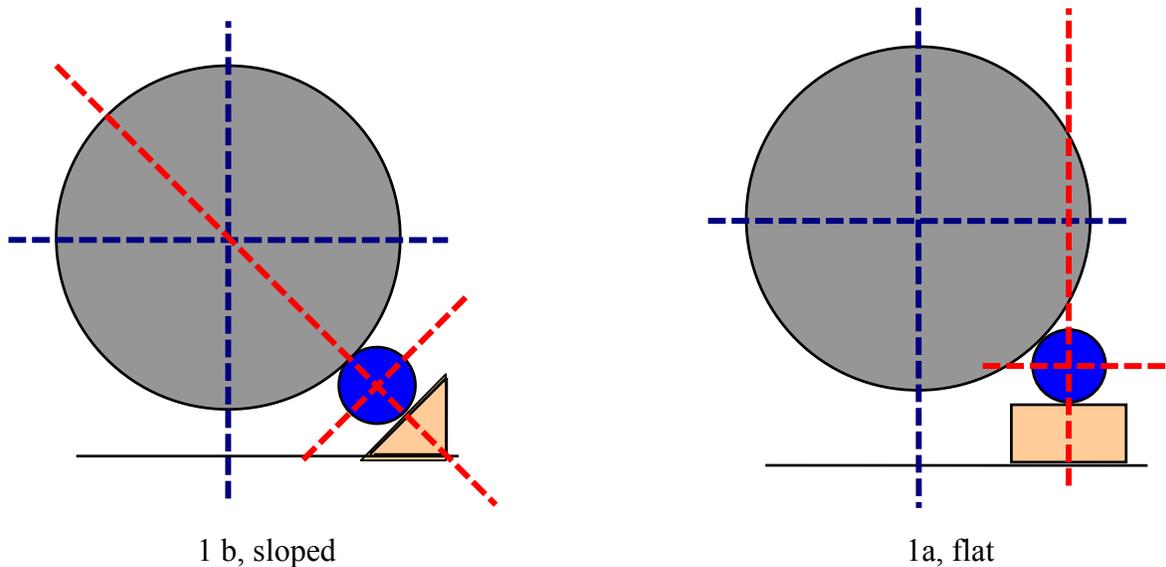


Figure 1

THE ASTEC TRUNNION DESIGN

The current trunnion design used by Astec is a refined version of a design patented by Barber-Greene. It offers distinctive advantages over other trunnion designs. The design is distinguished by the 41° (approximate) triangular shaped trunnion support section. For an example see **Figure 2**. This places the pivoting adjustment plate perpendicular to a line that would run from the center of the drum, through the tire/trunnion contact point and on through the center of the trunnion. The mounting angle of this plate ensures that the face contact angle will not change as the trunnions are skewed. There is also a center pivot pin that ensures the trunnion to drum centerline dimension can never be lost (see **Figure 6**). The following discussion refers to the recommended steps for adjusting trunnions on drums equipped with the current Astec style trunnions (unless otherwise noted). Other styles of trunnions and some drum designs may require that a different procedure be used. Most of the Astec Double Barrel Mixers incorporate this design. Exceptions are some of the smaller models.

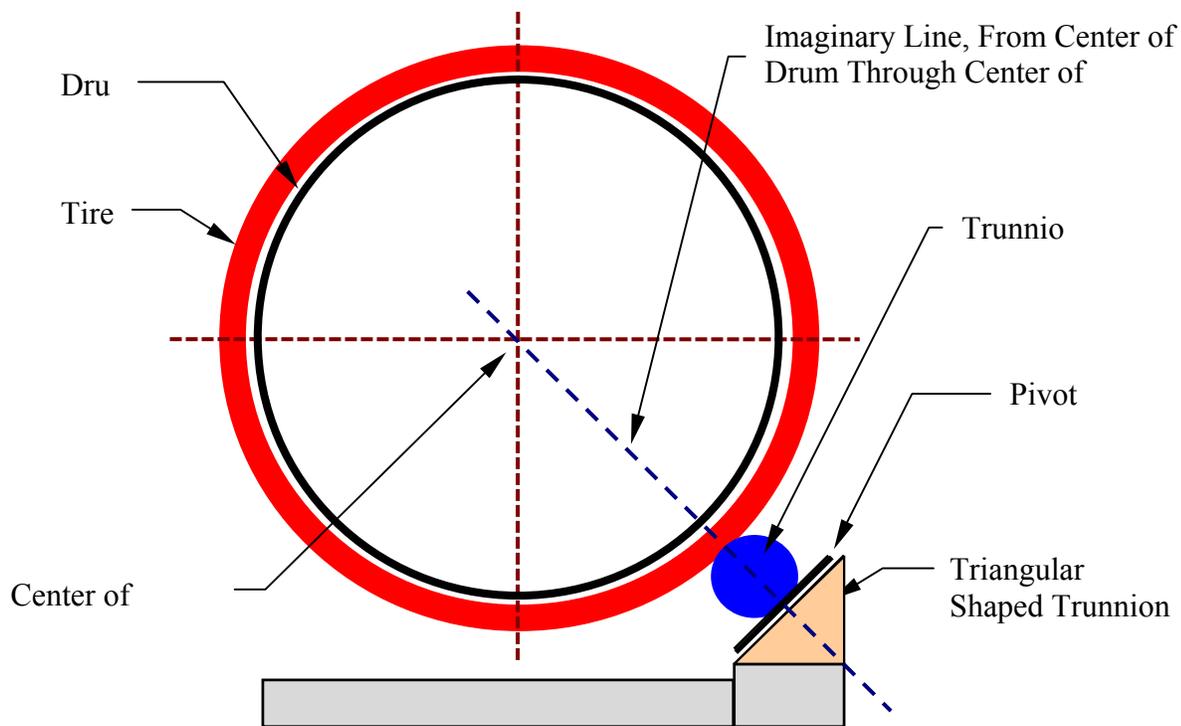


Figure 2 .

WARNING

Before attempting to work with this equipment, carefully read and follow the instructions given in the service manual. If there are any questions about the safe operation and maintenance of this equipment, contact the manufacturer's service department.

DANGER

DEATH AND INJURY MAY RESULT FROM WORKING WITH THIS EQUIPMENT WITHOUT FOLLOWING A "LOCK-OUT" PROCEDURE AS DESCRIBED IN THE OSHA REGULATIONS.

- **Never attempt to lubricate, clean, or adjust any machine part, unless it is stopped and the power is totally locked out.**
- **To avoid falls when working above ground level, use the proper safety, supporting, lifting, and suspension equipment. Inspect all such equipment and be sure it is in good condition.**
- **Account for all personnel before starting any piece of equipment.**

SETTING THE FRAME AND DRUM

Before you start there are several factors that should be considered. **Foremost the plant site must be flat, level, and hard.** Next, one must consider whether the drum is a portable or stationary model. On a portable drum the frame and drum must be set every time the plant moves. On a stationary unit it is often a one time affair. On an existing permanent installation, changes or corrections may be difficult. However, if there is a problem and the drum frame is a contributing factor, you have no choice. Beware of the effects changing the slope of a drum may have on any rigid components (asphalt piping, hot oil piping, natural gas lines, propane piping, duct work, electrical conduit, etc.).

On portable units proper “set-up” is critical to trunnion and tire life. Every time a plant moves the drum must be “set-up” again. If it is not “set” exactly the same way every time, then improper wear patterns will be the result. Remember, the trunnions and tire are constantly wearing into each other. If the contact angle changes for any reason in any direction, the wear and loading characteristics between the trunnion and tire will change. This forces the components to wear into a new pattern. During this “wear in” time component wear is accelerated. Also, as the components are “wearing in” a drum can be very difficult to control. Thus, it is critical that the drum frame be “set” the same every time. It is worthwhile to take the necessary time and proper care to do the set-up correctly each time you move.

It would be possible to fill volumes with different situations that may require different approaches. It is more practical to state the ideal situation, in other words, what we would like to achieve. The following three procedures string-line, level, and slope are actually all done at once. This is because adjusting one may change one or both of the others. For simplification we will address them individually. The order this author is going to follow may or may not work best for you.

These procedures apply to all drums regardless of trunnion design!

STRING-LINE

Run a line down **both** sides of the drum frame, from one end to the other. It is usually easiest to go along the bottom of the frame. If you have to use spacers at each end to clear structure or components, then do so. Spacers can be made of anything. Just make sure they are of equal length. On portable plants you may want to make them permanent. Pull the string tight! There can be no bow in the string, or this entire step is useless (or worse). Use a good string that can take the pull. I know of instances where the customer has used piano wire. With the string held away from the frame a measurement can be taken from the string to the frame to find high or low areas. Most portable plants have jacklegs. Use these to straighten the frame. Some portables may have the benefit of a hydraulic erection package. If so, fantastic! Just be careful not to over-lift a corner of the unit and bend the frame. On permanent installations use shims or whatever between the frame

and foundation to do the same. One benefit of the frame being straight is that all frame supports are more likely to be carrying the same load.

Keep in mind there are irregularities in the steel. So take measurements over an area. String-line accuracy directly affects how many shims will have to be used under the trunnions. This procedure is more critical on a portable unit than a stationary. On a stationary unit, once set, the frame should never move again (see **settling**). Thus, small errors can be corrected during the procedures given herein. However, on a portable unit you do not want to have to repeat everything every time you move. It is a lot of work to set face contact! The only way to insure you do not have to re-set face contact by re-shimming is to bring the frame back to a known position **every time** you move. The easiest position to find every time is also the right one ... **straight!**

SLOPE

The end-to-end slope of the drum should be predetermined. Slope is usually specified by the manufacturer in either inches per foot or in degrees. **Figure 3** is a table that will allow you to convert from one method to the other. A slope meter or a level and ruler (tape) may be used to determine slope. The level and tape method is usually preferable because a longer section of frame can be sampled with a level and tape. Also, most slope meters are simply not accurate enough (unless you happen to have a very good one). **Figure 4** demonstrates the correct way to use a level and tape to determine slope.

Setting slope is required when setting a new plant and any time you move a plant. Another reason may be because of engineering changes. If you do have to set a drum, or change the slope, here are a couple of thoughts to keep in mind:

- Unless the frame is perfectly straight (as in string-lined) you may measure different slopes at different locations. You may in fact, be forced to run string lines to even get straight enough to set slope. **Do not wait. Run a string line first.**
- You may want to try taking a slope measurement off the drum shell. Does it equal the frame? If not, why? Beware of uneven shim packs under trunnions. Also, watch out for excessive wear of the trunnions and/or tire, especially on older plants. Remember, it is the drum that needs to be sloped to the manufacturers recommended angle for proper function.

Length of Level in Inches	3°	4°	5°	6°	7°	8°
6	5/16	13/32	17/32	5/8	23/32	27/32
9	15/32	5/8	25/32	15/16	1-3/32	1-1/4
12	5/8	27/32	1-1/32	1-1/4	1-15/32	1-5/8
18	15/16	1-1/4	1-9/16	1-7/8	2-3/16	2-1/2
24	1-1/4	1-11/16	2-3/32	2-1/2	2-15/16	3-11/32
30	1-9/16	2-3/32	2-5/8	3-1/8	3-5/8	4-3/16
36	1-7/8	2-1/2	3-1/8	3-3/4	4-3/8	5
48	2-1/2	3-11/32	4-3/16	5-3/64	5-29/32	6-3/4

For those of you who are mathematically inclined, use the following formula to solve for the required vertical rise.

$$\text{Tangent (Slope Angle)} \times \text{length of level} = \text{Vertical Rise Distance}$$

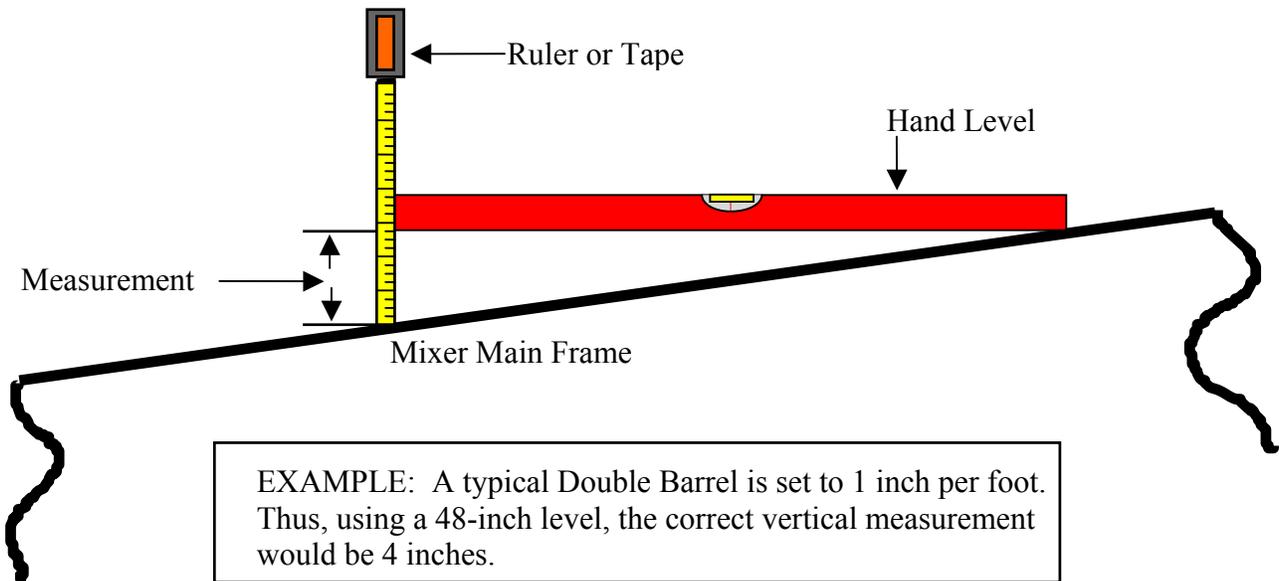


Figure 4. Example of using level to establish slope

LEVEL

Check the side-to-side level of the drum frame, using a device long enough to span straight across the frame. Of particular importance are the blocking points, which are generally also right under the trunnions. Make sure the frame is level side to side. Use the jacklegs, shims, or whatever is necessary to level the frame.

