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**Tight Wire No Longer Good Enough**
The most common method of turbine alignment is the tight wire. Although tight wire has produced good results for many years, it is increasingly becoming outdated. It takes too long to set up, is subject to vibration, which limits other work during alignment and is subject to catenary sag and other environmental influences. With power company consolidation and competitive power markets, shorter outages and more efficient turbines are critical to industry profitability.

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The L-705/L-706 Turbine Alignment System

High Accuracy and Long Range
The L-705 Steam Turbine Bore Alignment Laser is designed for turbine alignments up to 50 feet (15 M), although the laser can be used up to 100 feet (30M). Under good environmental conditions, the L-705 system has a bore centering accuracy of .002" (0.05 mm) over the whole range.

The L-706 Bore Alignment Laser is used for longer-distance applications up to 110 feet (33.5 M), where the angular resolution, which is three times higher than the L-705, allows the user to point the laser to .001" (0.025 mm) in 100 feet (31M). It has the same accuracy as the L-705 and when used with the fixtures and accessories of the L-705 Steam Turbine System, it is accurate to .005" in 100' (0.13 mm in 30 M).

Laser Virtually Eliminates Technician Measurement Variability
A big problem with tight-wire-based turbine alignment systems is trying to get good repeatability from one technician to the next. This is because the tight wire technique strongly depends on the technician's interpretation and skill, which has a big impact on repeatability from one shift to the next. With lasers, that problem is significantly reduced because laser beams do not have sag or kinks and are not susceptible to wind. In addition, by using sophisticated electronics to detect the laser beam, human interpretation of the readings is eliminated, making them very repeatable from one technician/shift to the next. This means that the technician will no longer record what he "thinks" the reading is; he will record what the reading actually is. Reduced technician variability means faster alignments and higher confidence in the alignment accuracy from one shift to the next.

Fast Alignment Can Save Days Off Outage
Sometimes days can be saved off an outage just from the fact that the L-705 laser system allows for other work to take place while the laser is being used. The tight wire, on the other hand, requires a lot of time to set up and settle down, and no other work can be performed while the wire is in use, as vibration will cause alignment errors. In addition, all the components (diaphragms, seals, etc) must be installed to do the alignment; otherwise the wire will have to be repeatedly broken down and set up again.

With L-705/706 Turbine Alignment System, components can be taken in and out of the shell while the laser is being used. Furthermore, the laser provides live data, which means that while the components are being moved, a large digital display shows a live display of the misalignment.

System Pays for Itself in Days
With higher accuracy and faster alignments, a steam turbine aligned with our L-705 will require less energy to generate a kilowatt of electricity and will come on line more quickly than when using other alignment methods. This reduction in cost is pure profit and can pay for the system in a matter of days.
Alignment System Features

- Set up in 30 minutes or less
- ± 0.001" (0.025 mm) in 40 feet (15 m) and +/- 0.0025" (0.13 mm) in 110" (33 m)
- Wireless data transmission eliminates need for long cables
- Simple, rugged fixturing
- Laser alignment setup is very similar to tight wire methods, so it is easy to use and learn and reduces training costs
- Laser and bore sweep unit use same fixture to speed setup
- A-1511 Wand Bore Target speeds data taking and is very similar to inside-micrometer methods used in tight wire alignment
- Portable, battery operated
- Dynamic display of component misalignment
- Wireless transmission of reference target data, eliminating long cables.

How the Alignment System Works – L-705 and L-706 Lasers

The L-705 and L-706 Bore Alignment Lasers are perfectly designed to perform alignment of gas and steam turbine bores. The system uses a laser, reference target, measuring target, inside micrometer sweep device, and fixtures to hold the laser and targets. Since the laser beam is concentric to the OD of the L-705/706 housing to within .0005" (0.013 mm), it can serve as one reference target. This saves a lot of time during setup.

On most turbine alignments, the rotor bearing bores are used as the references. This means that fixtures that hold the laser and reference target must be placed precisely in these bores to the set points determined by the manufacturer of the turbine.

The fixtures are hung in the bores using angle iron and special magnetic bases. Depending upon the size of the bore, either the A-501 Large Bore Sweep Fixture or the A-501A Small Bore Sweep Fixture is used to position the A-502 Laser or Target fixture so that the center is exactly on the reference points provided. The sweep unit is an inside micrometer that allows the fixture to be placed to any points desired (for example, .000" left, .009" right and -.010" bottom to an accuracy of .0005" or 0.012 mm).

