Setting Up a Machine Alignment Program

by
Bruce Lehmann
TKT Engineering Inc.

Accurate sawing requires attention to proper alignment and maintenance. Alignment is critical to modern sawmills using thin kerf saws. In fact, the improvements in machine design were critical to the development of thin kerf sawing systems. About two-thirds of sawing problems are caused by misalignment, not saw preparation. Good alignment reduces down-time and machinery wear and should be part of the quality control process and the preventive maintenance program: fix problems before they affect production or the quality of the finished product. This paper discusses the issues and procedures involved in upgrading and maintaining alignment.

Some Observations

1. Only about 50% of all mills have an alignment program, and only 25% of those do regular alignment checks.
2. There is a lot of talk about the importance and necessity of alignment, but very little action. Production and reduction of overhead costs are still priorities. Nor is alignment often included in scheduled maintenance programs. Usually, alignment is done only if a problem interferes with production or lumber sizes.
3. Many mills don't even have a machinist's level and the alignment jigs supplied with the machine have either been lost or they've collected dust in the cupboard since the machine was installed.
4. Few mills have any written standards to which the alignment of each machine must be maintained.
5. Alignment, other than for couplings, chains and belts, is not part of the millwright apprenticeship program.
6. Shifting of the machine foundation, whether from tides, frost or settling, is rarely the cause of misalignment. Usually, wear, incorrect replacement, loose bolts, pounding and damage from a jam are the culprits.
7. The cost of logs, delivered to the site, is from 60% to 85% of the operating cost of a primary sawmill

Indicators of Alignment Condition

Consistent production and sawing accuracy are the main benefits of good alignment. Production and accuracy are, therefore, indicators of alignment condition. Other indicators of alignment problems are maintenance costs and the amount of unscheduled downtime due to damaged saws or jammed cants. If alignment is poor, the wood has to be forced through the machine, increasing the forces that the parts have to withstand.

Saws are the weakest and most vulnerable part in a machine: they cannot withstand the abuse of the wood trying to move sideways. When the wood is not controlled, it will likely lean against the saws. When this happens, there will be more unscheduled saw changes

Table 1. Indicators of Alignment Condition	
Good Alignment	**Poor Alignment**
1. Failure of one part may have no effect on production or accuracy	1. Frequent, often emergency, repairs. Also, many saws are damaged or must be thrown out.
2. Machine can cut difficult species or frozen wood as well as it can easy species.	2. Fixing something makes things worse.
3. Few unscheduled saw changes	3. Deterioration, over time, of production and sawing accuracy.
4. Minimal increase in sawing deviation or unscheduled saw changes if kerf reduced or feeds increased.	4. Increasing kerf or reducing speeds necessary for difficult conditions.

Table 1 is a comparison checklist that indicates the alignment condition from external factors, without measuring anything in the machine. The lists are also a basis for calculating the costs of not keeping a machine well aligned.

Objectives of Alignment

Each component that touches the wood is there to support the wood or drive it through the machine. Together they achieve the following:

- Provide consistent support to the wood
- Ensure a smooth transition of control from one part of the feed system to the next
- Do not allow the wood to roll sideways
- Do not allow the wood to move sideways onto the saws
- Do not bend the wood

Machine components that are properly aligned also share the load. For example, a high bed roll will take all the force from the press roll, rather than distribute the load to the adjacent bed rolls. As a result, the bearings on the high roll will fair sooner.

These factors govern the tolerances for aligning each part. For example, if the bevel on a 6" board cut on a linebar resaw is to be less than 0.002" then the linebar must be plumb to within 0.004"/ft.

Alignment Tools

The measurements of alignment determine whether components are

- Straight
- Flat
- Level
- Plumb
- Square

How these measurements are done depends on the precision required and on the size of the machine being measured. A piano wire or a laser is usually needed for a complete alignment check, but many, if not most problems can be found with a few simple tools.

Eighty percent of alignment checks can be made with a basic set of measurement tools. Although checking the straightness of a carriage rail requires more sophistication, most surfaces or rolls that guides the wood must be either level or plumb. These tools are:

- A precision machinist's level
- An 8 foot aluminium straight edge
- A box level or "sine bar"
- A set of feeler gauges

For more information on alignment tools, see the companion paper, “Practical Alignment Tools and Techniques”.

