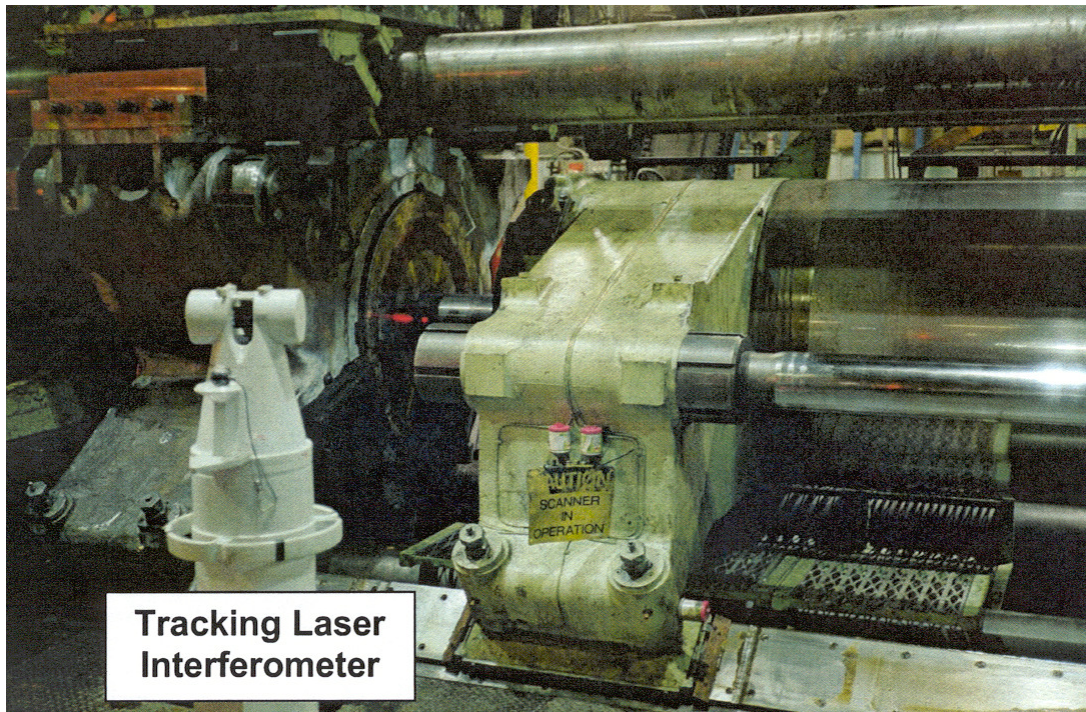


# Press Alignment

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**Tracking Laser Interferometer**

Figure 2-1: Laser alignment of an extrusion press  
*(photo from Advanced Dimensional Solutions Pty Ltd, [www.a-solution.com.au](http://www.a-solution.com.au))*

**Importance of Proper Alignment.** Predictable die performance requires good press alignment if there is to be equal flow in all ports of the die. As close tolerances have become more important and section walls have become thinner, alignment has become more critical.

Misalignment may also cause mechanical problems in the press --- uneven wear, tooling damage, and even “popping” movements as the misaligned press corrects itself during the stroke.

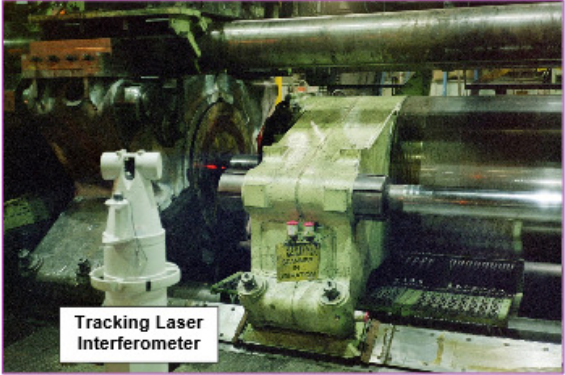
**Alignment Principles<sup>1,2,3,4</sup>**

The geometric or dimensional aspects of an extrusion press are fundamental to proper press alignment, which is required for maximum production quality and minimum downtime. The press should be installed according to the original manufacturer's specifications, especially with respect to tolerances. If their instructions and recommended procedures are carefully studied, the ideal 3-D geometric relationship of the press components can be determined. In general, the main 3-D geometric relationships of the static components of a simple extrusion press are as follows:

- the press base or bedplate should be level with respect to gravity, and the relevant contact points should lie in a flat plane.
- the back or resistance platen should be fixed perpendicular and the front platen located perpendicular to the base, with both platens parallel to each other.
- the pressure ring bushing should have its hole centered in the front platen with its front surface flat and parallel to the front platen.
- the guide ways for the crosshead and container should be straight and parallel longitudinally to the base, and should be symmetrically spaced about the press center line with the correct dimensions.


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## Optimize your Extrusion Press Alignment with Modern Technology



**Tracking Laser Interferometer**

- **Better press alignment and monitoring** techniques increase the productivity, efficiency and quality of extrusion.
- **Single day measurement** of the complete press gives you the total 3D inspection model for compliance.
- Compare any component against specified 3D geometry.
- **Measure and monitor** under operational conditions without dismantling the press.
- Traditional methods are unable to identify or correct many press alignment problems
- **Full press alignment measurement is faster**, more accurate and reliable.
- **Modern technology** replaces or complements traditional methods and tools for Extrusion Press Alignment.
- **Have your press Aligned or benchmarked** – any type and make of extruder.



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Information in this chapter is largely derived from the following papers:

<sup>1</sup> Mulder, Joseph E. V., and Smith, Gavin J., "Extrusion Press Alignment with Modern Technology," *Proceedings of 7th International Aluminum Extrusion Technology Seminar*, Vol I, (2000), p.455-463.

<sup>2</sup> Anthofer, E.J., "Press Alignment," *Proceedings of 2nd International Aluminum Extrusion Technology Seminar*, Vol. I, (1977), p. 169-173.

<sup>3</sup> Freese, Howard W., "Alignment of the Extrusion Press," *Proceedings of 3rd International Aluminum Extrusion Technology Seminar*, Vol. I, (1984), p.105-111.

<sup>4</sup> Bergman, John, "Press Alignment Using 3D Laser Technology," presented at AEC Press Maintenance Seminar, (2002), Chicago.

- the main cylinder, bearing bushing, flange, and ram piston should be concentric and centered on and perpendicular to the back platen.
- the crosshead should be center-mounted on the ram and fitted with a straight and centered extrusion stem perpendicular to the back platen.
- the press center line is the line joining the platen centers, and all the platen-centered components should lie on this line.
- the geometric center lines of each of the four machined tie rods or columns should be parallel to and symmetrically located about the press center line so that their mean is parallel and lies on the press center line.

It is clear that, as more components are added, a more complete 3-D model is built up equivalent to the original design drawings and, with the specified tolerances and critical dimensions, that this is the mathematical inspection template used during measurements for compliance of any of the press components.

Similarly, the 3-D geometric relationships of the moving components of the press are as follows:

- the ram piston and the extrusion stem move along the press centerline over their full stroke.
- the center line of the container bore is coincident as it moves along the press center line from its open to closed position, under container pressure and during various extrusion loads.
- the centerline of the tooling stack is coincident with the press center line in its closed state, under container pressure and during various extrusion loads.
- the billet loader positions the billet so that its centerline matches the centerline of the container and stem before it is loaded into the container.

These relationships must be correct when the press is at operational working temperature to allow for thermal growth effects. The above also implies that some sort of monitoring process of the major press components should be carried out during the various operational load and event conditions of ram and container pressure and extrusion.

## Alignment Procedures

The procedures and frequency for press alignment will vary according to the press design and condition and the quality control procedures of the plant. The original recommendations of the press manufacturer, if available, should always supersede the procedures described below. However, in the absence of complete alignment instructions from the press supplier, these will be helpful in setting up an alignment program.

Press Alignment procedures may be divided into two parts:

- **Alignment of the main press frame and components**, which must be carried out very precisely when the press is first installed; again after any period of neglect, for example, when beginning a new program of regular preventive maintenance; and rechecked periodically thereafter.
- **Routine re-alignment of wearing components**, which frequently vary due to steady wear and tear or replacement of components.

**Laser alignment** tools and methods are emerging as the best technology for quick and accurate press alignment, often replacing the **mechanical devices** used since the 1950's. At this time the laser tools may not be available to all extruders, so both types will be presented in this chapter.



Figure 2-2: Three-plane laser level  
(See [www.hamarlaser.com](http://www.hamarlaser.com))

## Recommended Tools

The tools recommended for performing press alignments may include the following:

**Machinist's Level.** A precision type level, it should have minimum 10-second accuracy (one division equals 0.0005 inches/foot or 0.004 mm/Meter). **Do not use on hot surfaces!**

**Surveyor's Precision Optical Level (Transit).** Typical accuracy is 0.0001 inches/foot.

**Laser Level (1, 2 or 3 Plane).** (Now commonly used in place of transit.) The 2- or 3-plane lasers will require fewer set-ups to complete the leveling. (Figure 2-2)

**Trammel Rod.** These are custom-built devices designed for measuring the distance between platen flanges (or between tie-rod nuts). A steel or aluminum tube is fitted with an inside micrometer or dial indicator on one end, and a spherical-ended pin on the other (see Figure 2-3). For accuracy, the trammel rods must be designed and supported to avoid deflection from their own weight; and insulated to avoid expansion from

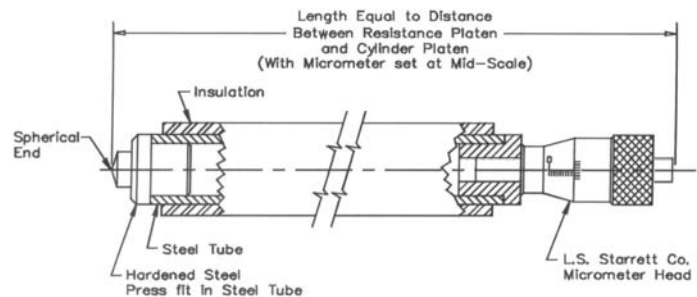


Figure 2-3: Trammel Rod device.