If one side of the frame is low the entire load will be shifted to that side. Often a problem in the frame shows up as a trunnion problem. For example, bearing failures only on one side. This problem often takes some time to show itself. One frame problem that does not take long to show up is the result of one corner being high or low. This is the worst situation you could create. In this case not only will the load be shifted, the amount of the total load any one trunnion is carrying will change as operating parameters change. This will tend to make the drum seem uncontrollable. This condition can be found not only by checking the side-to-side level, but it may also show up when string-lining.

SETTLING

Getting everything set perfect does not guarantee it will stay that way. Consider how heavy a drum is. Then add to this the fact that it is in motion. This motion naturally has a certain amount of unavoidable vibration. These factors can cause a foundation to settle. Perhaps you need to tweak the initial settings described above. Provide the best foundations possible. Make whatever preparations necessary to the ground before setting foundations. Remember the three things a plant site must be: flat, level, and hard. Use materials that will not crush or compact. With proper preparation you can avoid problems associated with settling. However, if you do start experiencing trunnion or tire problems, do not rule out the frame just because it **was** done right.

DANGER

DEATH AND INJURY MAY RESULT FROM WORKING WITH THIS EQUIPMENT WITHOUT FOLLOWING A “LOCK-OUT” PROCEDURE AS DESCRIBED IN THE OSHA REGULATIONS.

- **Never attempt to lubricate, clean, or adjust any machine part, unless it is stopped and the power is totally locked out.**
- **Any item that is subject to shifting during maintenance should be secured in a way that will prevent it from moving (even if all potential sources of energy have been locked out).**
- **To avoid falls when working above ground level, use the proper safety, supporting, lifting, and suspension equipment. Inspect all such equipment and be sure it is in good condition.**
- **Account for all personnel before starting any piece of equipment.**

TRUNNION ADJUSTMENTS

Once the frame is “set” you are ready to start adjusting the trunnions. There are two basic adjustments, face contact and skew. Following are general explanations of both.

FACE CONTACT refers to the contact area between the trunnion and tire. **Figure 5** shows “right and wrong” face contact. Basically, add or remove shims under the trunnion bearings until the surface contact is as even as possible. This sounds simple, but the catch is that the drum must be jacked up to change shims and lowered to check the results. This can be very time consuming. Thus, many people make their best guess and leave it. This is a big mistake. Component parts will always “wear in” to each other. How long this takes is determined by several factors. One of the most critical factors is how much contact area is being affected. If allowed to “wear in” to an improper face contact setting, the drum may become difficult, if not impossible to control. Also, replacement parts will not properly mate with the old parts, thus, they will wear at an accelerated rate.

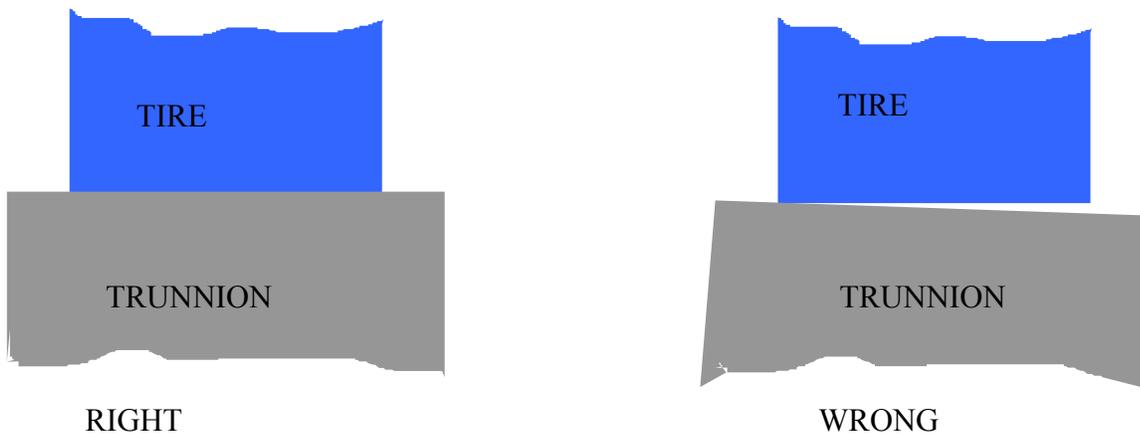


Figure 5. Face contact.

SKEW REFERS to the angle, or twist, of the trunnion in relationship to the tire. Skewing the trunnions is how we control the drum. The trunnions are used to “steer” the drum.

NOTE: On “sloped” style trunnions the face contact and skew adjustments can be made independently of each other without adverse affects. However, on drums with the “flat” style trunnion design, face contact changes as the trunnion is skewed. Face contact should be set, or at least checked, after each time the trunnion is skewed. It is possible to get close by first setting the trunnion(s) to zero skew, then estimating the initial amount of gap needed (and on which side of the trunnion it should be). The gap is closed as the trunnion is skewed. After skewing the trunnion the face contact should again be checked. Changing face contact after the trunnions are skewed may require that the trunnion skew be adjusted again. This may possibly require that the face contact be adjusted again.

After making any adjustments the drum should be run long enough to allow the new wear pattern to develop before making another adjustment. Adjustment results will change as the trunnion and tire wear into the new pattern. Make small adjustments and allow at least 20 to 30 minutes running at capacity before judging the results. The one exception to this rule is when a major adjustment must be made to prevent the equipment from damaging itself.

SETTING FACE CONTACT

Remove the guards so that the contact area between the tire and trunnion can be seen. See if there is gap, how large it is, and which side it is on. This will give you a good idea of the size and number of shims you may need to add or remove and from what sides. The smallest shim you have to work with is 1/32 of an inch thick. If you add or remove a shim from only one side of a trunnion, the effect will be 1/2 the thickness of the shim. Because of this you can adjust to within 1/64 of an inch. Remember what you are working with! It is near impossible to get perfect contact on a new component. An acceptable gap would be one that allows you to only slide a dollar bill in part way (no more than its width) from the edge of the trunnion.

On many units the face contact can be safely viewed while the unit is running. On elevated units the contact point can often be seen while standing on the ground, even with the trunnion guards on. Watching the unit run will allow you to see if the contact changes. This is especially important when working with new equipment. It is very difficult for a manufacturer to get a tire on a drum perfectly straight and even harder to do in the field.

To change shims you must somehow take the weight of the drum off the trunnion. Variations in frame and trunnion designs do not allow for a detailed explanation of how to jack up the drum. Some possible solutions may be found in the section “Lifting the drum” following this section. Some general rules to follow are:

- Do not jack directly against the surface of a tire if it can be avoided.
- Do not jack directly against the drum shell, if it can be avoided.
- If possible, raise one entire end at once.

You may have to lift just one side at a time by “tipping” the drum onto the opposite trunnion. If you do this, be sure to block between the tire and trunnion on the opposite side from where you are working so the drum cannot roll. In any case, do not raise the drum any higher than necessary. Just take the weight off enough to add or remove shims.

Once you get the weight off the trunnion, you will have to raise the trunnion, shaft and bearing(s). This can usually be done with a pry-bar.

The shim packs go under the bearings, on top of the pivoting plate. **Do not shim under the pivoting plate!** This will negate the benefit of the trunnion base design. See **Figure 6** for shim location.

Make sure whatever type of jack you use can carry the weight. Make sure the jack cannot slip. Weld or build platforms for the jack if necessary. Block or chain the drum so it cannot turn. Do not let your hands (or anything else) get into any area where you would be caught if the jack fails or the drum turns.

If there is paint or rust on the tires or the trunnions you may have to clean it off, or allow it to wear off, before establishing final face contact. Get as close as you can in the beginning. Do not allow the components to wear into an undesirable pattern. More often than not, the paint or rust will be so uniform that additional adjustments will not be necessary. However, the reaction of the drum to the trunnions will change rapidly as the surfaces wear down to good steel. **Keep an eye on it.**

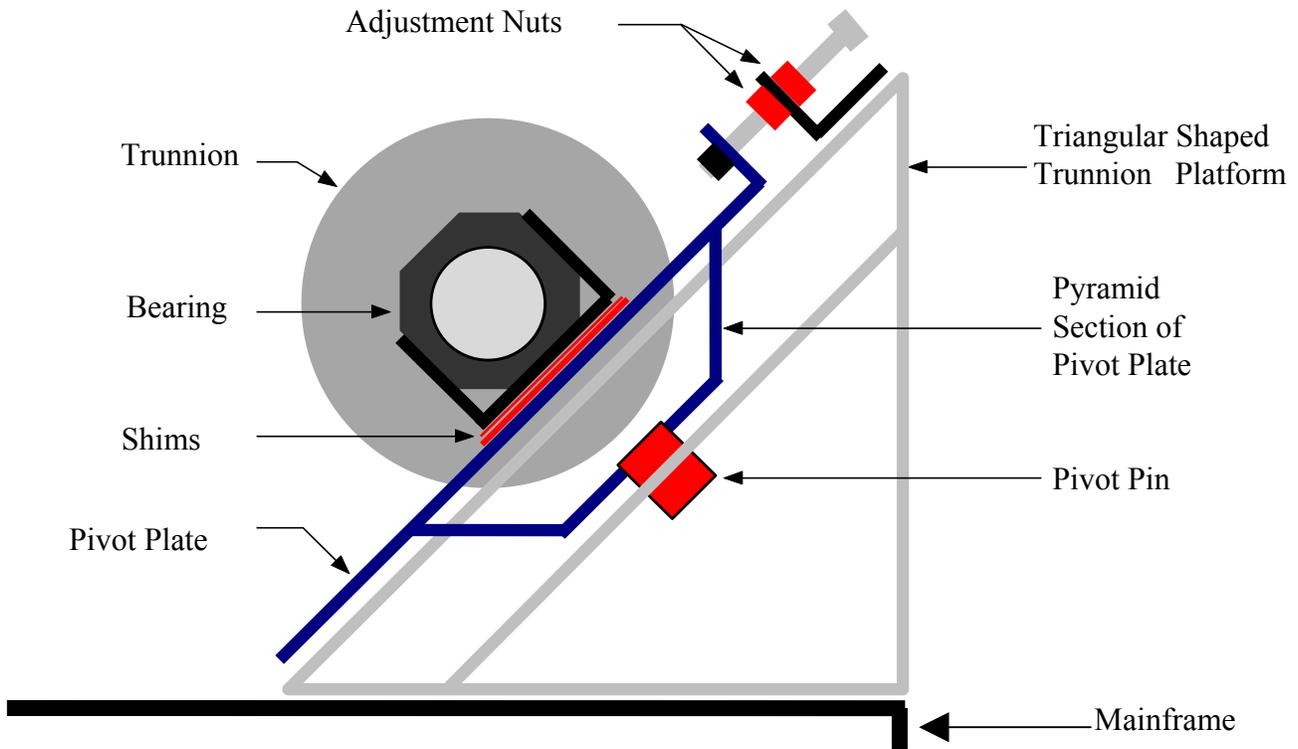


Figure 6. Side view of trunnion assembly.

LIFTING THE DRUM

If you are setting a new plant, moving a plant, or just happen to have a large crane, the easiest way to lift the drum is to use a crane. Simply sling around the drum and lift one end at a time.

Unfortunately this is rarely an option. If you are fortunate enough to be able to use a crane:

- Take care not to raise the drum too far. There may be structure or components that will be damaged if the drum is lifted into them.
- Go easy, do not “drop” the drum back onto the trunnions. This is a sure way to cause “flat spots”.
- As always, make sure all personnel are clear before raising or lowering the drum.