Reference Points

Establishing reference points for mounting a wire, or a laser line, is not a simple matter. Basically, it is a matter of trust. Do you trust that the reference points were in the right place to begin with and that they haven’t moved since? Do you trust your measuring skill?

I have found that if the mounts for the wire are designed and located properly, they do not move over time. And even if a mount moves, there are some techniques to minimise the effect on the measurements.

First, the mounts should be attached to a solid base that gives lateral support. Try to avoid using the machine frame as a base. Usually, there is some structural steel on the sides or end of the feed system. The frame of an infeed scanner is a good choice. The best way is to mount the wire on a horizontal bar that spans across the machine. Both ends of the bar are then dowel pinned and bolted to the base. Avoid mounting the wire on the end of a vertical post, unless it is very short because if the post bends, or the mounting for the post is too narrow , the wire reference will be in a different place each time the post is installed. If a vertical post has to be used, make its base as wide as possible and support the post with a strut.

One common problem is to use a wire that is too short. Often, the wire only runs the length of the machine frame. However, the wire should extend at least one log or piece length into both the infeed and outfeed tables. Otherwise there is no way of knowing whether the infeed, machining section and outfeed are aligned to each other.

Another benefit of using a long wire is that it will reduce errors from movements of the reference points. For example, even a error of 1/16 inch at one end of the wire will produce a skew of 0.001 inch/foot on a 60 foot wire. This error is small compared to, for instance, the lead of 0.001 inch/inch on a conical slabber head. This is one reason that the recommended procedure for setting head lead is to use a wire, even if the location of the wire is somewhat in doubt

There are no absolute points from which to set up the wire. There are few machine parts that can not go out of alignment over time. For instance, the wire can be set up perpendicular to the bottom head of a canter because it appears to be immovable and because it is bolted to the rest of the machine. As a first try, this can be a good reference. However, the final decision can be only be made once the location of the wire is known relative to the rest of the machine. The author has moved the bottom head of Chip-N-Saw, and it is an easy task.

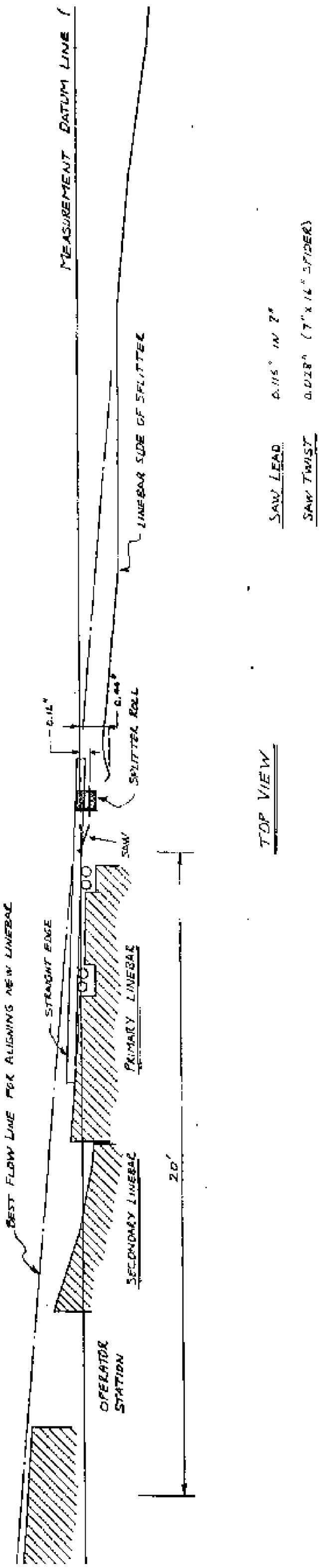


Figure 1. Scaled alignment drawing for a line bar band resaw.

Another example is to set the wire perpendicular to the arbour of an edger. This is a very convenient reference, but it may turn out that the arbour is not parallel to the feed rolls. In modern, line-bored edgers, there is rarely a problem with the rolls. However, the arbour door may not be locating in the proper place, or may be inconsistent. On some machines, the door bearing can be adjusted, which opens the possibility that it may become misaligned when a cant jams or the bearings are replaced. Again, the arbour can be used as a first try for positioning the wire, but this can only be confirmed if the rest of the machine is in line with the wire.