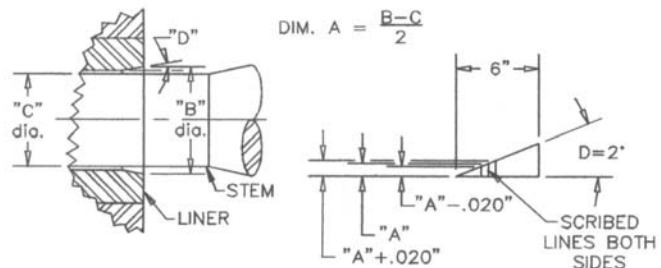


Figure 2-4: Container Taper Gauge

heat transferred by the press container heat.

**Container Taper Gauges.** Custom-made gauges as shown in Figure 2-4 are fabricated of an easily-scribed material such as aluminum, about 6 inches long with angle taper slightly greater than the taper of the container inlet or taper seal taper. Scribed marks indicate the accuracy of ram centering within the container.

**Adapter Blocks for Angled Guideways** (two required). For presses equipped with angled guide ways, these custom-made adapter blocks (Figure 2-5) provide proper reference points for leveling of the press frame.

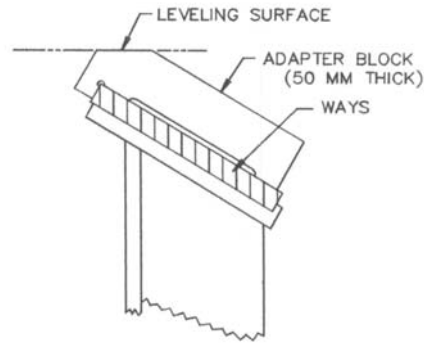


Figure 2-5: Adapter Block for Angled Guide Ways.

**Piano Wire (or Music Wire).** Diameter 0.4 mm to 0.5 mm (0.015" to 0.020"); tensile strength 250,000 to 500,000 psi (1700 - 3400 N/mm<sup>2</sup>).

**Fixtures for Piano Wire Tensioning.** Use of music wire for locating the press center line may be simplified by use of custom-made fixtures as shown in Figures 2-6 and 2-7, for tensioning and positioning the wire at the press platen and ram stem.

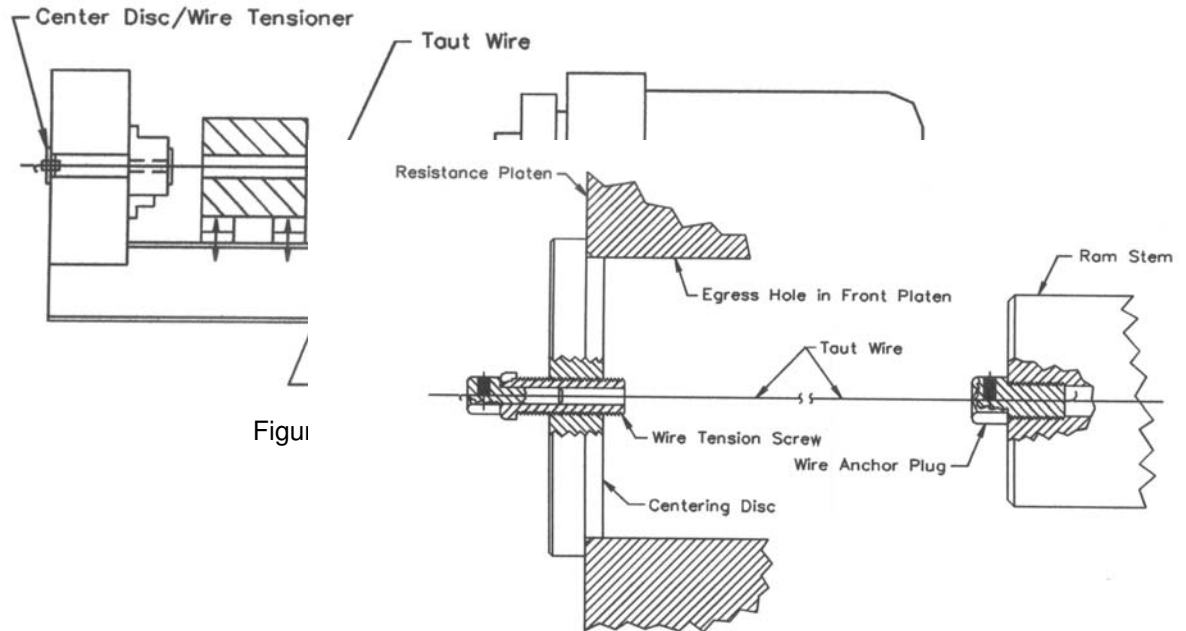


Figure 2-7: Fixtures for alignment with piano wire.

**Precision Tube Fixture.** Alternative alignment techniques may use a custom-machined tube, along with fixtures for the press platen and ram stem, as detailed in Figure 2-8.

**Base Centerline Fixtures.** Another system uses precisely located holes in the press base, along with special fixtures as detailed in Figure 2-9.

**Dummy Dies and Tooling Stack.** An alignment tooling stack with an appropriate center hole (Page 2-11) is used for checking centering to the container, stem, and pressure plate. An alternative type of dummy die with precision scoring (shown in Figure 2-12) may be used to quickly measure tooling-to-container alignment.

The following additional standard measurement tools are recommended:

**Dividers\***, **Calipers\***, and **Hermaphrodite Calipers\***

**Precision Square\***

**Straightedge\*** (typical 8 feet long)

**Plumb Bob\***

**Feeler Gauge\***

Note: the items marked (\*), plus the music wire, machinists level, surveyor's level, and inside micrometer for trammel rod, are generally available from tool suppliers; for example, from McMaster-Carr Supply Co., PO Box 4355, Chicago IL 60680-4355, Telephone 312-833-0300, Fax 312-834-9427, [www.mcmaster.com](http://www.mcmaster.com).

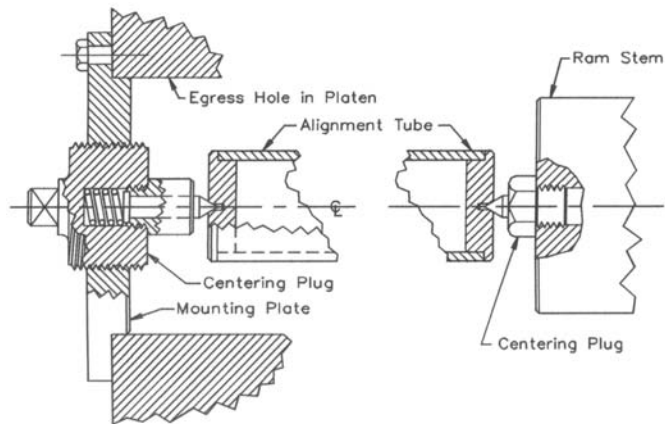


Figure 2-8: Precision Tube Fixture

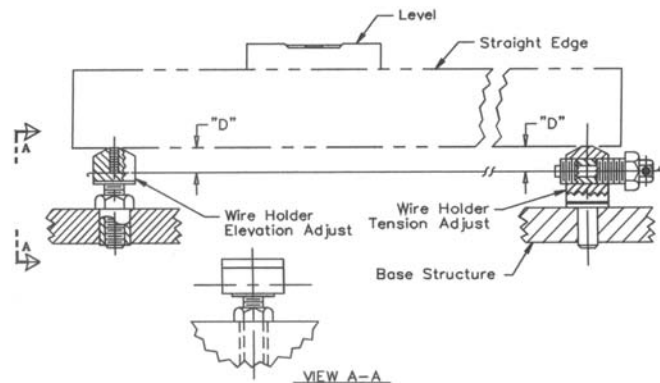


Figure 2-9: Fixture for Base Centerline Method

## Alignment and Leveling of the Fixed Press Components

The press base must first be square and level. When first installed the press base is usually set on shim packs on top of the press foundation, leveled, and then grouted in place. Normally, ½" to 1 ½" of grout is used. Anchor bolts should be tightened against the shim packs, which are located on both sides of each anchor bolt to avoid distortion of the frame. Leveling accuracy is normally 0.0005 in/ft (0.04 mm/meter).

With the passage of time, it is possible that the press base is no longer level. Possible problems include:

- settling of the foundation or the soil underneath
- deterioration of the foundation
- deterioration of the grout
- loose anchor bolts
- environmental conditions
- modification or mechanical damage to the press frame

Before leveling the press base, the condition of the grout and foundation and the tightness of anchor bolts should first be checked. If necessary, remove the grout; re-level and shim the base; re-tighten the anchor bolts; and re-grout. If the levelness continues to change due to foundation deterioration or settling, consult a geotechnical engineer concerning modern techniques of foundation repair, such as **pressure grouting** and **grout pilings**. Once correctly adjusted and stabilized, re-checking of the press base should not be required except at infrequent intervals unless there are unusual foundation problems.

It is also important to insure that tie rod nuts are tight and that the tie rods and nuts are not cracked. Any looseness will affect measurements.

**1. Level the Press Base in all directions.** Check the level lengthwise, then across the base, and then diagonally both ways (left front to right rear, right front to left rear). The desired variation from true level is maximum 0.0005 inches/foot (0.04 mm/meter). Re-level the base if it exceeds 0.0030 in/ft (0.25 mm/M) from true level.

The guide ways are the preferred reference points for leveling. In case of angled guideways, use the *Adapter Blocks for Angled Guideways* (Figure 2-5) to establish horizontal surfaces for use in leveling.

Measure 12 to 14 points along the length of each guideway. If using a laser level, measure along both the inside and outside of each way. First choose one way as a reference plane and then measure all other points against the reference.

**2. Level and align the Main Cylinder.** The platen or flange portion of the main cylinder must be perpendicular to the guideways and the centerline of the press base, and parallel to the front platen. To measure, place a precision square on the machined front surface of the platen, and check the horizontal leg of the square with the machinist's level. Maximum allowable variation from perpendicular: 0.0005 in/ft (0.04 mm/meter).

If using a 3-plane laser, measure the angle between the reference guide way and the main cylinder and front platen, in order to determine their squareness to the reference guide way.