Once both fixtures are swept in, the laser (L-705 for distances up to 50' (15 M) and the L-706 for distances up to 110' or 15 M to 33 M) is placed in one A-502L Laser Fixture and a T-218T Target is placed in the opposite A-502 Target Fixture. The L-705 laser is manufactured so that the laser beam is concentric (centered to) to the housing's OD to within .0005" (0.013 mm). With the fixture "swept in," the laser is inserted into the fixture and is thus centered to the reference points.

All that is needed now is to adjust the angle of the laser beam, using the two micrometers on the back of the L-705. These micrometers are adjusted until the reference target reads zero, both vertically and horizontally. The laser is now set up and ready for measurements.

Recommended System Configuration

<table>
<thead>
<tr>
<th>L-705 Bore Laser</th>
<th>R-1307-2.4ZB Wireless Target Readout (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-218T 2-Axis Turbine Target</td>
<td>A-501A Turbine Small Bore Sweep Unit</td>
</tr>
<tr>
<td>A-1511Wand-Bore Fixture</td>
<td>A-1519-2.4ZB Wireless 2-Axis Target</td>
</tr>
<tr>
<td>A-815 Steam Turbine Shipping Case</td>
<td></td>
</tr>
</tbody>
</table>

Optional Accessories

<table>
<thead>
<tr>
<th>L-706 Long Distance Bore Laser</th>
<th>A-501 Turbine Bore Sweep Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1308 Single-Axis Readout</td>
<td>A-1355-2.4ZB Ruggedized</td>
</tr>
<tr>
<td>A-815 Steam Turbine Shipping Case</td>
<td>Nomad PDA with Read9 Software</td>
</tr>
</tbody>
</table>
Measuring Diaphragm and Seal Alignment

For measuring an individual component, such as a diaphragm, there are two target choices.

The T-218T Target
The first is the T-218T Turbine Target. The T-218T works much the same as the reference targets. The target fixture (A-502A) is swept into the center of the bore using the A-501(A) sweep unit, then the target is placed in the fixture and the reading is taken. A positive vertical reading means the diaphragm is higher than the reference bores. A positive horizontal reading means the diaphragm is to the right of the reference bores. Since the data is live, the diaphragm can be adjusted until the reading is zero (or to an offset determined by the engineers).

The A-1511 Wand Bore Target
The second measuring target that can be used is the A-1511 Wand Bore Target Fixture with our A-1519-2.4ZB Wireless Target. Instead of using a fixture to "hang" a target in the center of the bore, the A-1511 uses fixed-length legs that are approximately equal to the radius of the bore. Two legs are used, each 90 degrees from the other. One leg has a measuring tip on it and the other is used for support. The A-1511 has replaceable legs and can be used on bores with a 12" (304 mm) to 6 feet (2M) diameter.

To take readings, the measuring leg and tip are placed horizontally on the left side of the bore and zeroed out using the Sweeping-Through-the-Arc method (typically used in tight-wire alignment) where the target is slowly swept through an arc, in the same direction of the laser beam, and the highest reading value is recorded. Next, the tip is placed on the bottom of the bore and the vertical measurement is recorded. The target measuring tip is then placed on the right side of the bore and the horizontal measurement is recorded.

Once all the measurements are recorded, they can then be entered into a spreadsheet to determine the component moves. After the moves have been determined, either the A-1511 or the T-218T can be used to align the individual components to their calculated locations. Again, the laser and reference targets do not have to be repeatedly setup and taken down when moving or replacing turbine components.

Good Repeatability Depends Greatly on Component Surface Condition
Both the A-1511 and T-218T measuring targets are very repeatable. However, in our experience, the A-1511 is much faster at taking the measurements. To get the best repeatability, some mechanism should be employed to ensure that each point on the diaphragm or other component is marked and the measuring tip is placed exactly on the same point. Given that the surfaces inside a turbine are usually pitted and rough, a radius tip should be used. For new turbine installations, repeatability of .001" (0.025 mm) or better is easily achievable. However, for older turbines, it becomes increasing more difficult to hold .001" repeatability because of the high level of pitting and corrosion.
**The A-1511 Wand Bore Target Procedure**

1. Place Pac-Man magnets at the edge of the first reference half-bore and place angle iron in them.
2. Affix A-502 Bore Target Fixture to the angle iron and roughly center using a tape measure.
4. The indicator is usually zeroed on either the left or right side. For now, assume it is zeroed in the 9 o’clock position.
5. Move the indicator arm to the 6 o’clock position and measure vertical axis ID. If it is the wrong ID, turn the adjustments in the A-502 until it is centered.