For a carriage, good reference points are at the ends of the V-rail. Usually, the ends of the track show no wear, and most of the pounding from log loading is far enough away to have some trust that the frame is not bent near the ends. Some people set the wire perpendicular to the bottom wheel of the bandmill, but it is far more likely that the bandmill, not the rails, will move, or that it was installed off-square. In any event, it is usually easier to move that bandmill than to move the rails.

The original alignment jigs supplied with the machine should not be fully trusted. They may have been bent from being dropped or if something is welded to them. There are no absolute reference points. Just points that you trust for the moment.

This leads to another issue. Unless you know where the wire is relative to the whole machine, it is not a good idea to make adjustments to the alignment. This is especially true if the alignment has not been checked for a long time. Even when re-installing a wire or laser, don't rely on the reference points. Also check that several points through the machine are in the same position they were the last time the wire was installed. If there are differences, it may not because the wire is set up wrong, but more points need to be checked until you find the problem, or your level of trust is sufficient.

The best method for locating the wire through the machine is to make a scaled drawing of the machine alignment based on measurements from a trial mounting of the wire. The author typically uses a scale of, say, ½ inch = 1 foot along the length of the machine, and a scale of 10:1 at right angles to the wire to magnify the misalignment. See Figure 1 for an example drawing. From this drawing "best line" can be found. It may be that the machine is quite straight, so only the wire needs to be moved. Otherwise, the decision must be made to move some of the components, and maybe the wire as well. The scaled drawing will also show how much the ends of the wire should be moved from their current "trial" position.

Skills and Knowledge

Alignment is more than measuring skill. The person responsible for alignment must also understand how the machine works and the consequences of being out of tolerance.

1. The measuring skills and the use of alignment instruments to take measurements with an accuracy of 0.001 inch.
2. Methods for recording the measurements and what changes were made.
3. Allowed tolerances for the alignment of each part of the machine.
4. Teamwork skills for working with the other trades people. This includes an understanding of the problems and goals of the other trades.
5. Know the assumptions on which the reference points were chosen and the goal to be achieved.
6. Able to "read the wood", as most alignment problems leave a signature mark on the wood. This is indispensable for quickly trouble-shooting a problem

Teamwork

If the mill is serious about alignment, a team should be assembled to set priorities and make the required changes. The number of core members of the team is small: just two or three people who will actually do the alignment work. Most likely, the core people will be senior millwrights, and a saw filer.

Ideally, each machine should have an alignment team, consisting of the core group, the filers who maintain the saws for that machine, the machine operator (or a production superviser), and someone from quality control. If the machine is computer controlled, an electronics technician can be brought in to handle setworks calibration. (With some machines, such as curve sawing edgers and 4 axis double-length infeeds, calibration may be a more appropriate term than alignment.)

One advantage of having an alignment team, is that it builds communication between the various trades. Information from the filing room on saw condition at the end of a shift and guide wear is important feedback for the alignment team. Quality control reports, and their interpretation, are equally important. There are so many things that can go wrong in a sawmill, that one person cannot keep track of everything: information from many sources is needed.

The alignment crew also needs to tell management, the saw filers, the machine operator, and quality control what changes were made. This way feedback becomes a discussion.

In-House or Contractors

Ideally, a mill should be able to do all of it's alignment work with the existing staff. This is desirable because machine alignment is an ongoing task, not just a job that is done once a year. Bearings, rollers and wear plates are replaced as needed, and they must be put back in the proper position. Relying on the bolt holes to properly locate the new part is not realistic. Some of these parts are critical to accurate and consistent sawing, and should be frequently checked. The more critical the part, the more often it should be checked. Some mills check the alignment of critical parts, such as guide lead, press rolls and line bars every weekend.

Most alignment work does not require a laser line or a tight wire. For the most part, just ensuring that a surface is level or plumb is all that's required. For this type of work, it is impractical to call in a contractor to do the alignment because the costs would be high and it may not be possible to schedule a visit on short notice. However, the work must be done, so it is necessary that the maintenance crew has the skills and tools needed to do the work.