Another important check: extend the main ram just far enough to accommodate the machinist's level on the ram surface (about 18"). At this point the main ram should be fully supported by the main ram bearing bushing. The main ram should be level to the same tolerance: 0.0005 in/ft (0.04 mm/meter). If the main cylinder's platen surface is perpendicular and the ram is not level, the main ram bearing bushing is likely worn and may require replacement. The guide shoes of the moveable crosshead should just be touching the guide ways in this position.

On some presses the perpendicularity of the main cylinder platen may be adjusted by jacking and shimming the rear cylinder support.

**3. Check the levelness of the tie rods.** Check the level in both directions -- along each tie-rod and across both the top and bottom sets of tie-rods at each end. The tie rods should be level to the same tolerances as the press base: 0.0005 in/ft (0.04 mm/meter).

**4. Check that the Front Platen and Main Cylinder Platen are parallel.** Distance between the two platens should be measured at each tie-rod, with the container at operating temperature. Measurement is made with the trammel rod (Figure 2-3), always measuring between machined surfaces. In some cases it may be easier to measure between the inside tie-rod nuts; in this case you will always measure the thickness of the nuts with a micrometer and add these dimensions to the trammel rod measurements.

Always support the trammel rods from the tie rods with "S" hooks to avoid deflection, and insulate the rods to avoid expansion due to heat from the container.

Maximum variation will depend on manufacturer's recommendation; in absence of this information, the maximum allowable variation between tie-rods should be  $\pm 0.003$  inches (0.075 mm). This measurement should be repeated under both no-load and loaded conditions.

Newer presses may have the tie rods encased in sleeves, which are machined to exact dimensions. In this case, the platens should always remain parallel, and it is not necessary to check the "tram."

**5. Check the pre-stress of the tie-rods.** Follow the press manufacturer's instructions for loosening the nuts and adjusting the prestress of tie rods. In the absence of such manufacturer's instructions, the following general procedure may be useful:

Prestressing of tie rods is usually accomplished by raising the press tonnage to 10% above the rating, using the main ram to stretch the rods, and then tightening the inside nuts and locking them to retain the prestress.

The inside nuts should remain tight, even under full load, and should not allow insertion of even a 0.001 inch feeler gauge (0.025 mm) between the nut and flange. Likewise when the load is relaxed there must be no clearance between the platen and outside nuts. With sleeved tie-rods, no space is permitted between the sleeve and platen. Any such space indicates a loss of pre-stress and requires re-torquing of nuts and rechecking of squareness.



## Alignment of the Moving Press Components

The so-called “dynamic” press components are cycled many thousands of times in a typical month and so are subjected to wear, as well as to heating and mechanical shocks. However, while your press has grown older and wear has accumulated, your customers’ demands for profile tolerances and wall thicknesses have become more difficult. Alignment between container, die, and platen pressure ring are more critical than ever. Following are the recommended procedures:

**1. Check the level and alignment of the main ram and ram stem.** Check that the main ram remains level and aligned with the press centerline (in the plan view) throughout its travel. On most presses adjustment is made through the guide shoes of the moveable crosshead. It is recommended to check at least 3 points of the travel. Level may be checked on the main ram with the machinist’s level or the surveyor’s level. It may also be checked on the ram stem after determining that the ram stem is both straight and parallel with the ram, and that the stem retention devices are properly tight.

Alignment in the plan view (left/right) is checked by first establishing the press centerline with a piano wire and using a plumb bob at three points along the ram stem travel.

If using a laser level, attach a receiver to the ram and track it throughout its entire stroke. The stem can then be tracked in the same way.

**2. Check the alignment between the front platen pressure ring, die stack/die changer, container, and ram stem.** There are several different procedures and fixtures for you to choose from, for measuring the relative alignment of these elements. You will probably use a combination of the following:

**A. Aligning moving components with laser.** The laser can be used to find the center of the die stack in relation to the pressure ring opening. A clear die stack such as the alignment tool stack will make placement of the receiver units easier. In a similar manner the stem’s centerline may be checked relative to the pressure ring and tooling stack; check it at various positions for the stem. Finally, the centers for the front and rear of the container may be checked if cold – if hot the laser beam will be distorted and inaccurate! For this check the sender is placed in the container bore and the receiver on the stem.

**B. Locating the die stack position by use of an Alignment Tool Stack:** While it is theoretically possible to measure the die location from the surfaces of the die carrier or die changer pocket, in practice it is recommended to use an alignment tool stack (pages 2-11 and 2-12) for more accurate measurement of centering. ***In every case, you should check both sides of the double die slide, or both die carriers if fitted with unistation or rotostation die changer.***

**C. Locating reference centers with the Piano Wire method:** You should have already established the correct alignment of the ram stem and front platen. Next a piano wire is placed in tension along the press centerline, according to Figures 2-6 and 2-7. The special *Front Platen Centering Fixture* and *Ram Stem Anchor Plug* are installed and used to apply tension to the piano wire and establish the center reference for checking alignment of the die stack/die changer and container.

**D. Locating reference centers with the Precision Tube fixture:** The *Precision Tube Fixture* shown in Figure 2-8 may be used to establish reference centers for alignment of the die stack/die changer and container. The wall thickness of the precision tube is selected to insure minimum normal sag even after it is machined and ground for straightness. For example, a 4-inch OD tube (100 mm) with wall thickness 0.250 inches (6 mm) will sag only about 0.001” (0.025 mm) in a length of 9 feet (2.75 meters).

The tube is fitted with end plugs that have locating centers as shown. Fixtures are shown for supporting and aligning the precision tube at the ram stem and front platen.

Note that the centering fixture for the front platen is fitted with an adjustable stiff spring, which accommodates expansion of the tube due to heat from the container.

**E. Locating reference centers with the Base Centerline system.** This method creates two precisely located holes in the press base, which are then used for accurate placement of a special taut wire system for checking centerline distances (figure 2-9). (Some press bases may not be suitable for this method, depending on the design of the press base.)

To establish the base centerline, the tie-rods are used as a reference and a taut piano wire is wrapped in criss-cross fashion as shown in Figure 2-10. Then a plumb bob line from the intersection of the crossed wires is used to locate centerline points on the press base. Two holes are drilled and reamed at these points: one 0.50 in (12 mm) and the other 0.75 in (19 mm). The two surfaces used for these holes should be approximately level with each other. Special wire holders (as shown in Figure 2-9) fit snugly into these holes to establish a taut wire centerline.

One wire holder is adjustable for height, the other one for wire tension. The wire is brought to true level, tolerance 0.0005 in/ft (0.04 mm/meter); level may be quickly determined by placing a straightedge across the wire holders and using the machinist's level. (The vertical distance "D" from the wire to the leveling surface should be machined the same on both wire holders.)

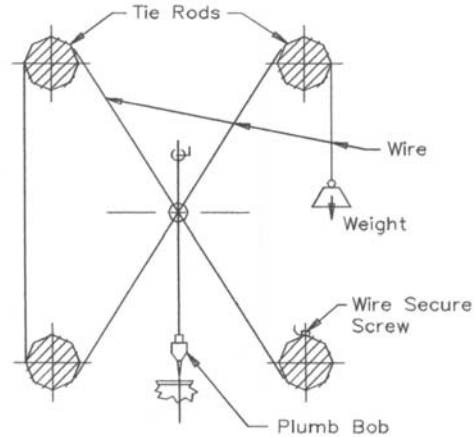


Figure 2-10: Locating the Centerline of the base

**F. Checking clearance between Container and Ram Stem with taper gauges.** The aluminum taper gages shown in Figure 2-4 are used as illustrated to check centering of the ram stem within the container opening. The gauges should be placed on the ram stem surface and against the container opening. The point of contact with the container opening, as compared with the inscribed marks, is checked at 4 points 90° apart around the ram stem. Clearance between ram stem and container should not vary more than 0.020" (0.5 mm) around the stem. This clearance should be checked at both ends of the container.

Note: similar taper gauges may be used with the *Precision Tube Fixture* system described above.

**G. Reference Dimensions for the Container Centers.** Because the actual openings of the container may contain nicks and irregularities, it is recommended to

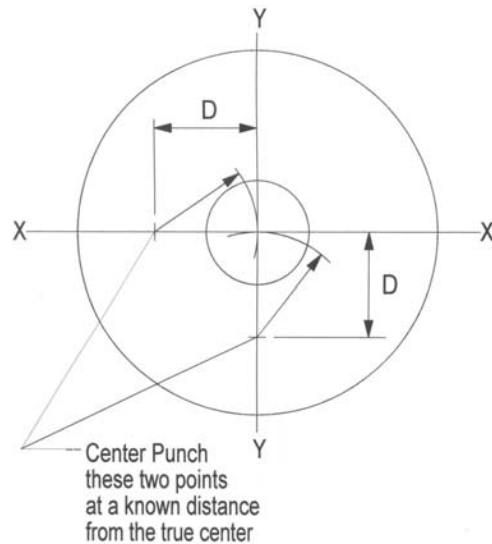


Figure 2-11: Locating the container centerlines

locate reference measurement points on the container faces. A center punch is used to locate reference marks at fixed distances from the actual center, on both the vertical and horizontal axes. Reference points should be marked on both the front and back container faces. Measuring from these points to the taut wire or precision tube described above is much easier and more accurate.

**3. Adjusting the Alignment of the Container and Tooling Stack.** The target alignment accuracy between the container and tooling stack in all directions is  $\pm 0.020$ " (0.5 mm). Caution: when using taper seal dies, exact vertical alignment is desirable, but the container should never be below the die centerline, in order to avoid upward thrust loads to the die stack and die carrier.

Adjustment procedure varies according to press design, and there are many different systems. The die stack must be at operating temperature. Most commonly, the die stack is first adjusted to match the pressure ring. Lateral adjustment is made by moving the threaded stop of the die changer. (Unistation and rotostation changers use a single stop for both die carriers, so this adjustment is made easier and more accurate.) Adjusting the die position vertically is more difficult; while a few presses have built-in adjustment, on most it is necessary to vertically shim the guide ways or "gibs" of the die changer.