6. Move the indicator arm to the 3 o’clock position and measure the horizontal axis. If it is wrong, turn the adjustments until it is centered.
7. Once the A-502 fixture is in the correct position on the centerline (or in turbine alignment, to “setpoints”) remove the A-501 and replace with the L-705 laser. Since the laser beam is concentric to the housing OD within 0.01 mm, the laser beam is now on the centerline of the bore.
8. Place a second fixture in the second reference half-bore and repeat Steps 4-7, placing the T-218T Turbine Bore Alignment Target in the A-502. Turn the L-705 angular adjustments until the laser beam hits the center of the target. The laser is now concentric with the centerline of the two reference half-bores.
9. Use either the same combination (A-502 and T-218T and Pac Man magnets) or the A-1511 Wand Bore Target to measure the other half-bores in between the two reference bores. Measuring each bore works the same as described in the diagram, but the target would be set up as described above.
10. To use the A-1511/A-1519-2.4ZB Wand Bore Fixture/Target, adjust the legs to fit the bore radius.
11. Connect to the R-1307-2.4ZB Readout.
12. Place the measuring foot on the left side of the bore and use the Top Dead Center (TDC) method to find the high point. Zero the A-1519-2.4ZB Target by pressing the ZERO button.
13. Move the measuring foot to the bottom of the bore. Use the TDC method to find the high point and record that point.

14. Move the measuring foot to the right side of the bore. Use the TDC method to find the high point and record that point.

15. Either enter the values obtained into a spreadsheet or do the calculation to determine the H & V alignment values.

16. Repeat for each bore, periodically checking the T-218T Reference Target data to make sure the laser did not drift (a common problem with all lasers). If the laser drifted, adjust the L-705/L-706 micrometers to steer the laser back to zero.
The L-740 Leveling Laser System

Measuring split or horizontal joints during an outage can take hours and hold up other critical work on a turbine. Traditionally split joints are measured with transits and usually require at a 2-man crew. The measurements rely on the human eye and are subject to interpretation by the operator, an inexact science.

The L-740 Ultra-Precision Leveling Laser was designed for high-accuracy leveling applications. It is accurate to about ½ of an arc second or .00003”/ft. (0.0025 mm/M). It is an extremely portable and very affordable alternative to traditional leveling methods like theodolites or transits. Its automatically sweeping laser plane and large-range targets with 00002” (0.0005 mm) resolution create a powerful tool for quickly checking the flatness of the split joint.

High Accuracy Reduces Optics Guesswork
Hamar Laser's L-740 is accurate to ±.003" (0.075 mm) in 100 feet (30.5 meters) or ±.0003" (0.0075 m) in 10 feet (3 M) under good atmospheric conditions. This accuracy turns the alignment process from an art using optics to a science using lasers. Optics can be considered an art because each operator "sees" the readings differently and essentially has to make an educated guess as to the correct number. With the L-740, this guesswork is eliminated because high resolution target electronics determine the alignment reading.

Reduce Alignment Work Crews
The L-740 only requires one operator, even on the very largest jobs. That frees up critical manpower to perform other tasks on the outage, helping to reduce the duration of the outage. In fact, the same technician can operate the L-740 Leveling System and the L-705 Bore Alignment Laser for turbine diaphragm and seal alignments.

Minimal Training Needed
The L-740 is so easy to use that it usually only requires 1 day of training and if our Plane5 software is purchased then it only adds 1 day to the training. Compared with optics where training can last up to 2 weeks, the L-740 can significantly reduce the time critical technicians are out of action when being trained.

Reduce Alignment Time by 50%
The L-740 Leveling Laser System can use multiple targets, which really speeds the data-taking process for split (horizontal) joints. In fact, up to 4 targets can be used simultaneously. The combination of automatically rotating lasers and multiple targets can easily reduce split-joint measurement time by 50% or more.

Wireless Targets and Readouts
With Hamar's new line of wireless targets (A-1519-2.4ZB/A-1520-2.4ZB) there is no need to string long extension cords to reference targets. The targets have up to a 1.2" (29 mm) measuring range and can be used up to 100 (30.5 M) feet from the readout. Other features like electronic zeroing help to speed setup.

Most Accurate Mechanical Levels Available
The L-740 Laser uses level vials that are accurate to 1 arc second (.00006"/ft. or 0.005 mm/M). Only expensive, difficult-to-use, and fragile electronic levels are more accurate. The combination of accurate levels and automatically rotating laser planes creates an alignment tool that is hard to beat.
Color Windows-Based Software
The L-740 can also be linked to our new Plane 5 flatness analyzing software. It is Windows-based software that can analyze almost any layout for flatness or straightness. Plane 5 will even analyze squareness if used with our squareness lasers (L-743, L-742, L-741, L-733, and L-732). Squares, rectangles, frames, circles, rings, and up to four sets of ways can all be easily analyzed with Plane 5. The alignment data is automatically downloaded by using our wireless data receiver, the A-910-2.4ZB.