So when is it appropriate to use an alignment contractor?

- When you have no alignment program at all, but need to get started.
- The mill crew has too many responsibilities just keeping up with regular maintenance. Hopefully, this is only a temporary solution.
- There is no one who will or can be a leader for the alignment team.
- When the mill crew is stumped by a problem and fresh ideas are needed.
- When the mill crew decides to upgrade its skills or methods and needs some training.
- For an review or audit of alignment practices.

What are some of the problems of using a contractor?

- No one in the mill takes "ownership" or responsibility for machine performance. If there is a problem, the contractor is a convenient scapegoat.
- The contractor only sees the machine for a few days a year, at most. They are not familiar with the machine or its history.
- Alignment is more that measuring skill. The person responsible for alignment must also understand how the machine works and the consequences of being out of tolerance.

Scheduling

Alignment checks should be scheduled, just as are other preventative maintenance tasks. When a part is misaligned, it will take more load than it was designed to take, and will, therefore, wear and fail earlier than expected.

The criteria for making the schedule are similar to those in a preventive maintenance program:

1. The more critical the part, the more often it should be checked. For example, guides, face plate clearances, press rolls close to the saw are examples of parts to check every month. On the other hand, the elevation of the outfeed roll case can be left to the annual alignment.
2. Parts that can be damaged easily should be checked more often. This can only be determined from the maintenance history of the machine, but items like guide posts and press roll arms are vulnerable to damage in a jam. Also, the bearing in line bar relieving rolls often fail. It is, however, unlikely that a the bottom wheel of a headrig will move.

A mill can "coast" for about 2 years before the effects of not keeping up with alignment start to show up. It will then take at least a year of steady work for an alignment team to get everything back into shape. Furthermore, after 2 years, both production and lumber size will suffer. In the long run, reducing the amount of time and money allocated to alignment is does not reduce the overall maintenance costs.

Manuals and Record Keeping
For an alignment program to survive personnel transfers and retirements, the knowledge of how to align a piece of machinery must be organised and recorded. Often a manual is needed because each machine has special alignment jigs, or there is a defined order for proceeding. If this knowledge is not written down, each alignment will be an exercise of reinventing the wheel, which is costly and frustrating.

The second purpose of a manual is to set the standards for allowable tolerances. If the standards are met, then the machine is "healthy". These tolerances should be agreed upon, and written down. Otherwise, each person will have to judge, as they go along, what is acceptable. The definition of "acceptable tolerance" varies from person to person and also tends to increase over time, especially towards the end of the day.

Keeping records of alignment measurements is useful because it becomes part of the history for that machine. With records, you will know how much has the machine moved since the last measurements were taken. From this information you can determine if some parts should be checked more often. The most valuable aspect of records is if notes on sawing performance before and after the machine is realigned. In the future, if there is some problem with , for instance, snipe at the end of the boards, there will be a record of the problem, and what had to be done to fix it.

Formal Alignment or Audit

At least once a year a formal alignment or machine condition audit should be done on a machine. A formal alignment has several functions:

Correcting problems that require immediate attention
Setting priorities for future maintenance.
Documenting the condition of a machine over time.
Identifying parts that should be watched for wear or easily misaligned.
Confirming the accuracy of quick-check jigs and the location of the tight wire.
Setting the schedules for preventative maintenance and alignment checks.
Confirming the accuracy of setwork positioners.
Training employees that are unfamiliar with the machine.

The goal in a formal alignment check is not to immediately fix the problems that are found. There is not usually time on a weekend to take all the measurements and to make the necessary changes. The goal is to obtain information for setting priorities, and scheduling work, especially for preventative maintenance. Mostly, it is an opportunity to take a step back and review the operation of the whole machine and its maintenance requirements.

Another aspect of a formal alignment is to check that the supports for the tight wire have not moved and that the quick-check jigs are still accurate. If the location of the wire can be trusted and its supports are designed for quick mounting on pinned holes, then the wire can be installed in a few minutes whenever it is needed. In this case, the wire can be considered a quick-check jig.

Typical Alignment Measurements and Tolerances

The following are typical of what is checked on these machines and how they are checked. Reasonable tolerances are also given.