Next the container must be adjusted to align with the die stack and also the ram stem. Once again, the container and die stack must be at operating temperature. Container adjustment is made with the adjusting screws on the guide shoes. Presses with center guides (top or bottom) and "X" or angled guide ways pose the greatest problems in making accurate adjustments, due to difficult access and the indirect nature of angular adjustments. Consideration should be given to retrofitting the press with guides which permit "logical" vertical and horizontal adjustments. (See page 2-15 and also Chapter C: Modernizing Older Presses.)

**4. Alignment of the Butt Shear.** On smaller presses (below 1800 Tons), the shear adjustment should place the shear blade 0.020" to 0.025" (0.5 to 0.6 mm) from the hot die face. On large presses this clearance may increase to as much as 0.125" (3 mm). However, the dimensions of the die stack must first be standardized and the position precisely assured by the position and dimensions of the die carrier or die changer pocket (and clamp if available).

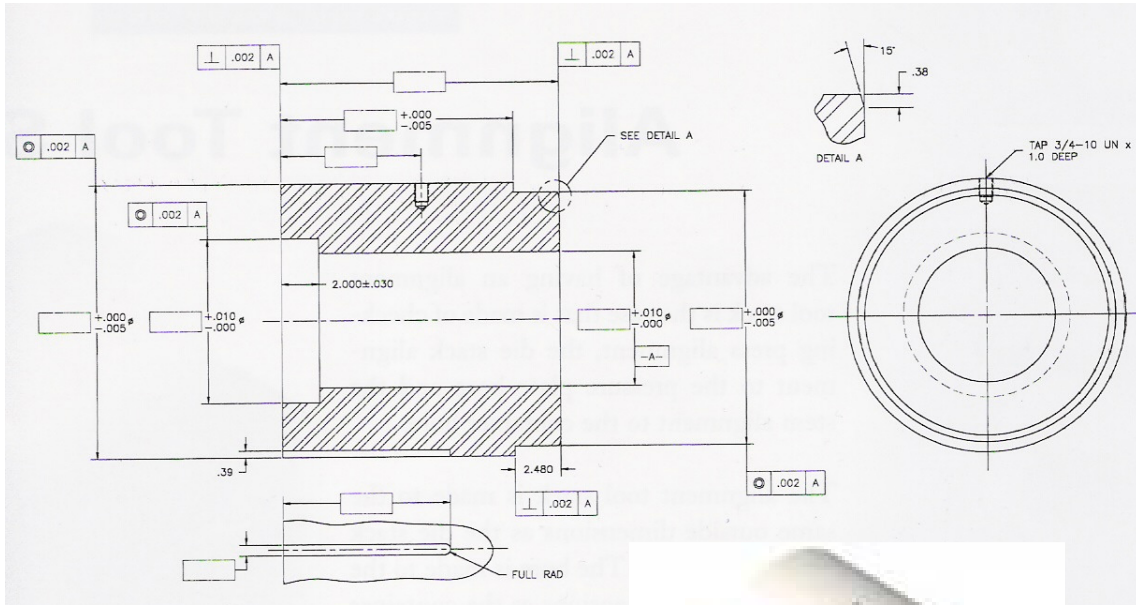
While many press operators operate with greater clearances, due to sloppy die dimensions and worn or loose parts, the result is a great risk of mechanical failures or collisions, and failure of the butt to separate from the blade properly.

The method of adjusting blade clearance varies according to the press design, but normally it is required to add or remove shims between the blade and its holder to achieve the necessary dimensions.

**5. Alignment of the Billet Loader.** The container, ram stem, and fixed dummy block must all be at operating temperature. Alignment accuracy of  $\pm 0.020$ " is recommended. Preliminary measurements may be made by any of the alignment systems described previously, but should then be checked with an actual billet or full-size dummy billet, and with the container in the sealed position. The means of adjustment varies according to the design of the billet loader and press.

Alignment should take place with the loader raised to the loading position, then blocked in place with a heavy timber in case of power or control failure. Presses which still use loose dummy blocks should be checked with a loose block on the billet loader.

## Use of the Alignment Tool Stack<sup>5</sup>



The advantage of having an alignment tool stack is the ease that is made of checking press alignment, the die stack alignment to the pressure plate bore and the stem alignment to the container bore.

The alignment tool stack is made to the same outside dimensions as the die stack and bolster stack. The bore is made to the same internal dimensions as the container bore and the pressure plate hole.



When the alignment tool stack is sitting in the die holder with the container sealed, you can look through the platen hole and check the alignment of the container to the die stack.

The stem should then be brought forward without the alignment tool stack, to the entrance of the container, and held so that the stem can be checked for alignment to the container bore. The stem should then be brought forward to the end of the stroke. It should be on center all the way through the container. If not, the stem is out of alignment.

### Press Alignment

Most often the problem is not a single one, but a number of small ones which add up to a major problem.

Problems with press alignment can often start from the press foundation and bed, which can move over time from normal use. Foundation bolts and shims can become loose, allowing the press to shift.

Some presses are supplied with a pair of alignment blocks. In this case, the ways are on an angle and the alignment blocks can be placed on the ways with a straight edge and machinery level. This will soon tell the story (of course, more efficient lasers can be used if available).

Should the bed of a press be out of level, problems will multiply as you proceed with alignment.

<sup>5</sup> Pages 2-11 and 2-12 are taken from Castool Bulletin "Alignment Tool Stack."

The tie rods should be checked and maintained within .005" (.127 mm) in all directions.

The main ram (with level bed) should be moved out approximately 30" (750 mm) and a machinery level placed on top of the ram. The ram can then be leveled with shims under the main ram shoes. If the stem is not level, both the crosshead pressure plate and the stem should be checked.

With the alignment tool stack installed in the die slide, align the pressure platen hole and container bore to the alignment tool stack. If you have misalignment between the container and the alignment tool stack, check the die changer for height and the base of the die changer for level.

The alignment tool stack should then be removed from the die carrier and the stem moved forward and centered to the container bore (a taper wedge is useful for this purpose). Looking through the platen, the stem should then be moved slowly through the bore of the container; it should be in the center of the bore all the way through.

After the stem is aligned, align the billet loader so that the plates are approximately 0.020" (5mm) above the bottom of the container bore.

The face of the stem should be checked for mushrooming. If mushroomed, the stem must be stress relieved, checked for cracks and machined.

The extrusion cycle should also be checked. The container should only open 3/4" to 1" (20 to 25 mm) before the main ram starts to retract. This is usually accomplished by adjusting limit switches. This will reduce the damage caused to the alignment tool stack and container face during the ram return.

Many problems are caused by aluminum build up on the sealing face of the container or the die. This may be due to poor butt shear adjustment, bad loader alignment, or a butt lodging between the container and the die which forces the container to move. A tilt switch can be installed to stop serious damage to the stem and the loader if this occurs.

Another area which should be examined is the main ram bushing and the main ram packing. If there is wear in this area there will be signs of oil leakage and the stem will be out of parallel. A short term solution is to rotate the bushing 180°.

## Quick Checks of Press Alignment

Following are two procedures which may be used for quickly checking alignment between the press container and die stack, for example, in the case where daily monitoring of alignment is desired.

**1. Checking alignment of Container with Die Stack by means of a Scribed Blank Die.** A fast check of the most critical alignment -- between the die and container -- may be made with only a brief operating pause, by means of the *Scribed Die Blank* as shown in Figure 2-12. The special die is loaded into the die changer and used with a 2-inch thick (50 mm) billet slice, which may be hand loaded into the container (cold). After suitable press tonnage is applied to the blank, the upset billet slice is retrieved and set aside for measurement. Centering is easily measured at the peripheral ring and "cross-hairs". Each die carrier or die slide pocket should be checked in the same manner. Due to the quick nature of this test, it may be conducted daily, according to the sensitivity of production requirements to tooling alignment.

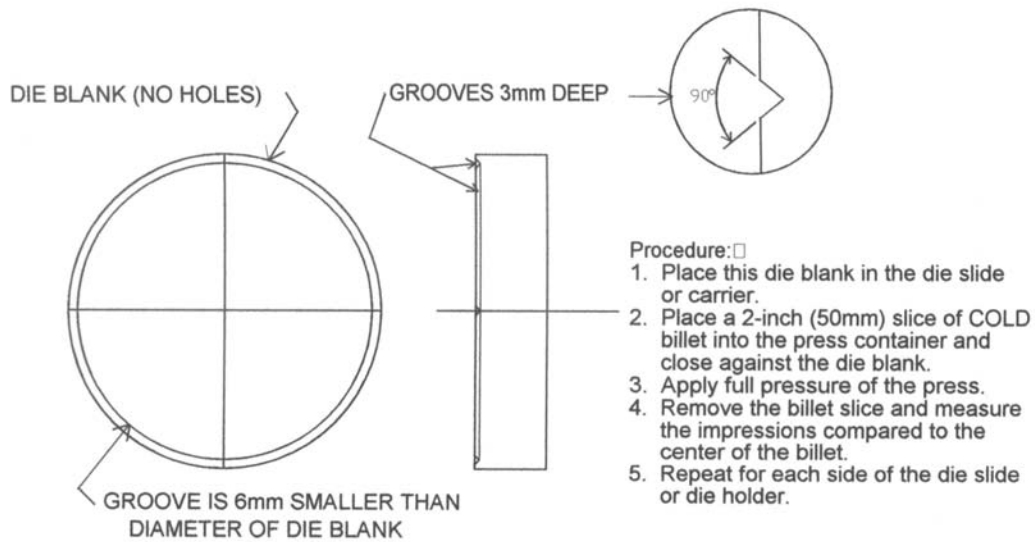


Figure 2-12: Scribed Dummy Die for Fast Check of Alignment

**2. Checking alignment between Container and Die Ring by means of a cardboard imprint.** With this method, a sheet of cardboard is placed by hand between the container and die stack; mark the top position for the sake of orientation. Close the container onto the cardboard and then reopen it. The result should be circular impressions on each side of the cardboard, from the container opening and die ring. Next the cardboard is taken to the office, where the centers of both circles are located by geometry, using a

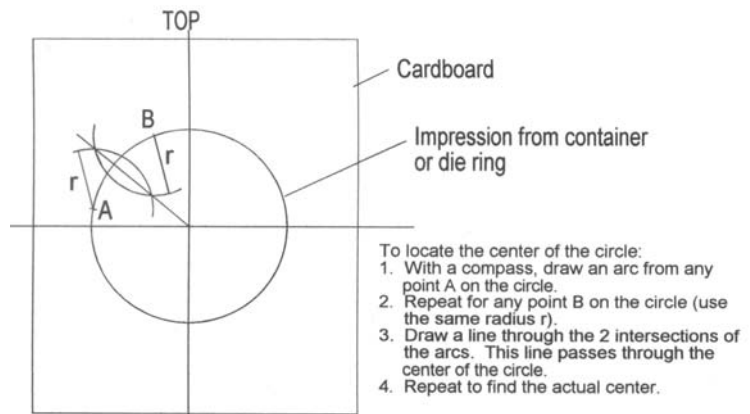


Figure 2-13: Comparing the centers of the container and die ring

compass (see Figure 2-13). By passing a pin (or compass point) through the cardboard at one of the centers, it is possible to measure the misalignment, if any, between the two circles.