Most of the time you are going to have to use a jack, or jacks, to raise the drum. Again, if possible it is preferred to raise one entire end at a time. This is preferred to “tipping” the drum to one side because it is much less likely that the drum will roll. However, it is still recommended that the drum be blocked between the trunnion and tire not being raised to reduce the chances that it may roll.

When blocking a drum to prevent it from rolling block the trunnions that you are **not** taking the weight off. Make “stops” that can be placed between the tire and trunnion. Wood wedges work very well, especially hardwood, and are easy to make. Steel has a tendency to slip on steel. Hard rubber can also be used, as can many other materials. Place a “stop” firmly between the trunnion and tire on both sides of the drum to prevent it from rolling in either direction.

It is also possible to use chains, cables, winches, come-along, slings, ropes, shipping brackets, and many other items to keep the drum from rolling. The idea is to prevent the drum from turning, not bind it solid. It must be able to move enough to allow the weight to be taken off of the trunnion you are changing the shims on. For example, chaining from the tire to the frame in both directions will prevent the drum from rolling, assuming the chains are tight. However, as the other end of the drum is raised the chains will tighten more. At some point something will have to give. Just be sure whatever technique you use to hold the drum will not damage anything.

How big of a jack is needed? The size of jack needed depends on how large a drum is being lifted and where the jack can be put. Most of the time a 20-ton hydraulic bottle jack will do the job. A typical 8-foot drum, or dryer, will weight 15 to 20 tons (just the drum, this does not include the frame or burner), so a jack this size can easily lift one end. It can be used to tip larger units. The problem is usually where to put it.

I have seen cribbing used to build a platform to set the jack on. This is fine. Just remember the drum is setting at a slope. If cribbing, blocking, or some other form of platform, is used make sure it is solid. You are either going to have to place blocks, or shims at the top of your platform so it matches the slope of the drum or you will have to let the jack sit crooked to it. Either way you will have an angle, either above the jack or below it. Make sure your jacking system is sound.

On many drums there are supporting frame members spanning from one side of the frame to the other. These “crossing” frame members are often heavy enough to jack against. Being part of the frame they will usually also be setting at the same angle as the drum. These are the first things I look at when searching for a jacking point. However, rarely can they be used.

If there is a crossing frame member directly under a tire, it is usually too close to get a jack into. The problem is compounded when working on the end where the thrust rollers are. Even if there is room there is usually not enough extra to allow for a pad. It is not good practice to jack directly against the tire face. It is better to have a pad. A piece of brass works well. If none is available use steel. Anything to help prevent the jack from indenting the tire face. You want to use something that is smooth and covers as much area as possible. More often there is beam crossing the frame somewhere under the drum shell. It is definitely not a good idea to jack against the drum shell. The drum shell is not designed to carry a heavy load form the outside, and definitely not when that load is applied to a small area. It is very easy to dent or buckle the drum shell. Some drum shells are only 5/16 of an inch thick. Some are 1/2- inch thick. The thicker shells may be stronger but they are also heavier. If you absolutely have to jack against the shell get as close to the end of the drum as possible.

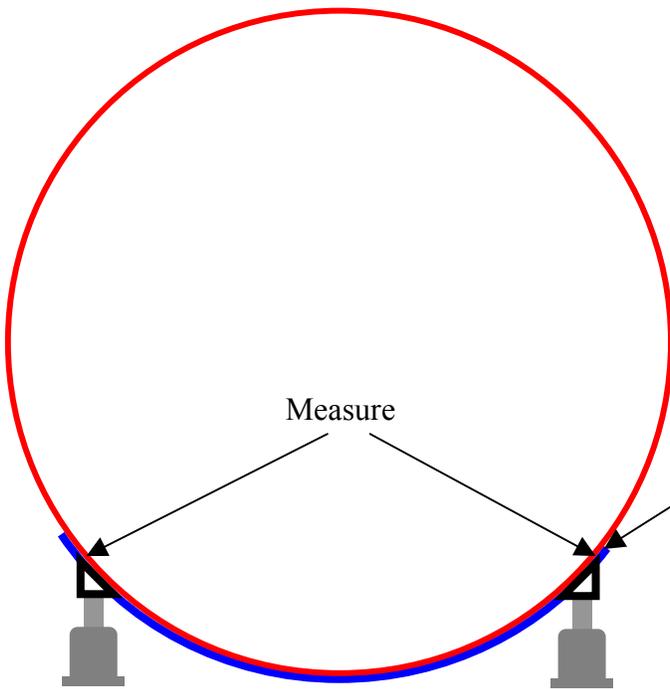


Figure 7a. Saddle with jacks for lifting drum.

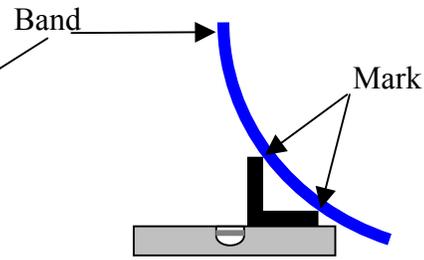


Figure 7b. Establishing angle location.

A very good technique that can be used to lift one end of a drum is to build a saddle. A saddle can be used against the drum or tire. The saddle I am describing can be made with two pieces of heavy angle iron for the jacking points and a piece of bar stock or plate for a band. Please refer to **figure 7a**.

Before building a saddle determine if you can use one. Saddles can be made to fit just about all drums, but there are exceptions to everything. Determine where you can put your jacks. As shown in **figure 7a**, there will be two jacks involved, one on each side. The jacks can sit on the mainframe or on a crossing member. If given a choice, position the jacks so the angles will be level (please refer to the paragraph explaining how to determine the length of the band, which follows).

To make a saddle, start by making the angle pieces the jacks will push against. Cut two pieces of 3 inch by 3 inch or larger angle to a length equal to or greater than its sides. This is not a critical dimension, just be sure you have plenty of room for the jack head. This is why a 3 x 3 angle should be the smallest considered. The angle must be a minimum thickness of 3/8 inch for drums up to 8-foot, and 1/2 inch for larger drums, the heavier the better.

To determine the length of band (bar or plate) needed you must first locate where the angles need to be. To do this you will need a level. Place the open side of an angle against the drum or tire so that one flange is vertical and the other horizontal (please refer to **figure 7b**). While holding the level against the bottom of the angle, move the angle up or down until it is level. When level, make a mark above and below the angle on the drum (or tire). These points should be directly above where you intend to put your jacks. If you cannot put a jack directly under this point move the angle in or out (up or down) until it is above a spot where you can place a jack. Make your marks here. Using a flexible tape measure around the drum or tire measure the distance between the two outside marks

(refer to **figure 7a**). Add at least 2 inches to this measurement for welds. This is the minimum length the band needs to be. If you want to add a little extra length to the band to add a hook or loop to each end, do so now. A hook or loop on each end will allow you to throw a rope over the drum, pull the saddle into place, and hold it while you position the jacks.

If you were not able to position the angles where they will be level, then you will have to weld a shim or plate to the jacking surface of the angle. This surface must be level. Level refers to a measurement taken straight out from the band, perpendicular to the main frame. The jacking surface will be at the same slope as the drum if you hold the level parallel to the frame.

Since the band is going to be under tension it does not have to be very heavy. A piece of 1/4 inch thick bar 3 inches wide will work fine. You don't need this much on smaller drums. You may want to use heavier material on larger drums.

Lay the band out flat and mark it appropriately as to where the angles need to be. Place an angle on the band. The open end should be against the band, just like it was against the drum. Make sure the angle faces are perpendicular to the sides of the band. This assures that the surface the jack is placed against will be at the same slope as the drum and frame. If the surface where you plan to put your jack is not at the same slope as the drum, make provisions now. The two jacking surfaces (the one the jack sits on and the one it jacks against) must be parallel to each other. This is to insure the jack will not slip. Once you have the angle positioned as necessary weld it to the band. Remember it will be carrying the weight of half the drum or more. Repeat the procedure for the other angle.

Do not worry about trying to roll, or pre-roll, the band to fit the drum. It will form to the drum (or tire) when you put it on. This is another reason it is nice to have a hook, or loop, on each end to run a rope through. You can use the rope to pull the saddle up tight. This will save you some jacking, especially the first time you use the saddle.

Finally, add your hooks or loops to the ends. A short piece of chain on each end works really well. This will allow you to either run a rope through a link or hook onto it with a chain or come-along. You only need three or four links. Weld the end link right to the outside of the band (please refer to **figure 7c**).



Figure 7c.

Tipping a Drum

You may run into a situation where you cannot lift one end. The drum may be too heavy. You may not have anyplace to put your jack, or jacks. Whatever the reason – you still have to set the face contact. To do this you have to somehow take the weight off the trunnion so you can change shims. You can tip a drum by placing your jack very close to the trunnion you are trying to work on. Sometimes it is necessary to place the jack right on the trunnion frame where you are working. The biggest concern when tipping a drum is safety. Safety must not be compromised. Be sure the jack is placed so that it can not “kick” out. Make wedges, brackets, shims, or whatever is necessary to position the jack so that it is square with both contact surfaces. Make sure the drum is properly blocked so that it can not roll as you lift it.

Setting face contact -- another possibility.

There is another way to set face contact other than changing shims. However, it requires that **all** the following conditions are true.

- The trunnions are of the “sloped” design.
- The triangular shaped trunnion platform section is separate and only bolted to the mainframe. See **Figure 6**.
- The unit is **not** trunnion drive.

When a trunnion is skewed on any plane other than perpendicular to a line that runs from the contact point between the trunnion and tire and the center of the diameter of the drum -- then face contact will change. This is the same principle discussed in the comparison of flat and sloped trunnion designs. Thus, by twisting the triangular shaped trunnion frame on the mainframe, face contact can be changed or set.

A good reason should exist before using this method to adjust face contact. Most trunnion designs are not made to be adjusted in this manner. Most units will not have a pivot pin or slotted holes in this area. Great care must be taken to not allow the trunnion frame to move away from the centerline of the drum frame, consequently loosing the critical centerline dimension. On most units the clearance between the bolts and the holes will determine how much adjustment can be made. **Do not remove the bolts.**

After adjusting make sure the trunnion platform is secure to the mainframe. It is sometimes desirable to make a small weld to insure the two frame sections cannot move (this is true for most designs that are not welded originally -- especially trunnion drive). Strategically placed blocks can serve the same purpose. Whatever you use, make sure it can be easily removed if ever necessary.

DETERMINING WHICH WAY TO SKEW TRUNNIONS

One of the most commonly asked questions is: which way do I have to turn (skew) my trunnions to make the drum move the right way? I highly recommend either of the following two methods:

METHOD 1

Go to the side of the drum that would be turning down towards you. In other words, this is the side to which the drum would roll were it to jump off the frame while running. Pretend you have hold of a trunnion shaft with one hand on each side of the trunnion—like the handlebars of a bike. It can be either trunnion **on this side of the drum** it does not matter. If you want the drum to go to the right, turn right. In other words, pull back with your right hand and push in with your left. If you want the drum to go to the left, turn left. It is the same procedure for both trunnions on this side. In fact it will be the same for all the trunnions. Once you have determined whether you need to make a right or left turn **on this side**, go to the other side of the drum. You will have to **make the same turn on the other side with both trunnions**. **The side faces of all trunnions must always be parallel!** If you were to view the results from directly above the drum this would be evident. Please refer to **Figure 8** for an exaggerated example. This method will work on any drum or dryer.

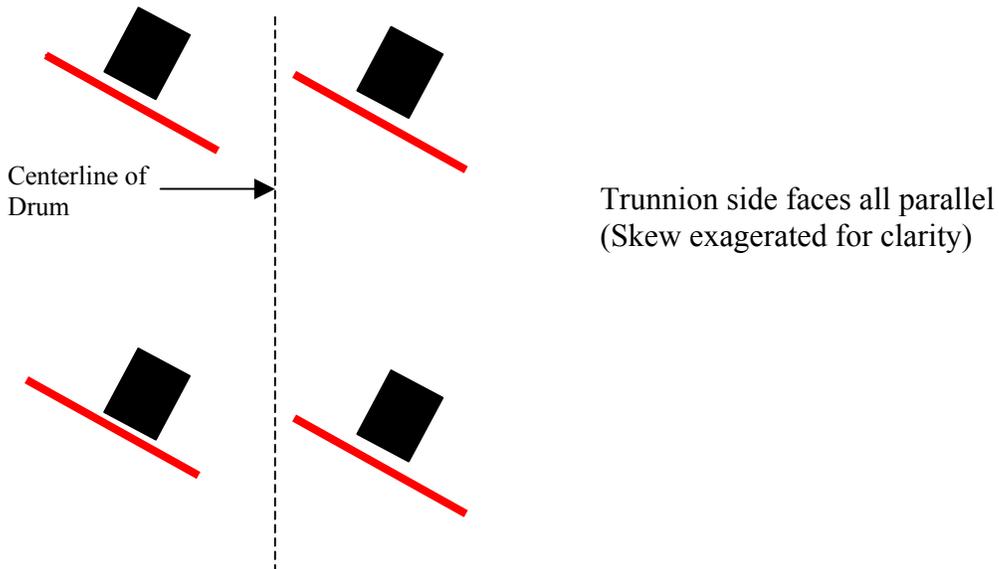


Figure 8

METHOD 2

The second method for determining which way to skew trunnions is to determine the direction of rotation. See **Figure 9**.