Canter with Horizontal Double Arbour

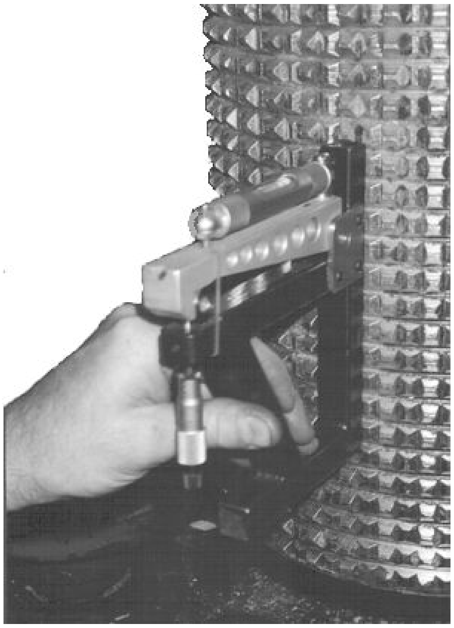
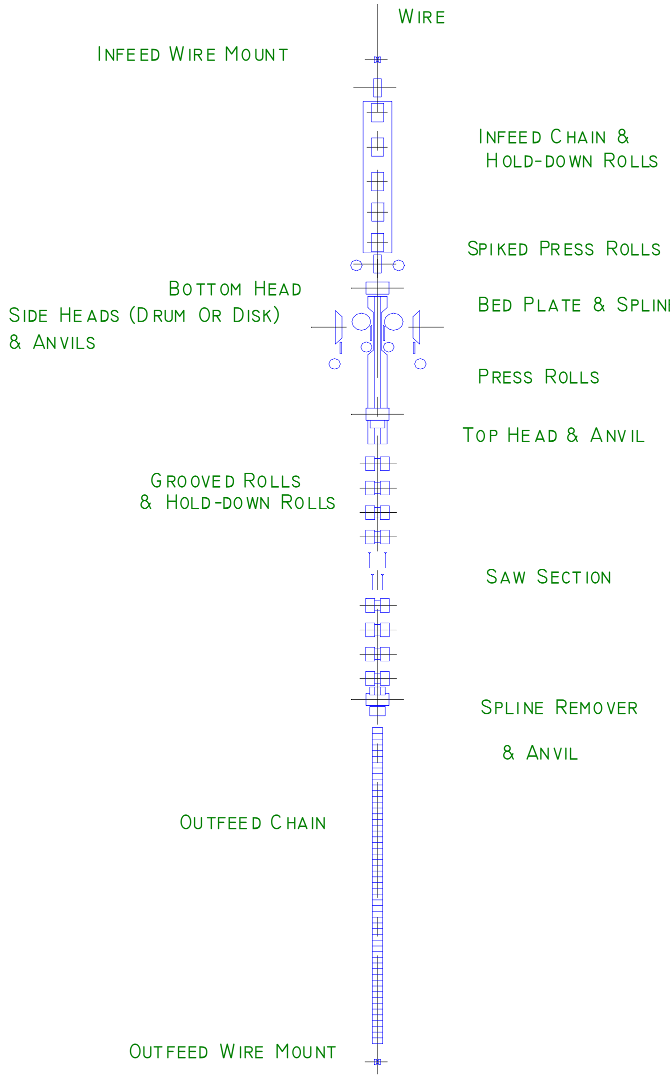


Figure 2. Checking the lean and tilt of a press roll with the sine bar.



It is important to run the wire through the infeed and outfeed sections, not just the machining section. The canter line must be aligned as whole.

Figure 3. General layout of a canter line.

Straightness of infeed chain (to tight wire)	±1/16"
Lead of infeed hold down rolls	±0.020"/ft
Lead of slabber head	±0.005" of required lead
Level of shoe and bed plate	±0.005"/ft
Knife clearance to shoe, side and top anvils	±0.005" of required clearance
Lean of press rolls	±.002"/ft
Tilt of press rolls	0.5°-1.5° (pairs within ±0.1°)
Looseness of gibs on side head and saw box	±0.005"
Straightness of the spline	±0.020"
Plumb of anvils	±0.005"/ft
Lead of arbours	±0.010"/ft
Lead and plumb of guide surfaces	±0.001" over surface

Horizontal Edger

The critical parts of an edger are the bed rolls, press rolls and the guides. The wood must not move sideways while it is in the saws.