### Continuous Electronic Monitoring of Press Alignment

Various systems have been developed to continuously monitor press alignment, either to provide a read-out of alignment or to activate an alarm when pre-defined limits are exceeded. This is a difficult application due to space limitations and the generally hostile environment around the extrusion press. The heated air around the press container has adverse effects on laser and optical systems, causing the light rays to shimmer and bend. Airborne dirt and potential physical abuse also affect long-term reliability of such systems<sup>6</sup>. Most of these monitor container alignment only. They often use a precision bar rigidly mounted to the container, and monitor its movement with precise electronic switches or encoders. Some examples:

- Some press manufacturers now install a fixture to the container and monitor its movement with a Balluff position encoder.
- Others use Linear Variable Differential Transformers (LVDT) to measure container position through contact with the guide ways. An accurate position is then available on-the press controller screen.
- Freese<sup>7</sup> proposed a system of as many as eight LVDT devices mounted on air cylinders at 45-degree angles to the vertical. The cylinders are actuated periodically to bring the LVDT's in contact with the container holder. Sensor readings are converted to X and Y components and compared to reference data for the same points.

For further information, the reader is referred to the referenced paper.

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<sup>6</sup> Freese, Howard W., *ibid.*

<sup>7</sup> *Ibid.*

The following comments on alignment of dynamic press components are adapted from the referenced paper by Mulder and Smith<sup>8</sup>:

**Optical tooling** uses powerful alignment telescopes to obtain precise reference lines and reference planes from which accurate measurements are made with optical micrometers, optical tooling tapes, optical tooling scales, and micrometer measuring rods<sup>9</sup>. This orthogonal measuring system was developed for the aircraft industry during the war but has now been rapidly superseded in many industries by faster modern technology. For press alignment, an alignment telescope is mounted in the egress hole of the front platen to establish an optical center line, and a target on the ram stem is sighted in three positions along its motion. This system provides its alignment check of the stem and of the main ram, assuming the stem is straight and parallel with the ram. The telescope line of sight is set using either the bore in the die pressure ring or the intersection of cross-wires in two places made by the intersection of a taut wire criss-cross configuration over the tie rods (tie-rod referenced centering, see figure 2-10).

Limitations are that the bore is often badly worn and not parallel, and the tie rods center reference may be from asymmetrically spaced rods or may not be on the center line.

## Modifying the Press for Easier Adjustment of Alignment

Many older presses (and even some new ones) are fitted with “X” guiding systems, which have angled guide ways and can only be aligned by trial-and-error techniques. Ask the mechanic who must work with this type of guides and he will confirm: when you make an adjustment in one direction it causes an unintended movement in another direction. Correct adjustment involves a series of approximations, usually until he becomes frustrated and quits. Other designs use top or bottom center guides, which require that someone climb into the hot press to make adjustments; that is a dangerous and impractical job with the container at temperature, and if done cold the heat expansion must be “guess-timated.” More often than not, center guides are left unadjusted. The result is poor alignment, which affects dimensional tolerances of the profiles.

Many new presses now offer guide systems with “flat” or horizontal ways, so that all adjustments are in either vertical or horizontal planes. As a result adjustments are more logical and can be made quickly by means of calibrated adjustment screws.

Typical conversions are shown in figures 2-14 and 2-15.



Figure 2-14: Conversion of container guides to flat type (Photo courtesy of Lake Park Tool)



Figure 2-15: Conversion of X container guides to horizontal (Photo courtesy of OMAV)

<sup>8</sup> Mulder, Joseph E. V., Ibid.

<sup>9</sup> Kissam, P. (1962) *Optical Tooling*, McGraw-Hill, NY. 1962



Another design uses the same principle by installing "V" guides (Figures 2-16 & 2-17). As with flat guides, all adjustments are completely logical -- simple vertical and horizontal adjustments -- and are quick and accurate. All changes are made from outside the press frame and may be made with the container at full operating temperature. This system has been in operation for more than 20 years on numerous presses and has been trouble free.

An improved guiding system is often installed together with a new one-piece container housing, which also improves alignment and makes it easier to use fixed dummy blocks.

X-guides may be converted to flat or V-type by welding or bolting on specially-made fixtures.

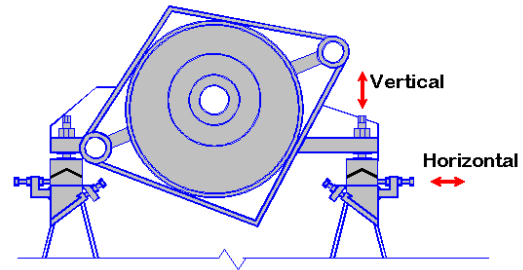


Figure 2-16: Conversion of container guides to V-type for easier adjustment



Figure 2-17: Container guides modified to V-type

*Editor's Note: The following is condensed from a paper presented at ET 2000 entitled, "Extrusion Press Alignment with Modern Technology," by Joseph E.V. Mulder & Gavin J. Smith, from the Industrial Measurement Centre, Department of Surveying, University of Otago, New Zealand. It provides an insight into new technologies for press alignment. While detailed procedures are not presented, the information will be useful to anyone working to set up a more sophisticated method for measuring extrusion press alignment.*

## **Extrusion Press Alignment with Modern Technology**

by Joseph E.V. Mulder & Gavin J. Smith, Industrial Measurement Centre,  
Department of Surveying, University of Otago, New Zealand

Modern three dimensional Coordinate Measurement Systems (CMS) such as optical triangulation with electronic theodolites, or optical polar ranging with laser tracker systems, provide a 3-D global approach or "combined picture" of the 3-D geometric relationships (position, attitude and geometric characterisation) of all press components.

This paper discusses the advantages of modern technology approaches to replace or complement the traditional methods and tools of extrusion press alignment.

The combined measurements for the static, moving components, and operational monitoring phases were carried out on an older extrusion press that had alignment problems. The adjustment solution applied enabled continued production at minimal cost for a press that would otherwise have been out of production for a long untenable major overhaul.

### **Background**

The methods and application of the various traditional tools for press alignment are essentially linear one dimensional (1-D) incremental discrete measurements of components which together may give the full geometric condition of the machine with respect to gravity, and then give an indication of what corrective adjustments are best. More likely, each alignment sequence is heavily dependent on a previous one, thus requiring corrective action before being able to go onto the next one, or before being able to suitably relate the components together to their specified geometric characterization (flatness, levelness, parallelism, squareness, symmetry, and center line linearity). A full press alignment determination with traditional techniques is very time consuming (several days) with some parts having to be measured in a dismantled state and others only able to be made with the press in a cool state. Measuring press alignment in the traditional way requires considerable time and uncertainty associated with the incremental buildup of the 3-D geometric component relationships from 1-D measurements. The result is a task that would be undertaken only reluctantly or as a very last resort, particularly if it required an unscheduled outage cutting into production, or even during normal scheduled maintenance. However, some simple press adjustment tasks and checks on an individual component are likely to be more practical and economical using the traditional methods.

Modern three dimensional (3-D) Coordinate Measurement Systems (CMS) provide a 3-D global approach or "combined picture" of the 3-D geometric relationships (positions, attitudes, and geometric characterization) of all press components. A full press alignment measurement is faster, more accurate and reliable, and has several other advantages over traditional methods, described earlier in this chapter.

Though these traditional methods and tools have stood the test of time and many are still used today, there are now more efficient techniques using modern technology which not only complement the traditional ones but in many cases replace them. Offset reference points, lines or scribe marks can be provided by the modern methods during the measurement task to facilitate subsequent adjustment by mechanical methods.

## Modern Technology

Modern three dimensional (3-D) Coordinate Measurement Systems for large-scale dimensional metrology make use of optical measuring systems using different types of instruments. These systems are essentially portable Coordinate Measuring Machines (CMM) allowing rapid deployment to immovable objects for in-situ high precision 3-D measurement. Those based on triangulation techniques (horizontal and vertical angles only) use precision electronic industrial theodolites and high resolution video cameras; and those based on polar location (horizontal and vertical angles and electronic distances) use precision total stations, tracking laser interferometers, and laser radar scanning. Associated system software allows individual or various instrument combinations for the on line measurement of the 3-D coordinates of selected object points and a wide range of analysis functions to process the object point data. There are also other 3-D measuring systems such as mechanical touch probes which use a multi-axis articulated arm with angle encoders, and other hybrid systems based on laser scanning and other rapidly emerging technology. Some of these are not generally practical yet, or have limited range, or are lower accuracy systems unable to meet tolerance requirements. Precision optical systems typically measure, within a 10m cube (33ft cube), object space to better than 0.1mm (0.04inches) and more often to better than 0.025mm (0.001inches).

Digital video cameras are used in close range photogrammetry and videogrammetry systems, particularly where large amounts of data points are required to be captured instantaneously and/or when the object is deforming rapidly. Recent videogrammetry systems for industry such as V-Stars<sup>10</sup> are now capable of very accurate (better than 10 ppm at close range) real time co-ordination of pre-targeted points and single point targetless measurement with hand held probes using multi-headed camera systems.