On drums with counter-clockwise rotation (viewed while standing at low end of drum) adjust as follows to make the drum move up-hill:

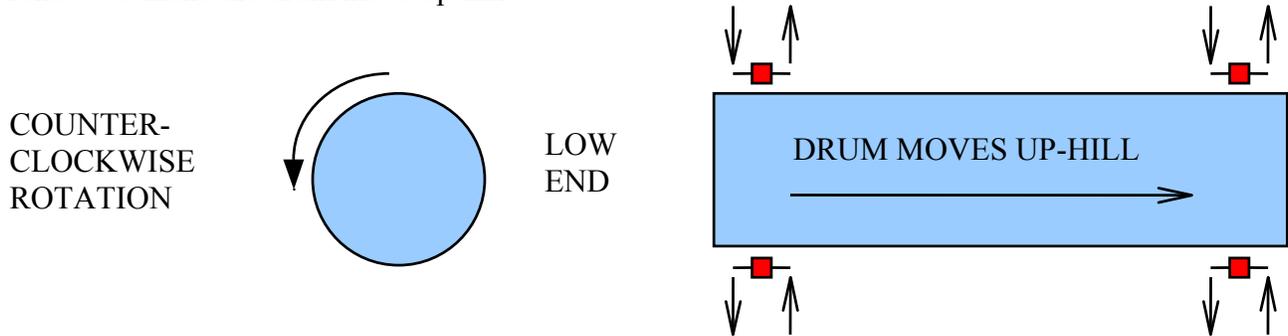


Figure 9.

When facing any trunnion, the right side should be pushed in towards the tire, and the left side should be pulled out.

To make the drum move downhill, skew the trunnion in the opposite direction of the above procedure.

For a drum with clockwise rotation (viewed while standing at the low end of the drum). Adjust as follows to make the drum move up-hill. See **Figure 10**:

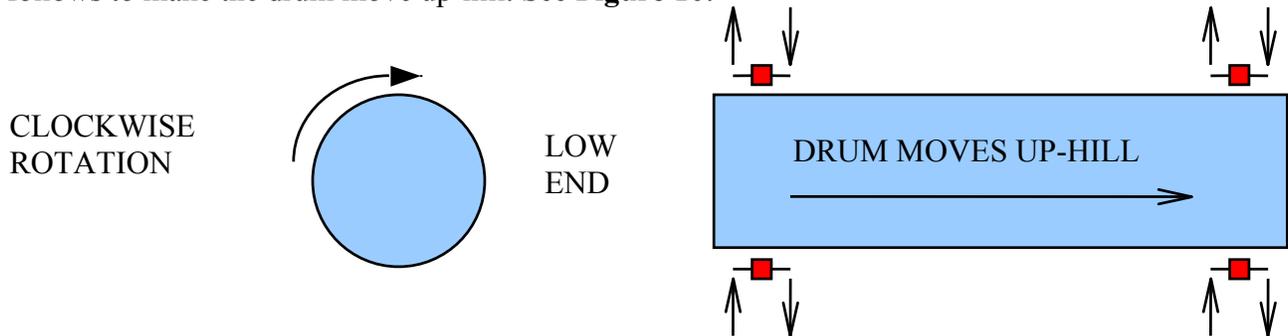


Figure 10.

When facing any trunnion, the left side should be pushed in, towards the tire, and the right side pulled out.

To move the drum downhill, skew the trunnion in the opposite direction of the above procedure.

This procedure will also work on any type of drum.

FINDING ZERO

Zero skew is when the sides of a trunnion are parallel with the sides of the tire it is against. In this condition the trunnions are not trying to steer the drum in either direction. This of course assumes the sides of the trunnion and the sides of the tire are square with their respective faces. If the trunnion or tire has been allowed to wear at an angle, then it will be of no value to establish zero (please refer to **Improper Face Contact**, in the **Appendix**). Failure to find zero after repairs, moving a drum, or at start up is one of the major causes of trunnion failures.

Loosen the bolts that hold the trunnion pivot plate to the base frame. These are large bolts that pass through slotted holes. There is usually a nut that you will have to hold. Using at least a four-foot straightedge (the longer the better), place the straightedge firmly against the side of the trunnion so that it extends up along side of the tire (see **Figures 11 and 12**). The trunnion is wider than the tire, so it will extend past the tire on at least one side. It does not matter which side you use. However, the side that overlaps the tire the most is usually the easiest to use. It is also acceptable, and often easier, to run the straight edge along the side of the tire under the drum. Running the straight edge under the drum sometimes also makes it easier to visualize which way the trunnion must be turned to make the measurements equal. This is particularly true when working on the “flat” style trunnions.

Measure the distance from the straight edge to the center of the tire at two points (refer to **Figure 12**). These points need to be as far apart from each other as possible. In other words, get as high (A) and as low (B) as possible to take your measurements. Be sure you are measuring to the tire. Again, measure to near the center of the side of the tire. Beware of the rolled edge that naturally develops on the outside of the tire. **Do not measure to it.** Zero skew is the point where both measurements are equal. At this point the trunnion and tire are parallel to each other.

The rolled edge is a result of normal wear. The tire is soft and simply gets rolled out.

We know that the trunnions need to be skewed in the up-hill direction. Thus, when setting zero, you should **skew the trunnion beyond zero in the downhill direction and then come back up-hill to zero.** This will take the backlash out of the threads of the adjustment nuts. This way when you do start to make your actual adjustments turning one flat of a nut will make the same change on all trunnions. To skew the trunnion you have to loosen the adjustment nut(s) on one side of the pivoting plate adjustment bracket before you can tighten the other side. **Turn the nuts not the bolt!** Use the nuts to move the pivot plate. You may need to loosen some nuts more than the nut you tighten. This is important to do now because of the **center pivot pin.** Please refer to **Figure 6** for a reference of part locations.

Many times trunnions are neglected because the adjustment nuts are too hard to turn. Often this is because the pivot plate is jammed tight against the pivot pin. This pin fits quite snugly into its hole. There is less than 1/32 of an inch of clearance. Thus, it is easy to jam the pin by applying too much force to the adjustment nuts. **If you cannot move a nut do not force it. Go to the other side.** As you push (or pull) on one side of the pivot plate the bolts basically get longer or shorter. Since the plate is pivoting, the bolts must be able to slide within their slots. It may be necessary to loosen all the nuts except the one you are trying to tighten.

After you have finished setting zero on all trunnions, **replace all guards.** It will not be necessary to have them off any longer.

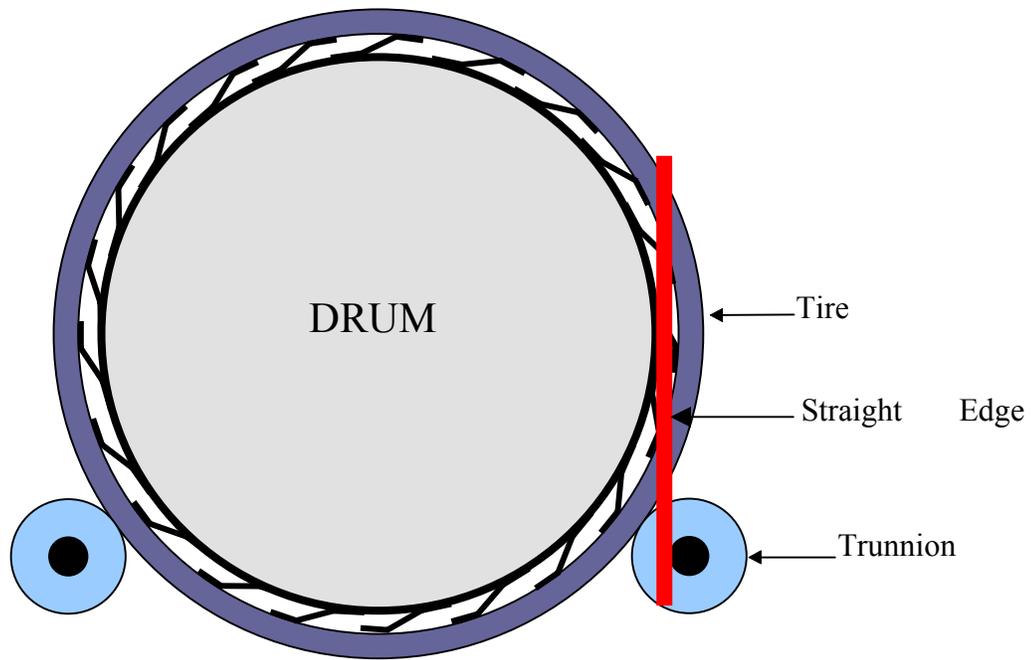


Figure 11. Using a straightedge along side of tire.

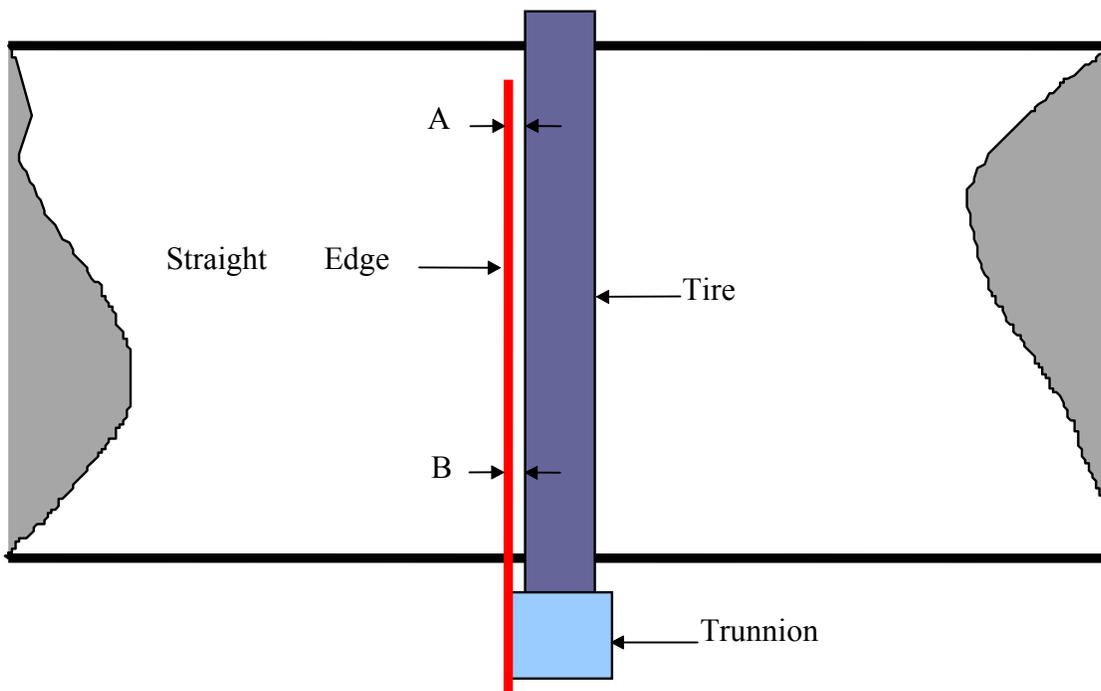


Figure 12. Measurement points A and B for setting

CROOKED TIRE

Should you ever encounter a tire that does not go around straight (when the drum is running the sides of the tire weave back and forth), then you cannot measure to the side of this tire. This is because the sides of the tire are not square with the drum. The measurements you will get will depend on where the drum stops. In this situation you must establish a line you can measure to.

To establish this line first make whatever adjustments necessary to get the drum so it is not moving up and down. Make sure the drum is not bouncing off of either thrust roller. Remember, just because you make the drum “float” between the thrust rollers doesn’t mean the drum is properly adjusted. Obtain a rather sharp and hard tool with some length. A long chisel will usually work fine. With the drum rolling brace your tool against the trunnion guard and slowly move it in until it makes contact with the tire. You would use your tool similar to the way you would use a cutting tool on a lathe. It is usually safest to work on the side of the drum where the tire is turning up and away from the trunnion. Scribe a line into the face of the tire. You now have a line that is square to the drum. This mark doesn’t need to be a deep gouge. It only has to be visible. Measure from the straight edge to this line to establish zero.