Uneven bed rolls result in fast bearing failure of the high rolls. Also, the high rolls act as a pivot for both vertical and sideways movement of the cant. Because the ends of cants are usually not square, the cant will be pushed sideways as it hits or falls off a high roll.

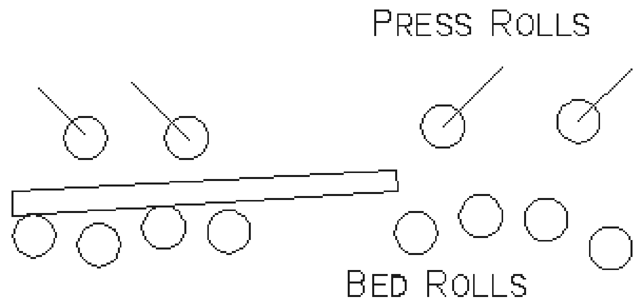


Figure 4. Uneven elevations of bed roll.

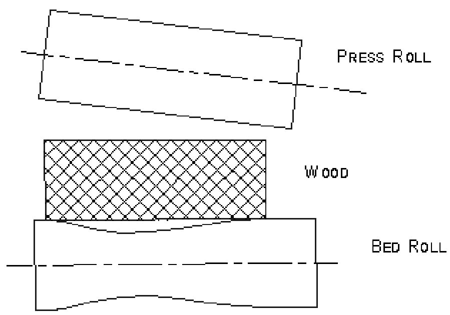


Figure 5. Bed roll and press rolls not parallel. Wood will "walk" to open side.

The most reliable method for assessing a the feed system is to run a cant through the machine when the saws have been removed. Start with no press rolls to assess the condition of the bed rolls. To identify problems with individual press rolls, bring down only one roll at a time.

Finally, if the cant walks in one direction, flip the cant over and run it through the machine again. If the cant walks in the other direction, then the cant is bevelled.

Other problems are worn rolls (hourglass) and twisting of the press roll frames when the cylinders apply pressure.

Lead of infeed rolls	±0.020" over width of machine
Elevation of infeed rolls	0 to 1/16" below bed rolls
Elevation of bed rolls	±0.020"
Level of bed rolls	±0.005"/ft
Lead of bed rolls	±0.002"/ft
Diameters of bed rolls	±0.010"
Level of arbours	±0.005"
Level of press rolls	±0.005"/ft
Lead of press rolls	±0.002"/ft
Lead and plumb of guides	±0.001" over surface