**Coherent laser radar scanning** is a new emerging technology with much potential. It too is suitable for capturing large amounts of data points very rapidly (1000 points/sec.), and with an accuracy of 2.5 ppm<sup>11</sup>. This technology is similar to the laser tracker described below except the distance is measured using coherent laser radar (absolute distance) instead of a laser interferometer, and the points measured are in vertical sweep scan columns up and down the object instead of single-point contact measurement to a stationary or active retro-reflector.

The choice of the most appropriate measuring sensor(s)/system is dependent on the application and often on access and availability. For extrusion press alignment, which is the subject of this paper, only those instrument systems that are more appropriate will be further described in detail as their principles and techniques represent the majority of modern 3-D CMS. These systems are the theodolite triangulation system, the single station polar system, and the tracking laser interferometer; and of these the theodolite system was used in the specific press alignment example discussed here.

### Multiple Theodolite Triangulation Systems

This triangulation system makes use of two or more electronic theodolites intersecting their lines of sight at the point to be measured.

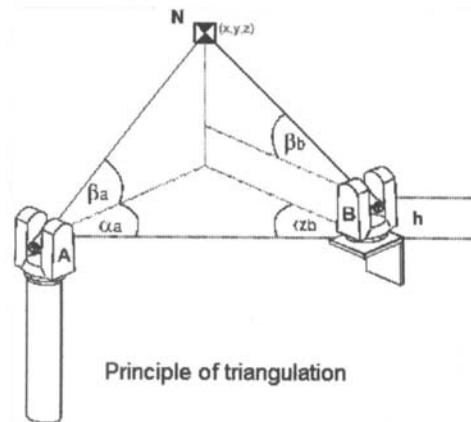


Figure 2-18: Two theodolites intersecting at point N

<sup>10</sup> Leica 1997, Product information on *V-Stars - Videogrammetry systems for industry*, U1-341-OEN - III.97, Leica AG, Heerbrugg, Switzerland.

<sup>11</sup> White, D. A., "Coherent laser radar: True non-contact 3-D measurement has arrived," *Quality Digest*, August, 1999.

The vertical and horizontal angles from each sensor are recorded in the interfaced computer and processed to provide 3-D point coordinates, (Figure 2-18).

The theodolites (sensors) are set-up at the endpoints of freely selectable bases chosen to provide good intersection geometry. The origin, scale and orientation of the coordinate system are established by definition of one sensor, observations to a calibrated known length scale bar, and a bundle adjustment of sufficient measurements to a minimum number of geometrically well spaced reference points around the object being measured. The theodolite co-ordinate system can readily be transformed into an object coordinate system via control points with design coordinates. Targets sighted by the sensors can be to a line or point feature on the object; a sphere, plug, magnetic, or tape target; or a laser dot or hidden point rod (for obscured locations). This is a portable, non-contact, self checking, point-by-point measuring system which can be expanded from a simple dual manual theodolite array to a multiple-sensor automated arrangement using motorized-robotic theodolites with video target acquisition suitable for large point numbers and their repetitive measurement.

Various names for this triangulation type system have included Electronic Coordinate Determination System, Remote Measuring System, Electronic Triangulation System, and Computer Aided Theodolites. Remote measuring systems have been well documented in many publications<sup>12, 13</sup>. Coordinate accuracies achieved with this system for objects less than 10m (33ft) are typically 0.03mm (0.001 inches).

### Single Station Polar Systems

Polar point determination can be carried out with a single instrument called a precision total station. This is an electronic theodolite with an integrated electromagnetic distance measurement (EDM) device that requires a retro-reflector to return the EDM beam. The two angles (hz & vt) and a distance are transmitted to driving software on-board or to an interfaced portable computer to provide 3-D coordinates of points measured (see Figure 2-19) for the polar measurement principle). This is a single-operator, contact measurement sensor that is fast and mobile, is geometry independent, and has its own inherent gravity referenced coordinate system. EDM is the system accuracy limitation at about 0.1mm (0.004 inches) to 0.5mm (0.020 inches). Targets consist of retro-prisms, and reflective tape though some modern total stations now have reflectorless (non-contact) capability. Modern system features are automation and robotics via servomotor driven theodolite and optics, and video target acquisition for automatic point inspection.

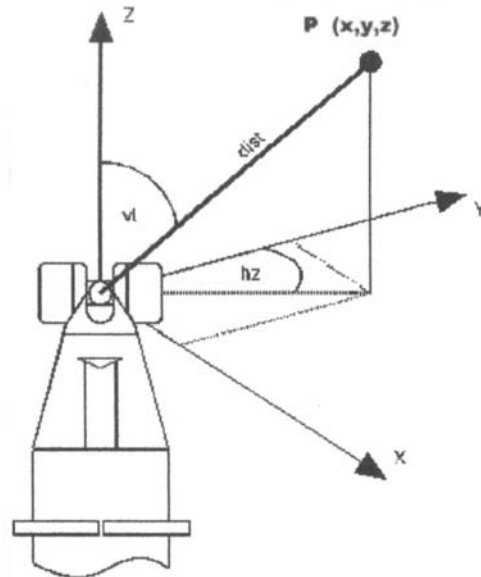


Figure 2-19: Polar coordinate principle

<sup>12</sup> Kennie, T.J.M., and Petrie, G., *Engineering Surveying Technology*, Blackie and Son Ltd., (1990).

<sup>13</sup> A comprehensive overview of remote measuring systems and applications is given in: Mulder, J.E.V., "The use of remote measuring systems for deformation monitoring," *New Zealand Institute of Surveyors Centenary Conference*, Wellington, New Zealand, October 1988, P1-17. *New Zealand Surveyor* VOL.XXXII(5), SN275, August, 1989 P.467-483.

## Tracking Laser Interferometer

The tracking laser interferometer (Figure 2-20) is a polar measuring system that uses a single beam laser interferometer to measure distance differences to a retro-reflector and a two axis motor-driven tilting mirror with optical encoders for horizontal and vertical angle measurement. A position sensing device (PSD) detects changes in the position of the reflected laser beam caused by shifts in the optical center of the reflector and applies mirror corrections via the motors to track the reflector's center. Correction monitoring occurs at 3000 times per second enabling the tracking and polar point measurement of a moving reflector at up to 1000 times per second. A factory calibrated and user re-definable distance from the mirror to a fixed home point provides the initialization facility for absolute interferometer distance determination. A recent addition to these trackers is a high precision EDM coincident with the laser path to measure absolute distance to the reflector to re-initialize the interferometer whenever its beam is interrupted. Figure 2-20 shows the components of a tracking laser interferometer. This is an accurate (5 to 10 parts per million of the distance), high integrity, single operator, contact measurement sensor that is mobile, collects vast amounts of 3-D data points very rapidly, is geometry independent, has its own inherent coordinate system, and can track and measure a single point on a moving object at high speed (4m/sec (13 ft/sec)). Other system features are infrared remote control, voice recognition, and programmed automation.

The modern CMS software now also allows combined systems of multiple theodolite systems and polar determination systems to be used together for special or larger measurement projects.

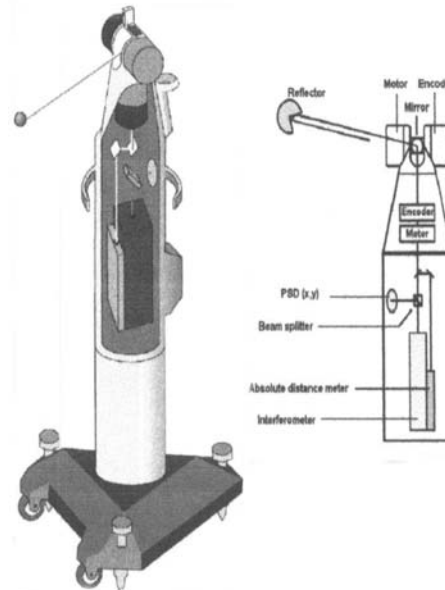


Figure 2-20: Tracking laser interferometer component details

## The Application of CMS to Press Alignment

All these 3-D CMS's essentially sample objects or components to determine their geometric shapes and spatial relationships so that these can be compared to design for establishment or adjustment purposes. For example, the position and orientation of the geometric axis of a tie rod is determined by sampling an appropriate distribution of points along its form to process a best fit cylinder shape. Further analysis of this axis with those of the other tie rods and the press center line for parallelism will give compliance information. Instead of physically establishing a center line with a piano wire or rod, a virtual center line is mathematically defined which corresponds far more accurately to the true geometric one than the mechanical reproduction. This means that all the points and components required for the complete press inspection can be measured in one session and analyzed in 3-D as required in any combination.

Not only can the overall static state of all the press components be measured in one go and in any order, but so can all the moving components at their various positions or continuously along their entire path of travel, and under operational conditions of temperature. This may be indispensable to achieve alignment corrected for true thermal growth effects. Moreover, the geometric characterization need only be relative and not necessarily with respect to gravity. For example, if a press base was tilted but still entirely correct geometrically, it would still function

properly, though a gravity based relationship allows the application of the traditional alignment tools more easily and in a complementary manner to CMS.