SKEWING TRUNNIONS

From zero, the trunnions will need to be skewed in the up-hill direction. Theoretically, we would like to keep the side faces of all trunnions exactly parallel. However, all things are not created equal. **Every trunnion is not carrying the same load.** Because of the flights in the drum, more material is being carried to one side than the other. Normally more material is on the discharge side. Thus, trunnions on the discharge side of the drum are carrying a heavier load than the trunnions opposite them. Also, since the drum is on a slope, the downhill trunnions usually carry a heavier load than the up-hill ones. The weight difference varies with the amount of slope. Additionally, in many drums all the “material” is not introduced at one end and carried all the way through. Drum mixers with center inlets for recycle are an example. The uphill trunnions are carrying only the drum and virgin material, while the downhill trunnions are bearing the full production load.

It is beyond the scope of this paper to cover all possible situations. Following are instructions for adjusting the trunnions on two different types of drums. By identifying which description most closely matches your equipment, it is hoped that the reader may find a section that will give him a more specific (and condensed) set of instructions. In previous revisions it was necessary to read the entire document. Although recommended, the author realized this is not an easy task (to stay awake). The down side of addressing “groups” of drum and dryer designs is that it becomes necessary to repeat. In order for each section to contain step-by-step instructions, many sections repeat because the operation is the same for other units. In some places the author has chosen to refer the reader to another section instead of repeating it ... my apologies. In other cases, a section may appear to be the same as another, but the reader is cautioned to look for differences.

DRUMS AND DRYERS – (WITH OVER ½ INCH PER FOOT OF SLOPE – WITH SLOPED TRUNNIONS)

Start by setting the frame. Check string line, level, and slope. Make any adjustments needed. Refer to the appropriate sections if needed.

Set face contact. On drums, and dryers, with sloped trunnions face contact should not change as the trunnions are skewed. So set face contact as close to perfect as possible.

Run the drum and check face contact again. If the face contact is still acceptable begin setting each trunnion to zero. If the face contact changes find out why. Is the tire face worn inconsistently? Depending on the cause there may be nothing you can do but allow the trunnions and tire to wear into each other. In this case set the face contact to the most consistent, or average, condition.

After all trunnions have been set to zero-skew, re-check the face contact. Remember: if face contact changes then there is a problem with the geometry of the trunnion base. Also, remember to come up to zero from the downhill direction.

Remember, some drums are better balanced than others. However, trunnion loads on dryers and drums are usually as follows:

1. The downhill discharge trunnion is the heaviest loaded trunnion on a drum.
2. The downhill trunnion opposite discharge is the next heaviest loaded.
3. The up-hill discharge is next.
4. The up-hill trunnion opposite the discharge is carrying the lightest load.

Considering these statements you should make a drawing similar to the one shown **Figure 13**. This drawing will help you keep track of trunnion adjustments as you make them.

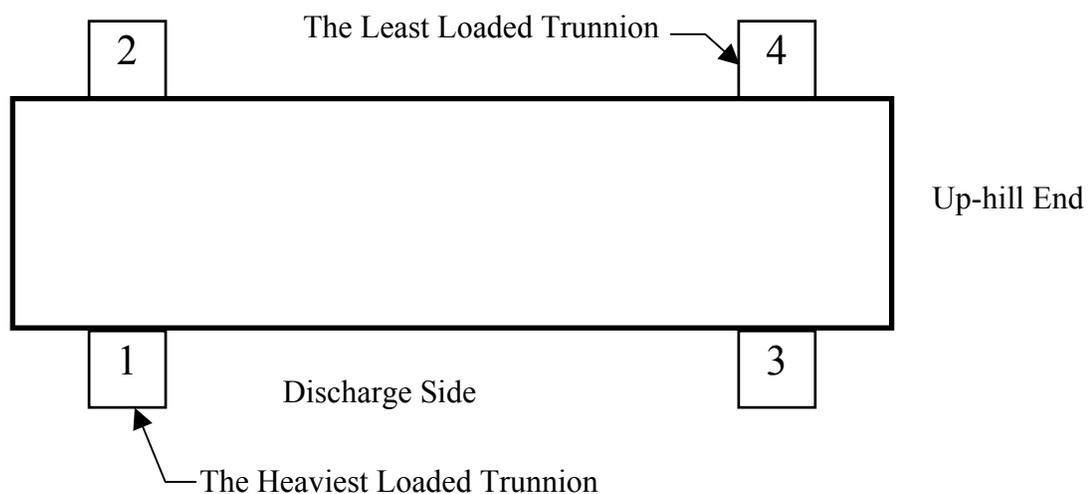


Figure 13. Trunnion loading and adjustment drawing.

A drum with all trunnions at zero skew should run against the downhill thrust roller. **Drums move up-hill when loaded** because the trunnions are skewed in the up-hill direction and they are gaining traction as weight increases. Since traction and friction are (in this case) near linear and friction is a force, **the more a trunnion is skewed the more load it is required to carry**. Drums inclined at lower slopes require less trunnion skew than drums at steeper angles.

If the drum needs to be moved immediately, turn all trunnions in the up-hill direction the same amount not to exceed the maximum amount needed. This varies greatly from drum to drum. One of the factors that determines the amount of initial adjustment is whether your adjustment bolts have coarse or fine-threads. Most drum mixers, especially those made by Barber-Greene, require about 1/2 of a turn of the nuts. The initial adjustment should get the drum up-hill enough to take pressure off the downhill thrust roller but not enough to make the drum “float” when empty.

A “flat” refers to the flat sides of the nuts. Since the nuts are generally always hex head there are six flats on a nut. Thus, one flat equals 1/6 of a turn. Flats are an excellent way to keep track of how far each trunnion has been skewed. Using a drawing like **Figure 13**, all you have to do is make a mark each time a nut is turned a flat.

Final adjustment must be made with the drum fully loaded and hot. The drum must be fully loaded because of the traction created by the weight. The drum must be hot because steel expands as it is heated. Since the thrust rollers are generally both on one tire, the tire on that end of the drum will be held in place on the trunnions. As the drum grows the other tire will move across the face of the trunnions it rides on. This brings into play different surfaces than when a drum is cold. Again, ideally it should float between the thrust rollers. It is very difficult to get a drum to float all the time. Changes in drum weight due to production rate or type of mix will cause the drum to move. Hopefully, the drum will run full more than empty, and at capacity. So skewing adjustments should be made to meet these conditions.

When making your final adjustments, the secret is to go slow and easy. **Do not make large adjustments**. Adjustments should be one flat at a time, on only one trunnion at a time. Wait, give the drum time to react to the adjustment. Record your adjustments. **Do not adjust more than one trunnion at a time**, unless large adjustments are needed (as described above).

The last thing you ever want to do is go too far. **You cannot just back up!** If you try to adjust a drum downhill you will have to take up all the backlash in the threads before you will get any results. As soon as you start turning the adjustment nuts downhill you are lost ... start over. You no longer know much the trunnion, or trunnions, you turn are skewed. Any adjustments you make from this point will be just guesses.

ADJUSTMENT ORDER

As shown earlier, different trunnions are carrying different loads (see **Figure 13**). Also, as discussed, as a trunnion is skewed, the force against that trunnion increases. Thus, start final adjustments with the least loaded trunnion. **If any trunnion(s) is to be skewed less than the others, make sure it is the one(s) carrying the heaviest load.** In other words adjust trunnion number 4, then 3, then 2, then 1. If more adjustments are needed, continue with the same pattern. If the drum is riding satisfactorily after skewing number 4 and 3, leave it alone. Later, if more adjustment is needed turn number 2.

Another way to look at the trunnion loading is that the downhill trunnions are the coarse adjustments and the uphill the fine. There is nothing wrong with this technique. However, you should first get close using the adjustment order above.

It is very important to maintain an order and divide adjustments between all the trunnions. Being the heaviest loaded trunnion on the drum, it is possible to “control” a drum with number 1 alone. **Do not!** This is an often-made mistake. It will indeed allow you to make the drum “float”. It may in fact “float” all the time. But, it will chew up one set of trunnions after another. A drum that never moves is probably badly out of adjustment. If you are losing trunnion bearings and they are always on the downhill end (especially the downhill discharge), it’s a good bet that one of these trunnions is controlling the drum.

Another very common mistake is to set them and leave them. I agree that if everything is running and looking good -- do not touch them. Remember though, improperly adjusted trunnions may run for weeks without evidence of trouble. However, once the trouble shows up, the effect is cumulative and the trouble usually advances rapidly to a critical stage. The problem is the mistaken assumption that once they are adjusted they never need to be touched again. **Trunnion adjustment is a continual process, especially on new or portable equipment.** You may need to make an adjustment several times a day in the beginning. Soon this will become once a day, or once a week, then once a month. If the plant is never moved again you may never have to touch them again unless they wear out naturally.

When a new drum is put into service, watch the surface of the tires closely. If small “pattern” or scar marks repeat themselves around the periphery of a tire or trunnion, no matter how slight, immediately look for the cause. Most likely the trunnions are out of parallel enough to cause the thrust of one trunnion to fight the other. Or the trunnions at the opposite end of the drum are opposing the pair that is wearing. If left uncorrected, the small scores will get deeper and eventually deep enough to cause flaking of the metal and vibration (**see Scarffing, appendix page 42**).

FOR DOUBLE BARRELS ONLY

The following instructions are intended for use with an Astec Double Barrel Drum Mixer[®] with sloped style trunnions only. If you are not sure if these instructions should apply to you, contact the Astec Service Department at (423)-867-3754. Applying these procedures to machines other than a Double Barrel Drum Mixer with sloped style trunnions may result in premature wear or failure of components.

SETTING THE FRAME AND DRUM

First, **the plant site must be flat, level, and hard**. The proper fit up of all components depends on it. If the site is not firm enough to properly support the equipment, no amount of adjusting can correct to problems that will result. **The drum must set on a firm, flat, and level foundation**.

The following three procedures (slope, level, and string line) actually are all done at once. This is because adjusting one may change one or both of the others. For a more detailed discussion of slope, string-line and level please refer to the appropriate section in this document.

SLOPE

The end-to-end slope of the Double Barrel is predetermined and set at 1 inch per foot (25.4 mm / 304.8 mm). **Figure 14**, demonstrates the correct way to use a level and tape to measure slope.

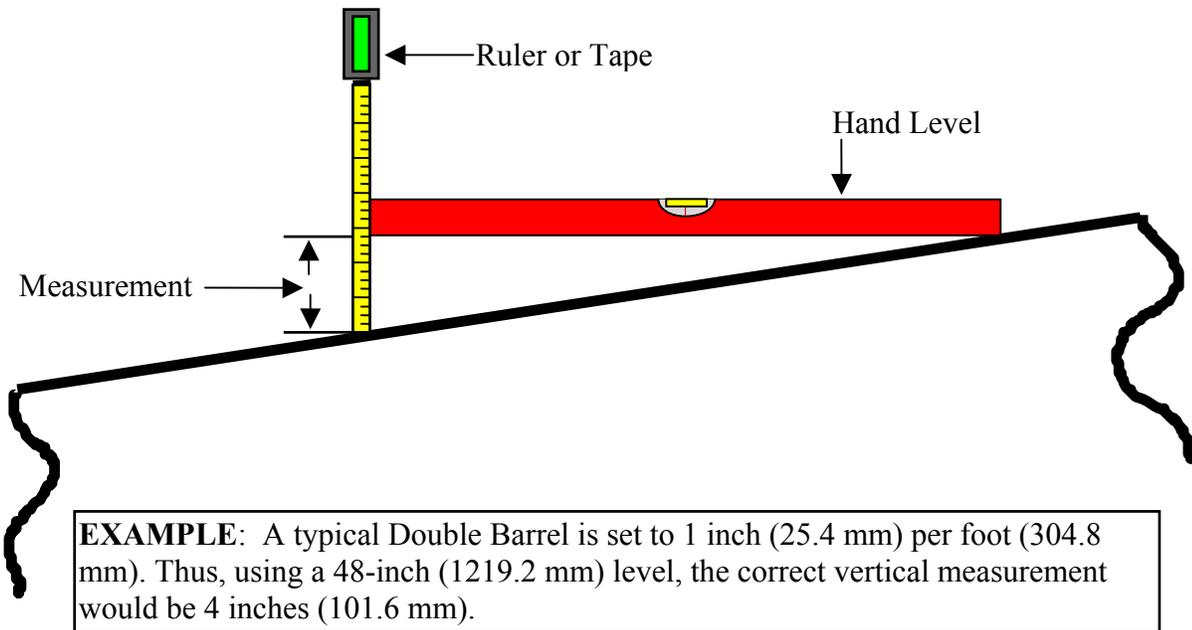


Figure 14. Using a level and ruler to measure slope.

STRING-LINE

String line means straight. Make sure the frame members are straight from one end to the other. You can sight down the frames on most Double Barrels. On others you may have to run a line down both sides of the drum frame. In some cases a laser can be used. It is usually easiest to go along the bottom of the frame

String-line accuracy directly affects face contact. Face contact must be re-established every time a plant is moved. On a portable unit you do not want to have to repeat everything every time you move. It is a lot of work to set face contact! The only way to insure you do not have to re-shim is to bring the frame back to a known position **every time** you move. The easiest position to find every time is also the right one ... **straight!**

LEVEL

Check the side-to-side level of the drum frame, using a device long enough to span straight across the frame (if possible), or a water level. Of particular importance are the blocking points, which are generally also right under the trunnions. Make sure the frame is level side to side. Use the jacklegs, shims or whatever is necessary to level the frame.