Vertical Arbour Edger

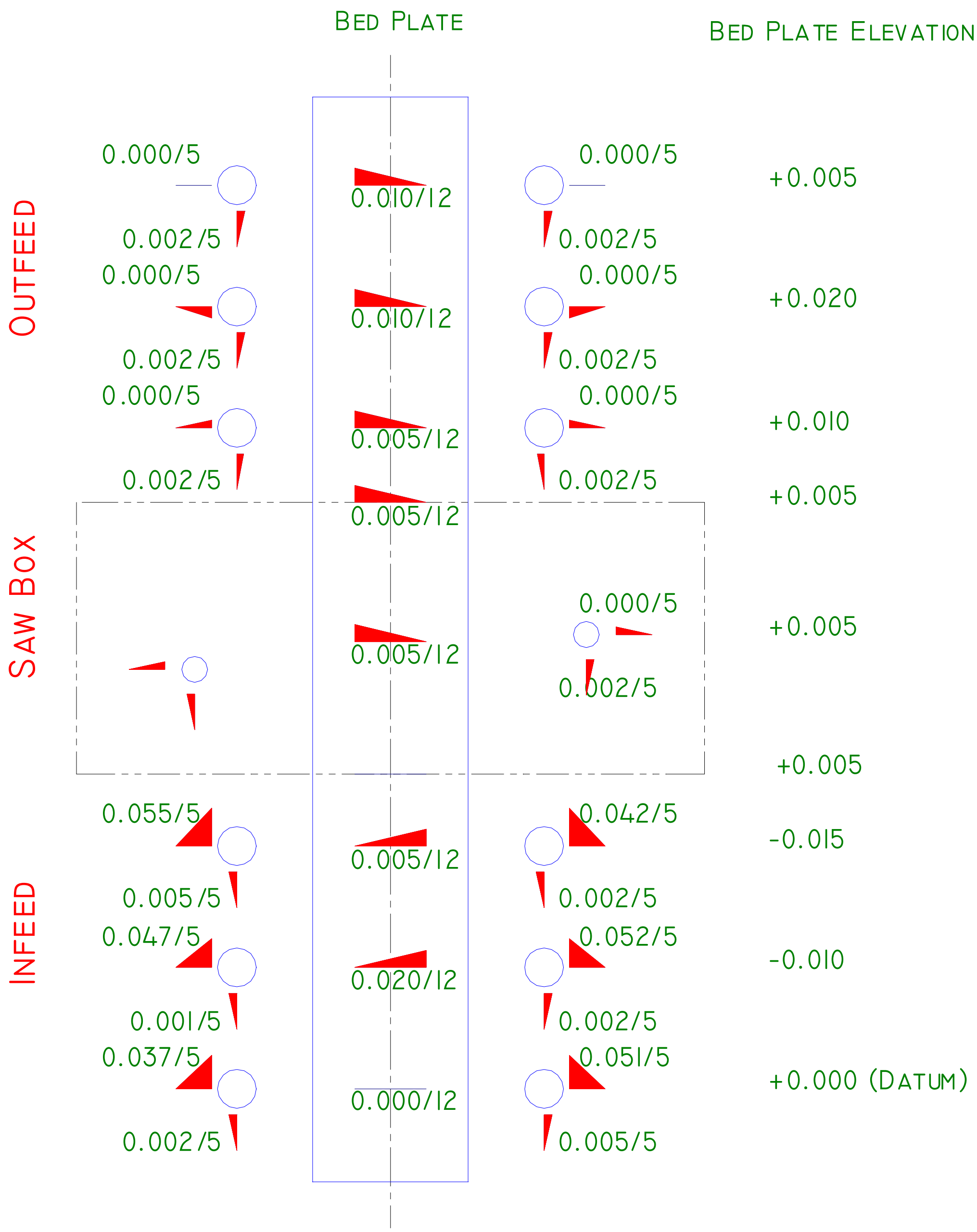


Figure 6. Typical alignment measurements for a Vertical Arbour Edger. Note bend and twist of infeed bed plate and the rise in the outfeed bed plate. Infeed rolls leaning forward about 0.5°. Missing from the drawing are the level measurements of the guide reference plates. Also, more level measurements are usualy taken in the saw box.

Headrig Carriage

A fast method of checking the carriage is to place a level on one of the bunks and watch the changes as the carriage moves down the track. The level should not change more than 0.010"/ft., otherwise the carriage will roll sideways, resulting in twisted and bevelled back-stand boards. Actually, most of the sideways movement of the knees is from the sideways rolling of the carriage due to wear of the flat rail, not distortion of the V-rail.

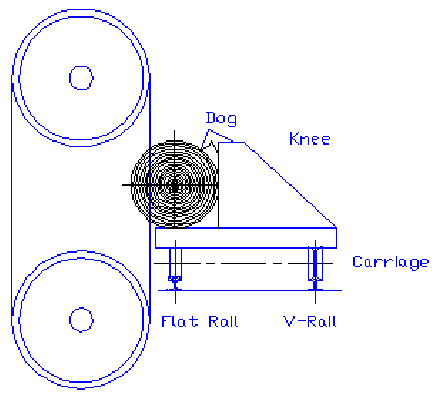


Figure 7. General layout of a carriage headrig.