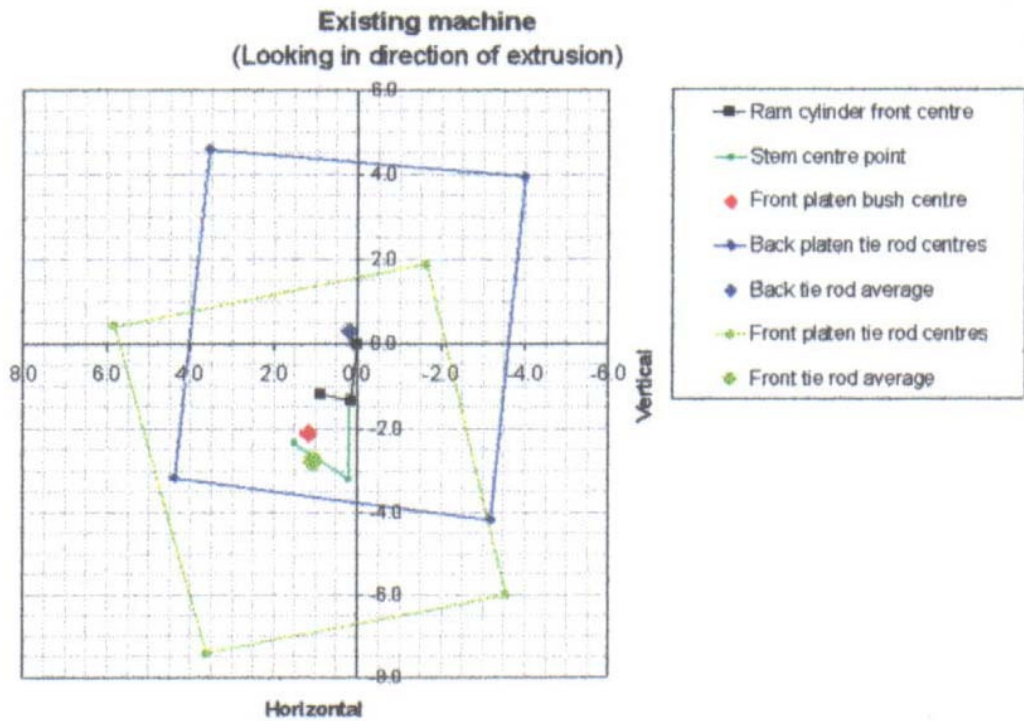


Figure 2-21: Initial mis-aligned state of press components

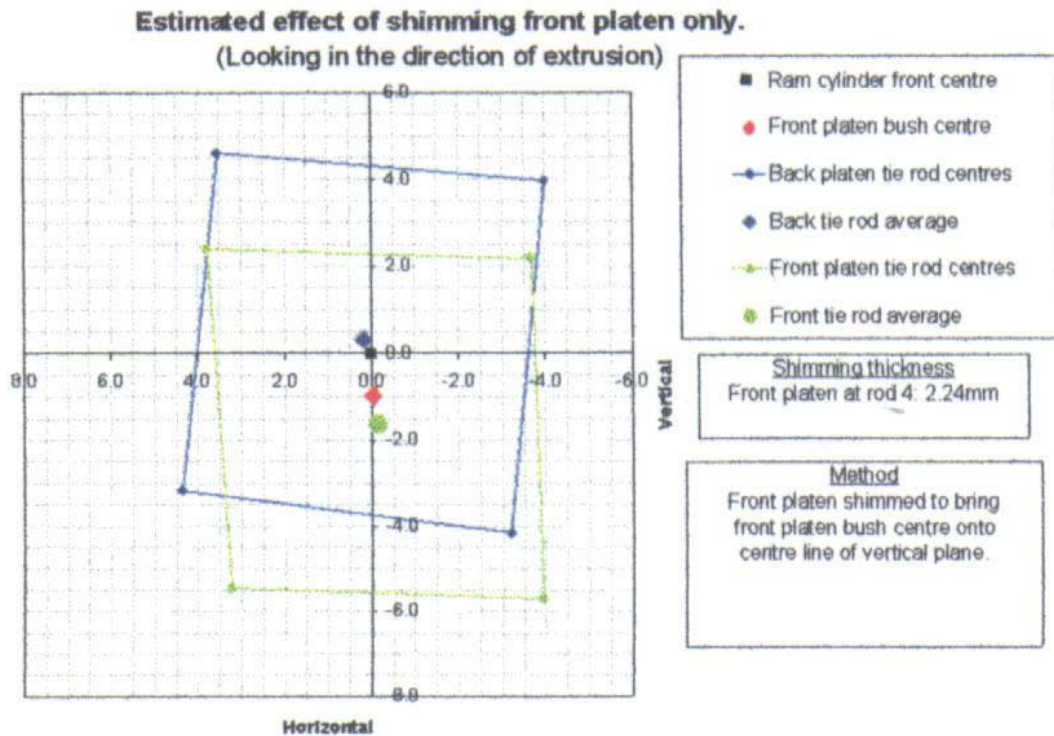


Figure 2-22: Adjustment solution 1: front platen only

A further diagnostic capability is to combine the CMS with dual axis digital tilt indicators to monitor the movement and distortion of general or specific press components under various operational load and event conditions of ram and container pressure and extrusion. Changes in location and angular attitude of press components between different load and event conditions can be determined or monitored by measuring the altered locations of 3 points on each relevant component, or the relative changes in tilt between a fixed and moving component. The tilt indicators provide a continuous stream of data showing the time-tagged changes in tilt as the press goes through its various operations. The exact time and correlated event when a suspect dynamic component has unacceptable movement or distortion can easily be diagnosed when the stream of data is graphed.

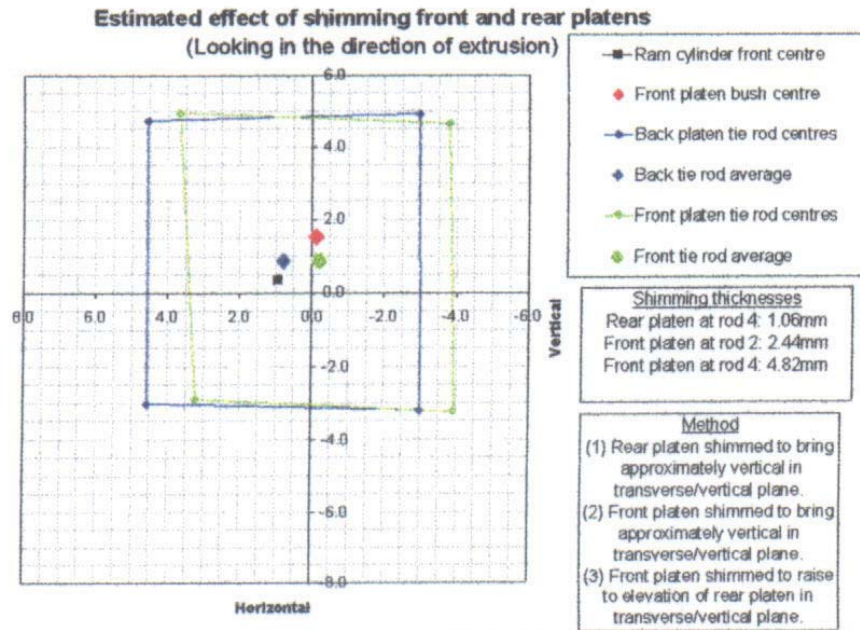


Figure 2-23: Adjustment solution 2: front and back platen

The combined measurements for the static, moving components, and operational monitoring phases were carried out recently in a single day on an older extrusion press (1650 ton) that had alignment problems due to badly worn moving components and a poor damage restoration record at installation. The purpose was to determine the press alignment condition to help determine its long-term repair requirements. Figure 2-21 shows the initial condition of the press and Figures 2-22 and 2-23 give two optional solutions for adjustment. The adjustment solution (2) was applied and enabled continued production (with no more sheared bolts!) at minimal cost on a press that would otherwise have been out of production for a long untenable major overhaul.

Another aspect is the manner in which the container (liner) seals onto the die holder, through the tool stack onto the bolster or pressure ring, onto the die holder carrier, and onto the platen pressure ring in the egress hole of the front platen. These surfaces, whether they are flat or taper seals, determine the attitude and consequent press misalignment under operational extrusion pressure, and their measurement is of primary importance. The determination of the above component hole centers with respect to the press center line is considered of secondary importance, though parallelism of the assembly center line with that of the press is important. For example, if the face of the platen pressure ring is not parallel to the front platen (determined by measuring the machined tie rod seats), the center of its hole will not provide correct alignment.

Equally, after many hours of production, the inside of the container liner and the egress hole in the front platen are hardly going to provide the original machined surfaces, nor are the correct positions of the centering disc or mounting plate for the taut wire or precision tube methods necessarily reproducible or related to the pressure ring attitude. Special plates can readily be designed to aid the measurement with the CMS of the surface attitude and the center of each hole in combination. Figure 2-24 is a diagram of a flange target plate suitable to fit both the pressure ring and the two ends of the container liner. The smaller diameter stub fits into the hole and has three points of contact (2 adjustable to allow for various diameters and to facilitate rotation) to locate the target centrally in several positions as it is rotated. A carbon fiber rod with omnidirectional target is mounted on the outside edge of the flange and is measured in each of the rotated positions. A geometric circle fit to these 3-D points provides a center of rotation and axis that respectively define the center of the hole and the perpendicular to the vertical surface of the pressure ring. The critical face of the flange target provides the surface contact of the flange to the vertical surface of the pressure ring (or liner) which at each rotated position is measured under pressure so that the attitude is correctly replicated.

It is unlikely that most aluminum extruders will be able to justify owning their own 3-D coordinate measuring systems, though they may be able to contract this service through a larger firm. Although CMS's have been set up as turnkey systems for effective use by industry at minimum skill level for their specific in-house measurement project requirements, their application to single-use situations such as for extrusion press alignment may not justify the operator knowledge and training required. In any case, these 3-D measurements are carried out by specialists or professional services in industrial measurement or large-scale metrology.

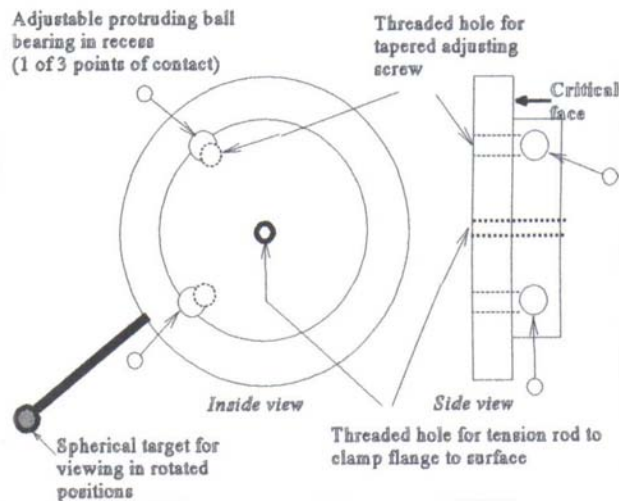


Figure 2-24 Flange target plate

3-D CMS measurement for extrusion press alignment can provide significant benefits when carried out especially for reactive and preventive maintenance but also in conjunction with the other condition monitoring and maintenance management techniques.