TRUNNION ADJUSTMENTS

SETTING FACE CONTACT

Remove the guards so that the contact area between the tire and trunnion can be seen. See if there is a gap, how large it is, and which side it is on. Determine the amount of shims that will be necessary to add or remove. If you add or remove a shim from only one side of a trunnion, the effect will be 1/2 the thickness of the shim.

To change shims you must take the weight of the drum off the trunnion. If possible, raise one entire end at once. If this is not possible, and on most of the larger units it is not, then you have to lift just one corner at a time, by “tipping” the drum onto the opposite trunnion. Be sure to block between the tire and trunnion, on the opposite side of the drum from where you are working so the drum cannot roll. In either case, do not raise the drum any higher than necessary. Just take the weight off enough to add or remove shims. Once you get the weight off of the trunnion, you will have to raise the trunnion, shaft and bearing(s). This can usually be done with a pry-bar.

The shim packs go under the bearings, on top of the pivoting plate. **Do not shim under the pivoting plate!** This will negate the benefit of the trunnion base design. See **Figure 15** for shim location.

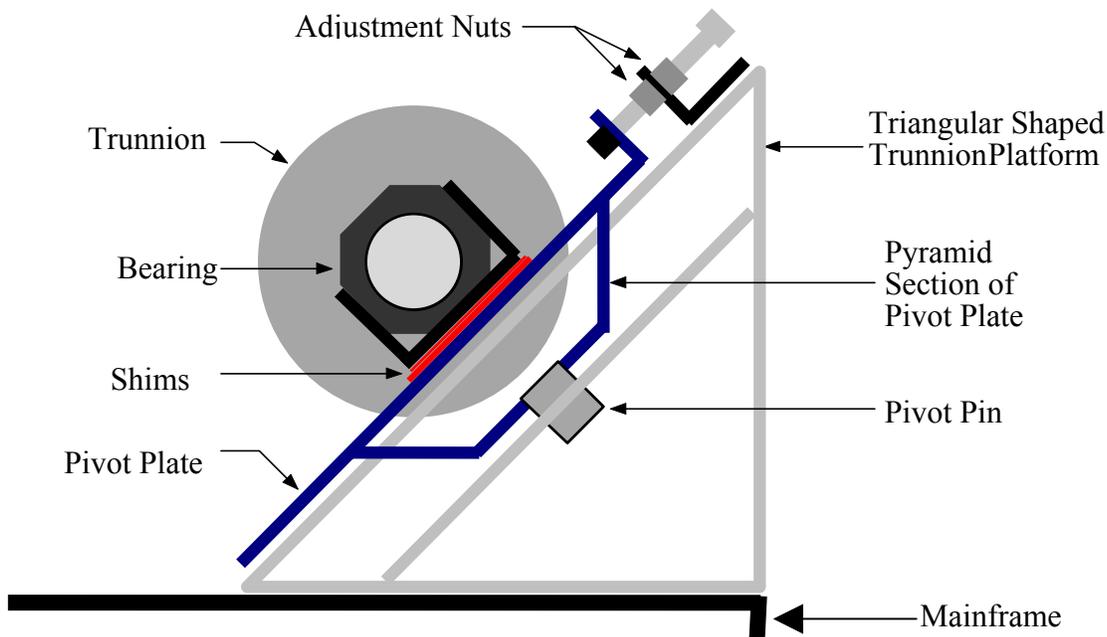


Figure 15. Side view of trunnion Assembly.

FINDING ZERO

Zero skew is when the sides of the trunnion are parallel with the sides of the tires. In this condition the trunnions are not trying to steer the drum in either direction. Failure to find zero after repairs or at start up is one of the major causes of trunnion failures. Start up also refers to any time a drum is moved.

Loosen the bolts that hold the trunnion pivot plate to the base frame. These are usually 7/8 bolts that pass through 1 inch slotted holes. Starting with models after late 1997 this will be a bolt welded to the frame extending up through slotted holes in only the pivoting plate. This will place the “nuts” up. If the bolt head is up, pre-1998, there is a nut on the bottom you will have to hold.

Using at least a four-foot straightedge (the longer the better), place the straightedge firmly against the side of the trunnion so that it extends up along side of the tire (see **Figures 16 and 17**). The trunnion is wider than the tire, so it will extend past the tire on at least one side. It does not matter which side you use. However, the side that overlaps the tire most is usually easiest to use.

Measure the distance from the straight edge to the tire at two points (refer to **Figure 17**). These points need to be as far apart from each other as possible. In other words, get as high (A) and as low (B) as possible. Beware of the rolled edge that naturally develops on the outside of the tire. **Do not measure to it. This measurement is critical! Best results are obtained using a dial caliper or some other type of precision measuring device.** Zero skew is the point where both measurements are equal.

To skew the trunnion, you turn the adjustment nuts, **not the bolt!** There are two nuts on each bolt. They work together. You have to loosen one before you can tighten the other. Many times trunnions are neglected because the adjustment nuts are too hard to turn. Often this is because the pivot plate is jammed tight against the pivot pin. Please refer to **Figure 15** for a reference of part locations. This pin fits quite snugly into its hole. There is less than 1/32 of an inch of clearance. Thus, it is easy to jam the pin by applying too much force to the adjustment nuts on just one side. **If you cannot move a nut do not force it. Go to the other side.** As you push (or pull) on one side of the pivot plate the bolts basically get longer or shorter. Since the plate is pivoting, the bolts must be able to slide within their slots. It may be necessary to loosen all the nuts except the one you are trying to tighten.

Come “up” to zero from the downhill direction. This will take the backlash out of the threads of the adjustment nuts and bolts. We know that if we are going to skew a trunnion any amount, it will be in the up-hill direction (this means the trunnion will be trying to move the drum in the up-hill direction). For an explanation of how to determine skewing direction read the section titled “Determining which way to skew trunnions.”

After you have all the trunnions set to zero, run the drum for a few minutes with the four locking bolts loose. This will allow excess stresses in the trunnion assemblies to “average out.” Then check zero again. If the trunnion is still at zero then tighten the locking bolts. If it has changed then set it again and run the drum again. If it continues to change you have a problem. One possibility is the tire is not straight on the drum, please refer to the section on setting zero for possible solutions to this problem.

If in doubt as to whether a trunnion is at zero or skewed, be sure the trunnion is **NOT** skewed downhill. Be sure you err in the up hill direction if you are not sure. Every time we have seen a major trunnion, or tire, wear problem ... one trunnion, or more, has been skewed in the downhill direction.

After you have finished setting zero on all trunnions, **replace all guards.** It will not be necessary to have them off any longer.

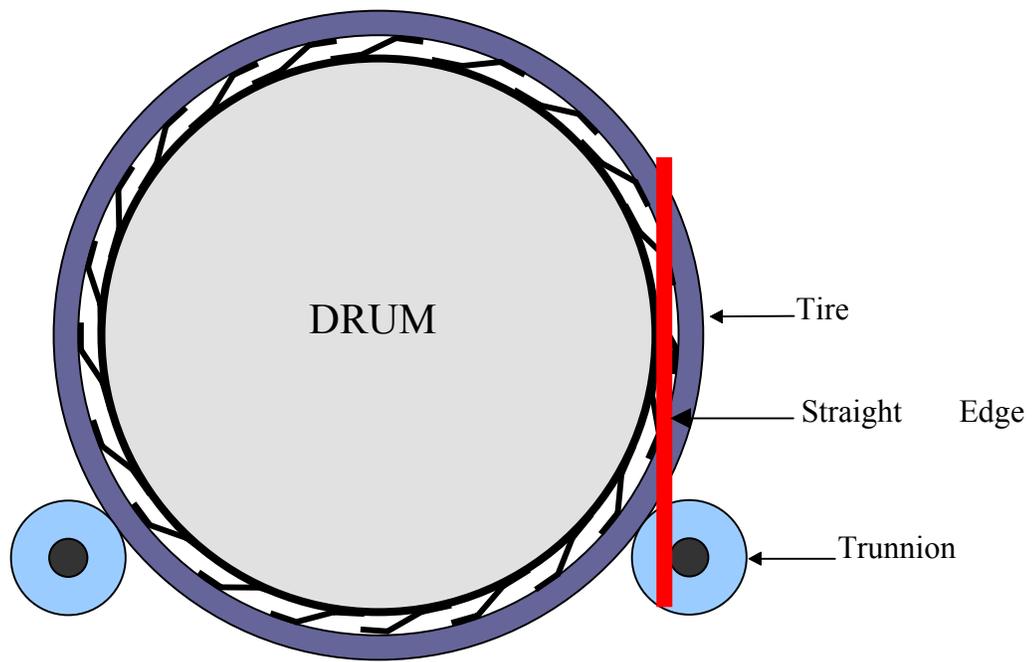


Figure 16. Using a straightedge along side of tire.

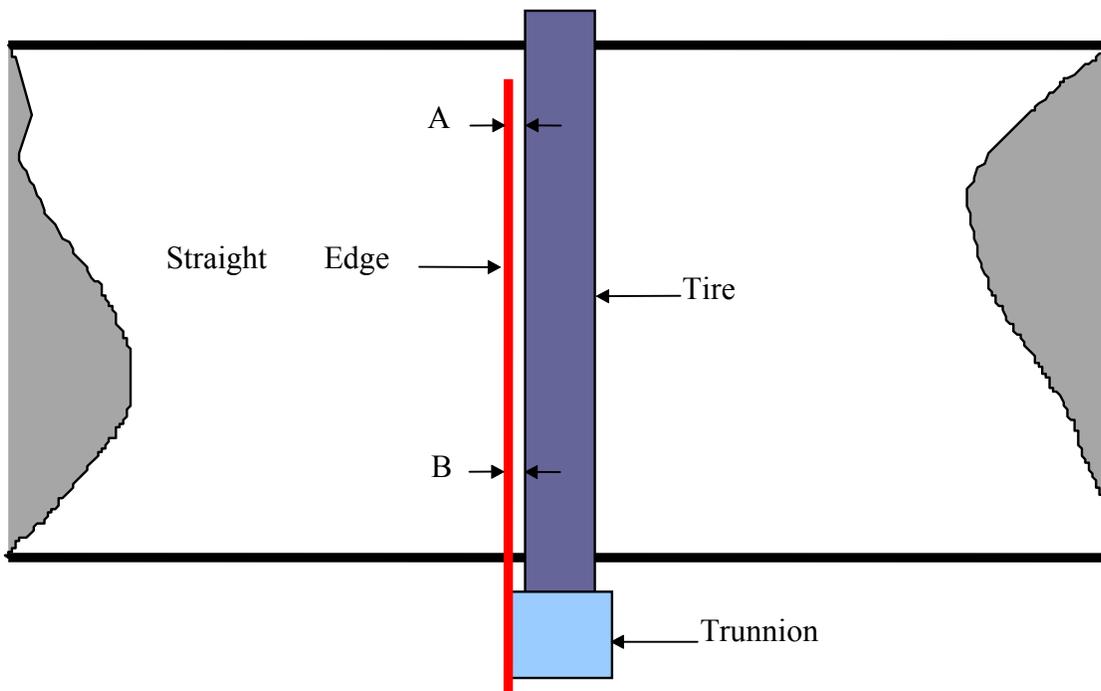


Figure 17. Measurement points A and B for setting

SKEWING TRUNNIONS

From zero some trunnions will need to be skewed in the up-hill direction. In regard to trunnion loading the Double Barrel is better balanced than most drums. Double Barrels require very little up-hill skew. Still, all the trunnions are not always carrying the same load. So to adjust the Double Barrel we are going to start with the trunnion(s) with the most consistent load characteristics.

ADJUSTMENT ORDER

It is very important to maintain an order. All the time spent to establish zero on every trunnion would be wasted if you just start randomly skewing them now. Make yourself a map of the drum and trunnions. Label it in such a way that you can remember and identify which trunnion is which. When you skew a trunnion make a note on this map. Record which trunnion you turned and how much. Adjustments should be one flat at a time on only one trunnion at a time. A flat refers to one flat side of an adjustment nut (1/6 of a turn). If it is easier for you record the points instead of the flats, go ahead. It's the same thing.

Given the Double Barrel's well-balanced characteristics it is difficult to determine which trunnions are carrying what percent of the load. In fact we do not know for sure which trunnion is the heaviest loaded. However, we do know which is the most consistently loaded – the downhill discharge side trunnion. Thus, this is the trunnion we want to adjust first.