Straightness of V-rail	±0.010" over any 10 ft section
Elevation of flat rail	±0.010" over any 10 ft section
Relative elevation of V and flat rail	±0.060"
Sideways roll of carriage	±0.005"/ft
Level of skids	±0.002"/ft in front of saw
Plumb of knees	±0.002"/ft in front of saw
Saw-to-knee distance (between knees)	±0.005"
Setworks repeatability	±0.001"

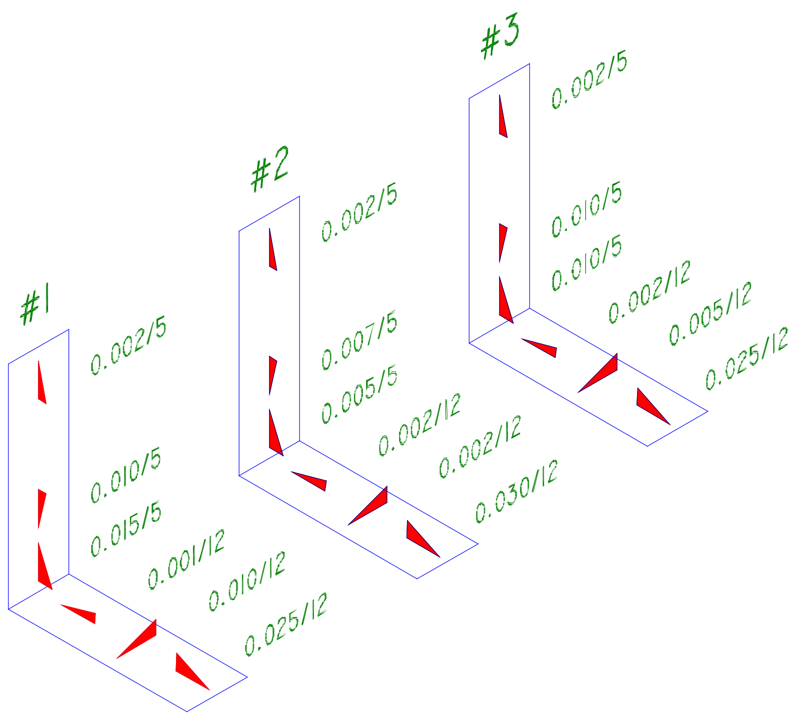


Figure 8. Typical level and plumbmeasurements of carriage knees. Note wear at bottom knee and bending of the front of the bunks.

Band Linebar Resaw

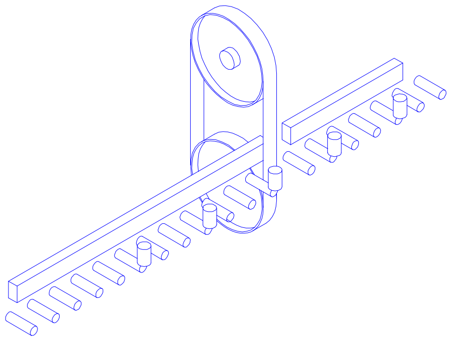


Figure 9. General layout of a band resaw.

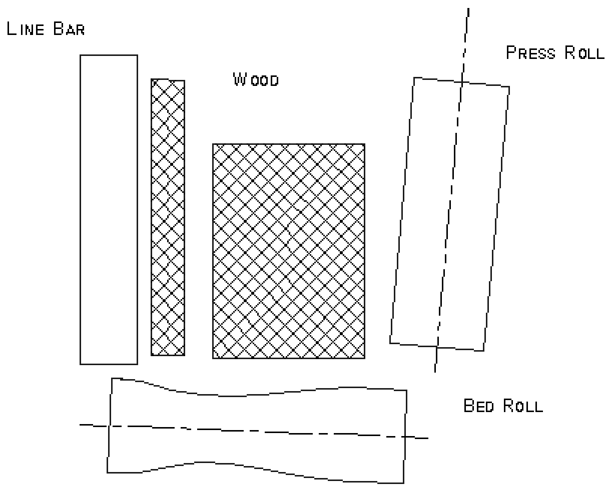


Figure 10. Effect of worn feed rolls and linebar. Width and weight of board will influence how it rides against the linebar.

Elevation of bed rolls	±0.020"
Straightness of linebar	±0.020"
Plumb of linebar	±0.002"/ft
Plumb between top and bottom guides	±0.002"/ft
Twist between guides	±0.002" over width of guides
Plumb of press rolls	±0.005"/ft
Tilt of press rolls	Leaning slightly forward