## Conclusions

The geometric or dimensional aspects of an extrusion press are fundamental to proper press alignment that is required for minimizing downtime and production wastage.

The main 3-D geometric relationships can be derived from the original press designer's or manufacturer's specifications, and, together with design tolerances and critical dimensions, provide the 3-D mathematical inspection model for compliance. Also, an understanding of the press operational principles provides compliance criteria for the diagnostic monitoring and adjustment of the moving components for the various operational load and event conditions. It is difficult to successfully build up the measured 3-D geometric relationship from discrete 1-D mechanical measurements using traditional press alignment tools.



Press alignment, inspection, adjustment and control are now more efficiently achieved using modern 3-D CMS technology which not only complements the traditional ones but in many cases replaces them.

Better press alignment and monitoring techniques increase the flexibility, productivity, efficiency and quality of extrusion.

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*The following information was received from David Turnipseed and is reprinted here for convenience of Wean United press owners. Unfortunately the diagrams referenced are not included.*

## **WEAN PRESS ALIGNMENT**

This section is devoted to press alignment and tram level. Each group is essential to proper press operation.

- A. Stem
- B. Crosshead
- C. Main Ram and Tooling
- D. Tie Rods

### **A. Stem Alignment**

The “squareness” of the stem (extrusion ram) with respect to the stem pressure plate, crosshead, and billet is very essential in order to prevent eccentric loading of the stem against the dummy block. A slight misalignment of the stem, in the center bore of the stem pressure plate, is magnified when the overall length of the stem is taken into consideration. A stem “out of square” in its “socket” by 0.025” could throw the tip out of square by as much as 1/8”. The *sketch on the following page illustrates the various points to be checked when changing a stem*. The stud nuts, diagonally opposite, should be tightened a little at a time in order to maintain uniform clearance between the stem holder and crosshead.

1. When changing the stem, uniform clearance must exist between crosshead and stem holder.
2. As stud nuts are tightened, be sure to check clearance at areas designated at points no. 1 thru no.6 inclusive.
3. Always be sure the nuts are tightened securely.



## **B. Crosshead Alignments**

Proper guiding of the crosshead is required in order to keep the ram movement parallel with the tie rods and “square” with the tooling. The crosshead inside gibs have been set, at shop assembly, for proper running clearance and to prevent the ram from drifting when traversing the last portion of the extrusion stroke. After the press has been leveled and grouted at field erection, the inside gib clearances should be re-checked. Normally, the clearances will change; if so, the shims should be re-adjusted for proper running clearance.

The gibs are shimmed bronze wear plates. The adjustment is by means of shims instead of adjusting screws to prevent unauthorized personnel from making changes in the clearance when they are not familiar with the full importance of these clearances.

The gib mounting bolts should be kept tight at all times. Check these bolts once a week. The gib clearance should be checked once per month.

## **C. Main Ram and Tooling**

After the press has been in operation for several months, normal wear of the crosshead bronze shoes will take place. As wear progresses, the ram, crosshead and stem will no longer move parallel with the tie rods and bed plate wear plates. As the stem drops, it will no longer be concentric with the container bore and may rub the “skull” in the container, causing inferior extrusions. The first tendency is to align the container with the stem so it will be concentric once again.

This procedure is incorrect because the billet centerline will be lowered and will not be concentric with the dies and tool stack. This leads to eccentric loads being applied to the tooling, thus causing poor metal flow and improper die deflections. Eccentric loads eventually result in breakage of components in the tool stack.

The proper procedure is to check the ram level, at the retracted position as well as advanced, to the “end of extrusion” position. The level of the bed plate should also be checked to determine the exact amount of “out of level” that actually exists. The crosshead wear plates should then be shimmed to bring the ram back to a level position. Once this is accomplished, the container elevation should then be adjusted to have the

stem concentric with the bore of the container liner. The final phase of tooling alignment is to extrude billets and examine the butts to determine if the die is low. If the die is low, the die slide should be removed and the wear strips shimmed to have the die, container and stem in alignment. The container guides should also be checked to keep the container lined up laterally with the tooling and stem. These checks should be made every four (4) to six (6) months.

#### **D. Tie Rods**

Pre-stressing of tie rods is done for the purpose of preventing stress fluctuations to occur in critical areas of the tie rods during normal operation. These critical areas are the threaded portions of the rods. Without pre-stressing the stresses would fluctuate from zero to maximum every time the press is loaded to 3000 psi. Should this be permitted to continue, without pre-stress, metal fatigue would eventually set in and a tie rod failure would occur.

Pre-stressing is accomplished at shop assembly by loading the press to approximately 3450 to 3500 psi. and setting the inside tie rod nuts prior to releasing the pressure. The “locked in” stresses, between the inside and outside nuts, prevent any fluctuation of stresses in the threaded areas of the tie rods. The tie rod bodies are only subjected to pure tensile stresses.

The press tie rods are set at shop assembly; the press is “squared” to within approximately .005”. The press should remain “square” for several months. However, a certain percentage of the pre-stress is lost due to the machined surfaces of the threads of the tie rods and nuts becoming “burnished in” during normal operation.

After six (6) months of operation, the press should be re-checked for squareness. The tie rod nuts should also be checked for loss of pre-stress, with the press at full load of 3000 psi. Should the inside surface of a nut separate from its contact surface with the platen, or cylinder housing, pre-stress is lost in that particular tie rod. When pre-stress is lost, the press should be re-aligned (“squared”) and the rods pre-stressed again. It will be noted that after the press is re-pre-stressed, it will retain its alignment for a much longer period of time because the threads have been “burnished in” and have taken a permanent “set”.

When the tie rods require to be re-pre-stressed, several items must be taken care of:

- a) The face of the main cylinder housing should be at right angles to the bed plate wear plates. You may have to block up under the main cylinder, if adjustment is required.
- b) Hydraulic system pressures will be adjusted temporarily, above maximum allowable operating pressure. The pumps must not be permitted to remain at elevated pressures for prolonged periods of time. Try to limit it to periods of time, not exceeding 10 to 12 seconds, and keep the pumps "short stroked".
- c) Oil temperatures should be kept at approximately 120<sup>0</sup>F, when the pumps are operating at elevated pressures.
- d) Necessary personnel and equipment must be on hand when the work begins.
- e) You will require two (2) sledge hammers, six (6) to eight (8) hot rolled steel pins to fit the holes in the tie rod nuts, a pin gauge bar with micrometer head, plus four (4) men.

With Port "B" of the pumps furnishing power for the "forward" or "extrude" portion of the circuit, the relief valves on Port "B" side of the pumps will have to be adjusted to permit pressurizing the system above the maximum operating pressure of 3000 psi. Note the position of each relief valve adjusting screw prior to making any adjustments. Remove the screws from the pumps when the motors are not running. Take the lock-nuts off the screw and re-install the screws, turning them "in" approximately two (2) turns beyond the point where the locknuts were set for 3000 psi.

Place the control selector switch in the "manual" position; start the main motors; position the die slide with the sticker hole at the press centerline and slide selector switch at "neutral". With the container closed against the slide, advance the main ram until the stem holder, or bumper, is in contact with the container. Note: For presses with a taper fit between stem and stem holder, the press tonnage must not be applied to the stem holder face. The load must be taken on the face of the stem. (Use a short cold billet, dummy block and solid tool stack.) Short stroke the pumps only enough to pressurize the system slowly. Set the relief valves for approximately 3350 psi. When adjusting the relief valves for higher

pressures, always do so with the pumps in the “neutral” position, or when the system is at low pressure. Always keep the sticker by-pass button depressed while pressurizing. Don’t relieve pressure suddenly by releasing the by-pass button. Position the manual unit lever at zero and allow the pressure to bleed off until it drops to 1000 psi. before releasing the by-pass button.

Pressurize the system to 3300 psi. and “sledge-in” the inside tie rod nuts, only at the cylinder housing end of the rods. Do this as quickly as possible; keep the system pressure steady while setting the inside nuts.

Bleed off pressure in the system and prepare to work at the platen end of the press. Pressurize the system once again and loosen the inside nuts at the platen. When the inside nuts are loose, bleed off system pressure and retract the main ram slightly to permit the surge valve to open.

Pin gauge the press at zero pressure, and record the readings. If the readings show that the press is “square” within .005” or .006”, proceed with pin gauge readings at 1000 psi., 2000 psi. and 3000 psi. Should the press be “out of square”, in excess of .012”, do not “load” the press until you have re-adjusted it. Adjust the outside nut of the tie rod that requires to be adjusted. The outside nuts can only be adjusted under “no load”. When making adjustments, the following information will be helpful.

Place a mark on the surface of the platen, at the nut periphery, and measure on the outside diameter of the nut, the amount of adjustment to be made. One inch of rotation of the nut is equivalent to advancing the nut a few thousandths of an inch.

The following chart covers various press tonnages; use the value that applies to your press:

<b>Rated Press Tonnage</b>	<b>Movement of Nut O.D. - inches</b>	<b>Linear Movement of Nut inches</b>
1550 tons	1	.007
1675 tons	1	.007
2200 tons	1	.0064
2400 tons	1	.0055
2500 tons	1	.006
2600 tons	1	.005
2750 tons	1	.005
3300 tons	1	.005
3500 tons	1	.005
3850 tons	1	.0046
5500 tons	1	.006

When the tie rod nuts have been adjusted and the press is “square”, at zero and at 3000 psi., proceed with the final phases of pre-stress.

Pressurize the system to 3300 - .3350 psi. and slug-in the inside nuts, at the platen. Release pressure in the system and pin gauge with pressure at zero. You may find that the press can be “out of square” after pre-stressing. This could happen when the nuts are being slugged-in and a fluctuation of system pressure has occurred.

When this happens, it will be necessary to make corrective adjustments. Pressurize the system to 3350 psi. and adjust the tie rod nut that requires it. Always remember that after pre-stressing, the tie rod that registers the longest length has been pre-stressed more than the other rods. Its adjustment would require you to “back-off” the inside nut at the platen end of the press. Make such adjustments as required so the press will be within tolerances at “zero” as well as at 3000 psi. After final adjustment, etc., re-set the main pump relief valves.