On Double Barrels only, start by adjusting the downhill discharge trunnion. Give the trunnion adjustment nuts one flat (1/6 of a turn). **Most of the time this is all that is needed!** If more adjustment is needed, give this same trunnion another flat. If more adjustment is still needed, then go to either trunnion on the discharge side (take your pick). Adjust that trunnion one flat, then another flat if necessary. On Double Barrels the rule to remember is: **Do not adjust any trunnion more than two flats in a row** ... move to another trunnion.

It takes very little up-hill skew to control a Double Barrel. Go slow! **Give each adjustment time to take affect before making another adjustment.** It may take an hour or more before you will see the results of an adjustment. **Do not adjust more than one trunnion at a time.** Again ... wait ... give the drum time to react to the adjustment. You must make your adjustments based on how the drum acts when running at capacity. However, never under any circumstances attempt to adjust a machine while it is running. You will have to allow the machine to be shut down before making adjustments. Most of the time it is only necessary to adjust one trunnion. If you have to adjust more than three trunnions – then there is probably another problem.

If you go too far you have to start over. The very reason we came up to zero from the downhill direction was to take out the backlash in the threads between the adjustment nuts and bolts. If you try to go backwards you will only be losing the “pre-load” you established by doing this. The pivot plate will be “floating”. It may take several flats to even get it to move any in the downhill direction. If you do turn the nuts enough to get it to move, that trunnion would now be “pre-loaded” in the downhill direction.

The last thing you want is for a trunnion to be adjusted below zero! This is one reason why it is so important to record how many flats each trunnion has been turned. It makes it possible to return to a desired point in the adjustment process.

Another very common mistake is to set them and leave them. I agree that if everything is running and looking good -- do not touch them. Remember, improperly adjusted trunnions may run for weeks without evidence of trouble. However, once the trouble shows up, the effect is cumulative and the trouble usually advances rapidly to a critical stage. The problem is the mistaken assumption that once they are adjusted they never need to be touched again. This is simply not true. The equipment moves, it vibrates, and components wear (please review the section on settling).

Trunnion adjustment is a continual process, especially on new or portable equipment. You may need to make several adjustments in a day in the beginning. However, once you get them right, you may never have to touch them again. Unless you move the plant or they wear out naturally.

When you finish making an adjustment, tighten all locking bolts. This refers to the bolts that hold the pivoting plate. The weight and movement of a Double Barrel is enough to cause a trunnion pivot plate to move if it is not locked down.

At all times, but especially after adjustments are made, watch the surface of the tires closely. If small “shadows” or “scar” marks start to appear on a tire or trunnion, no matter how slight, immediately look for the cause. Most likely one or more trunnions are skewed below zero. Left uncorrected, the “pattern” will get deeper, repeat all the way around the tire, and eventually get deep enough to cause flaking of the metal and vibration (**see Scarffing, page 42**).

APPENDIX

BALANCING THE WEAR

The whole object of trunnion adjustment is to get everything wearing uniformly, thereby greatly extending component life. Since the tire is soft and the trunnions are hard, logic tells us the tire will wear more. However, the trunnions are smaller, have less surface, and turn at a higher RPM. Because the trunnions turn more revolutions than the tire they should wear out first. However, there are two trunnions working on each tire. So what will wear out first? Usually, the one **you** have put the greatest strain upon.

Strain comes in many forms: over-skewing of a trunnion(s), improper face contact, worn tire or trunnion(s), heat, and even lubrication. Any one of these factors can cause premature failure. Following are brief reviews of some of these factors:

OVER-SKEWING

Skewing reduces face contact, even on the Astec “sloped” trunnion design. This is caused by an affect we have not yet discussed. Take any two cylindrical objects (soda cans work well). Hold them together side to side so that they are parallel to each other, like a trunnion and tire. Now turn them until they are perpendicular to each other. Notice what happens to the contact area.

This can cause the tires and trunnions to wear in a cup-and-dish pattern. This will also cause the drum to appear as though it is not reacting to trunnion adjustments—until it jumps out of the rut. Then it will move very quickly and very hard in the direction you were trying to go. (See **Improper Face Contact**).

As “flat” style trunnions are skewed the face contact angle changes. Initially after a “flat” trunnion is skewed, there is a loss of face contact. This is because one side of the trunnion was pushed into the tire while the other side was pulled away. This sometimes may cause the drum to initially move opposite the direction desired. The tire and trunnion will eventually wear back into 100% face contact and the drum will move accordingly. After the components wear back onto each other, consider what angle the two contact surfaces are compared to the drum. (See **Improper Face Contact**).

Skewing will also cause a trunnion to have to carry additional thrust as it tries harder to control the drum. A trunnion carrying too much load from this condition will usually result in bearing failures, but not always. It may present itself as high motor amp draw (especially on trunnion drives) or flaking. Remember that trunnions are only hardened 1/8 of an inch deep. Once you wear through that hard face you will be running similar metals and wear will increase rapidly. Also, since similar metals have a higher coefficient of friction, the problem compounds itself.

Loading continues to increase and adjustments will be necessary to keep up with the drum's reaction to increased traction.

IMPROPER FACE CONTACT

Anytime the entire surface of the tire is not contacting the trunnion there is improper face contact. What happens if face contact is wrong? A smaller area of the trunnion and tire is forced to carry the load. Thus, the force (pressure) applied to the area of contact will be greater and the contact area will wear faster. As the two components wear face contact is increased. It will eventually “wear in” to 100% face contact. As face contact increases, the coefficient of friction goes up, the reaction of the drum changes and trunnion skewing adjustments may be needed.

A very undesirable condition will likely result. The tire and trunnions will wear at an angle. The angles on each tire may, or may not, be equal to each other. They may be at different degrees. They may, or may not be, parallel to each other. When the two tires are worn at angles opposite to each other the condition is known as “barreling”.

It is possible to get to a point where the drum will seem to not react to trunnion adjustments at all. Many times we have heard of operators having problems with trunnion wear, tire wear, or bearings. When the comment is made that the trunnions are probably out of adjustment, the response is usually something like; “My drum is perfect, it never touches either thrust roller”. A drum that never moves has probably worn into a “barreling” condition, see **Figure 18**. It does not matter which tire is worn in which direction, if the angles are opposite to each other, the result is always the same. It is like a train running down a track. Normal trunnion adjustments make no difference. **If trunnions are skewed enough to make the drum move, the result can be disastrous. The drum will suddenly go as far as it can in the direction you were trying to get it to go.** Basically, the train has jumped the track.

Another possible “train track effect” wear pattern is “dished” or “cupped” trunnions. This problem is common with the “flat” style trunnions. Even when proper adjustments are made. To keep all trunnions parallel, the same side of each trunnion is pushed into the tire. (See **Determining Which Way to Skew Trunnions**). In other words, suppose the right side of each trunnion on a tire is pushed in towards the tire. This will cause that side of each trunnion to wear harder on the tire. If viewed from above the drum, notice that each trunnion is wearing on a different side of the tire. This will cause the tire to wear down on each side and be high in the middle. Since the trunnions will also wear to the tire, they will wear low in the middle. Now the rounded tires are rolling in a pair of ruts. The affect is the same as barreling.

When a customer states his drum moves up-hill empty and downhill when loaded, it is usually the result of improper face contact on one or more trunnions. The difference is the wear has not advanced to the point where it can hold the drum in place. Drums should always move up-hill when loaded, assuming all trunnions are skewed in the up hill direction. If it does not, the cause is some or all of the trunnions are worn at the same angle, see **Figure 19**. Please note, the Astec Double Barrel may be an exception to this rule (see **The Double Barrel**). The other possibility is one or more trunnions are skewed in the wrong direction.

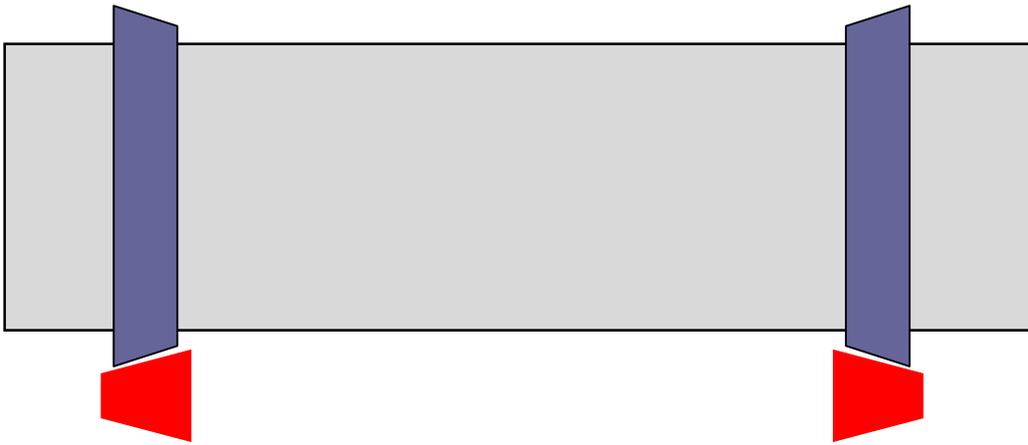
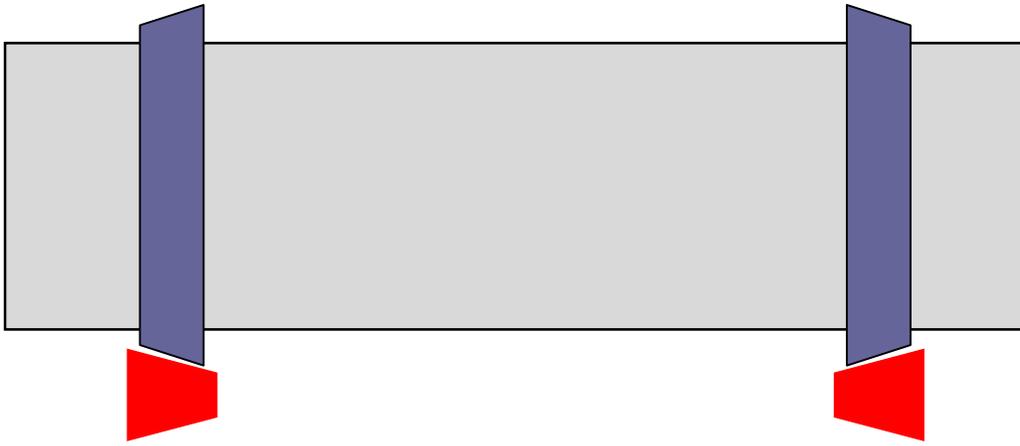


Figure 18. Note, angles exaggerated for clarity.

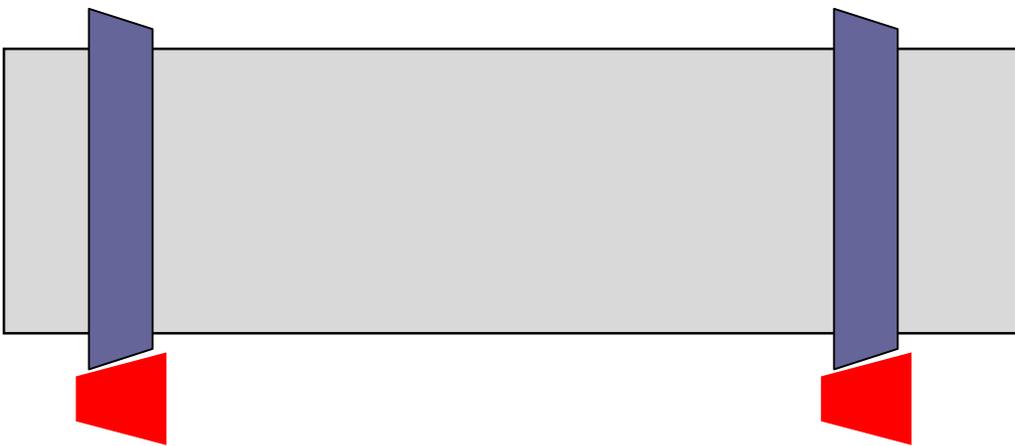


Figure 19. Note, angles exaggerated for clarity.

WORN TRUNNION

Can a worn trunnion be saved? Some people claim they can successfully rebuild a worn out trunnion. To do this properly the trunnion must first be built up with weld. The rod or wire used must have metallurgical properties suitable for turning on a lathe and then hardening. The welding must also have a uniform surface, not only in smoothness but also in hardness. After turning **the trunnion must be heat-treated**. If you are going to attempt to have this done, make sure that the shop you choose can handle all aspects of the rebuilding. Consider also that it is very difficult to get our trunnions off the shaft. So if necessary, can they do the work while it is still on the shaft?

You should consider the time, techniques involved, shipping, handling, and all other related costs. I find it very difficult to justify rebuilding trunnions, especially when you consider you now have a rebuilt component with a questionable life span.

NOTE: Matching worn trunnions with new ones greatly accelerates the wear on the new components. This may also require constant, generally ineffective, trunnion adjustment.

One of the main reasons for this is what I call “the uneven legged table effect”. When one leg of a table is too long, or short, the table will not stand steady. It will wobble and tip as weight is applied to different areas. Even though a drum is a cylinder it is still rather rigid. It is theoretically possible for a drum to run and not even contact a trunnion. Conversely, when just one new trunnion is put on a drum it becomes the “long leg”. No matter where the load is shifted, it never loses contact. In fact it will be carrying a greater load. This is why it will wear out at an accelerated rate. In addition to wearing faster, when just one trunnion is replaced the face contact angle on all trunnions is changed slightly. This causes the trunnions and tires to establish a new wear pattern. (See **Improper Face Contact**). These reasons are why trunnion adjustment will be difficult at best.

WORN TIRE

Can a worn or damaged tire be saved? This is a considerably more expensive item that is much harder to change. If a tire has an uneven wear pattern, first try to correct the problem with proper trunnion adjustment. If this fails, because the wear pattern is too deep, then it is necessary to resurface the tire. A sleeve is usually not an economical option, nor does it work very well. A tire can be turned or ground in place. There are companies that specialize in this. A simple technique that we have employed is to mount a weighted grinding stone against the tire. This grinds the tire as it turns. Please notice that tires can only be turned down. **A tire cannot be built up**. Tires are soft and must stay that way. Welding on a tire will cause it to be hardened and may make it brittle. The tire’s strength is the fact it can give. The rolled edges that can sometimes be seen on the sides of a tire are normal. (The reason you usually only see it on one tire is that the thrust rollers keep it worn off the one they ride against.) The drawback to grinding is the affect it has on the contact point between the tire and trunnion. Please refer to **Figure 20**.

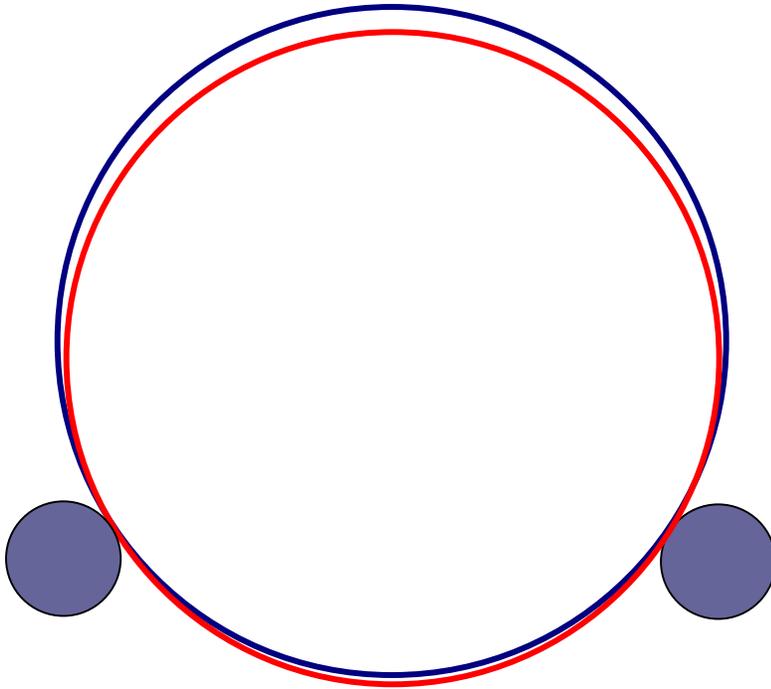


Figure 20.

When you reduce the diameter of the tire (the distance across a circle) it drops lower into the frame. As the drum tries to drop between the trunnions the contact point between them changes, it becomes higher on the tire and lower on the trunnion. **The forces acting on the surfaces of the two components go up dramatically.** The same affect happens if the diameters of the trunnion are reduced. On Astec “sloped” trunnions it is possible to partially correct this problem by increasing the number of shims under the trunnion. Since the trunnions are mounted at an angle in line with the center of the drum, shimming does raise the drum. It will also reduce the centerline dimension, although not linearly. **Beware, this can affect face contact, the slope of the drum and the way the drum "sets" on the trunnions.**

On many other styles of trunnions, allowing the trunnion to move out when adjusting can create the same problem. Another important feature of the Astec trunnion design is the center pivot pin, see **Figure 6**. It will not allow the trunnion to move out and loose the critical trunnion to drum centerline dimension. When making adjustments (on drums without a center pivot pin) it is easier to allow the trunnion to come out away from the drum than to push it under. To push the trunnion under the drum, the drum has to be lifted. Thus, over time drums not equipped with a center pivot tend to eventually lose their centerline dimension as the trunnions are allowed to move out.

BROKEN TIRE

How thin can you allow a tire to get? There is no formula for determining how much tire thickness is required on a used plant or how to determine when one will break. There are just too many factors involved. However, if one does break, and a replacement is not ready, repair it as follows:

- a. Grind out a V-groove on each side of the break. This is easier said than done. However, you will need a 100% weld so you must get all the way through the tire.
- b. Do whatever is necessary to get the tire realigned. You may have to rotate the drum to different positions to accomplish this.
- c. Pre-heat as large of an area around the break as possible.
- d. Use low hydrogen welding rods. Start with a mild rod (such as 6018) near the center of the tire. As you work to near the surface use a higher tensile strength rod such as 7018 or 8018. I have seen even 9018 recommended.
- e. Build up beyond the original surface of the tire.
- f. Grind as smooth and as even as possible to the original surface. Consider using a belt sander.
- g. Plan on having to replacing the tire.

The biggest problem you may have is the tire breaking again next to the weld. If this happens the tire was not preheated or cooled properly during the original repair, or the tire was hardened and crystallized. Either way a permanent repair will now be very difficult to obtain. Some times the tire may break again 45 to 90 degrees from the original break. If this is the case, additional supports will need to be placed under the tire. The load is being transferred for any one of numerous reasons, and the structural integrity of the tire has been permanently damaged. When installing additional supports do not weld the tire solid to the hot (burner) end of the drum and do not weld across the tire. On drums equipped with spring-loaded spokes there is no good way to permanently place a support. If a repair fails in either of these ways it will most likely be necessary to replace the tire.

SCARFFING

Scarffing or shadows are a form of tire wear that often require grinding to correct. However, if discovered and corrected early, grinding is often not necessary. Scarffing is a term we use to describe the appearance of lines across the face of a tire. Compared to a bearing (the tire being

the race and the trunnions the rollers) this condition is known as brinelling. The pattern usually starts out as small lines or shadows and only appears on a small section of the tire. They tend to be very evenly spaced. This is because of the constant surface speed of the tire. They are actually small flat spots or depressions. Every time a trunnion “hits” one of these spots it “hammers” the tire causing a vibration. This forging affect along with the rolling action causes the scarffing marks to get deeper, harder, and spread. If no corrective action is taken they will eventually circumference the tire.

There are many theories about what causes scarffing. Most, although logical, can be disputed. For example:

They are caused by the trunnions spinning on the tire ... May be possible on trunnion drives. But what about chain drives?

The vibrations of the chain against the sprocket segments cause them ... Quite often the frequency of the marks match the pitch diameter of the chain, and sometimes they do not. But what about trunnion drives?

They are caused by the tire bouncing off the thrust rollers -- Again possible, however, we have seen them on drums that never move and drums with no thrust rollers.

There are many others but there does not seem to be a single theory that applies to all cases. What we do know is that there is almost always detectable improper trunnion adjustment. And if trunnion adjustment is corrected soon enough the lines will disappear. If allowed to run for too long, grinding is necessary to clean up the tire. Combine this with proper trunnion adjustment procedures and the scarffing does not reappear. If the tire is ground and no trunnion adjustments made, the scarffing comes back. Thus, the key to neutralizing scarffing seems to be proper trunnion adjustment.

LUBRICATION

Another side effect of excessive heat is that lubrication in the trunnion bearings may run out of the bearings. This can also be caused by using the wrong lubrication, i.e., low temperature grease.

A real problem occurs if **any lubrication** is allowed to get on the trunnion or tire surfaces. First, it becomes very hard, if not impossible, to control the drum because of the inconsistent friction loss. The pressure created at the contact point is so high lubricant will continuously be squeezed out.

Second, the pressure at the contact point is of such magnitude between the trunnion and tire that it is literally possible for the lubricant to detonate, blowing small pieces of the tire or trunnion surface off. If the lubricant finds its way into a crack or pit, the hydraulic pressure created can also cause pieces of metal to be chipped off the trunnion or tire surface. This hydraulic pressure

is also great enough to cause a crack to grow, until it reaches the side face and is able to allow the pressure to escape.

The major cause of lubrication getting on the trunnion and tire surfaces is simply over greasing. Trunnions require very little grease. In fact the newest Astec trunnion bearings are permanently sealed and never require greasing. Follow the recommended interval and amount, and that's enough. Grease can get on the tire surface from over greased thrust rollers also. **Don't over lubricate!**

HEAT

Because the drum expands as it is heated it must have room for expansion, both in diameter and length.

This is why Astec uses spring loaded spokes under their tires. If there is not enough room under a tire for the drum to expand, something would have to give. Different manufacturers have used various designs over the years to compensate for expansion. Barber-Greene, for example, used a floating tire. This tire was not attached to the drum at all. Instead it was held in place by ears attached to saddles. The biggest problem with this type of design is wearing of the inside of the tire against the tops of the saddles. There had to be a gap, or space, between the saddles and tire. This was to allow for expansion. However, this gap also allowed the tire to spin. In fact it had to spin because the saddles and tire were different diameters. The more it spun, the more it wore. The larger the gap, the more it would spin. With the Astec "spoke" design this is not a problem.

There is not much we can do about the problem of the drum growing in length except recognize the problems and allow for them: for example, the problems of sealing the breaching. Regarding the trunnions usually only one end is affected. This is because the trust rollers are usually both on the same tire. Thus, the tire that is held in place by the thrust rollers does not move very much on the trunnions. However, the other tire can possibly "walk" from one side of the trunnion to the other as the drum expands. Actual changes depend on type of drum, diameter, length, and operating temperature. It is not unusual to see a drum grow two inches from cold to hot. One of the reasons the trunnions are wider than the tire is to allow the tire to stay completely on the trunnions as the drum moves and expands.

TRUNNION DRIVES

There are a few special considerations when dealing with units equipped with trunnion drives. It is important to think of each trunnion and tire like a gear ratio, each trunnion driving against a tire, and the tires driving the drum. However, don't forget that the drum acts like a shaft. Thus, we basically have four (sometimes just two) motors driving one shaft. If you change the diameter of any trunnion you will change the speed at which that trunnion tries to turn the tire.

This will cause it to either carry more of the drive load or transfer that load to the other trunnion(s). If you change the diameter of a tire, you will change the ratio between it and both trunnions it rides on. This will cause the trunnions at one end of the drum to try to turn the drum faster than the trunnions at the other end -- but they cannot, because the drum is solid. This will cause the pair trying to drive faster to carry more load. Often this is the reason for excessive amp draw on a motor, or pair of motors. Any condition mentioned earlier in this paper, wear, new parts, grinding of the tire, or any component change that affects the trunnion rpm (such as a gearbox of a different ratio) should be avoided. **Keep all parts matched.**

There are reasons to keep trunnion/tire ratios even other than amp draw. As a trunnion or tire wears its diameter is reduced. Under normal conditions since all components are wearing together, the affects of wear are gradual and slow. Thus, we never notice some of the changes taking place. It is when a sudden change is made that the affects of time become apparent. The problems discussed in the preceding sections on worn trunnions and worn tires also apply to trunnion drives. Since the drum all essentially ties the trunnions together there are additional factors. If a trunnion, or trunnions, is trying to drive at different speeds something has to give. This may be the motor or the drive belts. It could possibly end up being the gearbox. Or, the tire and trunnion(s) have to slip. All are undesirable conditions.

On Barber-Greene plants there is quite often a “floating” tire on the burner end of the drum. The primary intent is to allow for heat expansion. It also tends to provide an additional “slip point.” Since the tire is not fixed to the drum it is not uncommon to see it move around the drum as it is run. This is because the tire and drum are not turning at the same speed. The gap between the saddles and tire, as viewed between them on top of the drum while stopped and cold, should only be 1/16 of an inch. If allowed to continue to wear, the difference between the drum speed and the tire speed will become greater. This is because unless a drum is perfectly centered in a tire there is a planetary gear affect. This affect can happen on any drum even if the tire is “fixed” to the drum. It can even affect the life of components of a drum that is not trunnion driven, but not as readily. This planetary affect, like any gear reducer, has the ability to increase the strain on components tremendously.

Another potential problem, special only to trunnion drives, can occur during start up of the drum. When an electric motor is energized it tries to reach its rated speed instantly. This can create a substantial side torque, or jerk, on the gearbox, trunnion shaft, and trunnion frame. Unless these components are very firmly held in place the trunnions can actually be skewed by the motor. This is obviously not desirable, especially if this happens in a direction that changes face contact, **see Setting Face Contact - Another Possibility.**