Alignment System Features
- Continuously rotating diode laser with 100' (30.5 meters) radius operating range
- Instant on with virtually no warm up
- Setup in as little as 5 minutes
- Laser base includes pitch and roll adjustments
- Laser planes flat to ½ an arc second (.00003"/ft. or 0.0025mm/M) in 180º sweep and 1/4 arc second (.000015"/ft. or 0.001 mm/M) in 90º sweep
- Precision level vials accurate to 1 arc second (.00006"/ft. or 0.005 mm/M)
- Standard Target: A-1519-2.4ZB Single-Axis Wireless Target with 0.0005" (0.013 mm) Resolution
- Laser and target fit into a small, portable shipping case
- Uses A/C adapter or battery pack
- Plane5 software quickly records and analyzes flatness data

How the Alignment System Works – L-740 Laser

Using Reference Points
1. Place the L-740 laser either on the split joint or and instrument stand. Level both level vials.
2. Place one A-1519 target on the split joint as close to the laser as possible. Zero the display on the R-1355. The target has now been set to zero on the first reference point.
3. Move the target along the “pitch” axis to the farthest point from the laser (this is the second reference point). Adjust the laser pitch adjustment until the R-1355 display is zero. Bring the target back to the first reference point. If the display does not read zero, re-zero the display. Repeat this process until the target in both reference points reads zero.
4. Place the target on the farthest point along the “roll” axis and adjust the roll adjustment until it reads zero. The laser is now parallel to three reference points.
5. Move the target to the desired measurement points and any deviation from zero is a measure of the flatness of the split joint.

Using 1-Arc-Second Levels Instead of Reference Points
To level a surface, put the laser on an instrument stand or stable mounting surface and level in two axes. Next, place a single-axis target, such as the A-1519, on one reference point and zero it (this is done electronically by pressing a button on the target or readout).

Move the target to a measurement point on the surface, where it displays the deviation of that point from the reference point. If the display shows a plus (+), the measurement point is higher than the reference point. A minus (-) indicates that the point is lower than the reference point. If the measurement point has an adjustment pad under it, use the target and readout as a live digital indicator and adjust until the display shows zero. The measurement point is then in the same level plane as the reference point.

The levels can be calibrated in the field using an easy 15-minute procedure and usually hold calibration for several months.

Using Plane5 Flatness Software
Our Plane 5 software can be used with the L-740 to quickly download flatness data for analysis and reporting. When simply taking data, Plane5 employs a least-squares, best-fit algorithm to eliminate any slope errors in the data from the laser not being parallel to the surface. What this means is that the laser does not have to be bucked-in to reference points to check flatness, which saves about 10 minutes of setup time.
**The S-680 5-Axis Coupling Alignment System**

Hamar Laser developed the very first 5-axis live alignment system in the early 90's. It quickly became the standard by which other systems were judged. Our new S-680 Wireless Coupling Alignment System sets a new standard. With features like internal Bluetooth® wireless communication, super-linear PSD technology, a 5-axis target with automatic sweep function, sub-micron resolution, the largest cell range in the market and updated alignment software, the S-680 is rapidly becoming the first choice for coupling/shaft alignment applications.

### S-680 Reduces Bearing/Seal Costs

Properly aligned motors and pumps will last longer, perform better and use less electricity. The S-680 is an extremely fast and highly accurate tool to align motors to pumps. Not only will you perform motor/pump alignment in record time, but you will also increase the life of your motor bearings and seals, saving you thousands of dollars annually in reduced maintenance costs. And depending on how many motors you have, the S-680 will probably pay for itself in the very first year.

### Lasers Are Simply Faster

After 10 years of laser shaft alignment, it is now an established fact that lasers are simply faster than indicator based methods. The bigger the motor, the more time saved during alignments. We had one customer tell us that they reduced the alignment time on one motor from 2 days to 4 hours! This time saving can be especially helpful on critical machinery where downtime is very costly.

### Live Data in 4 Axes and Shim Values Really Speed Alignments

The S-680 shows both the horizontal and vertical misalignment for both angle and center at the same time in real time. No longer will you have to guess how far your horizontal moves are going. In addition, our updated Couple6 Windows-based software now runs on a ruggedized, hand-held PDA. The software calculates shim values for you, saving additional time.

### Indicator Methods Not Accurate Enough

With the advent of vibration analysis and thermal imaging, it is becoming clear that indicator-based methods are no longer good enough. To reduce vibrations and bearing-destroying heat, motors must be aligned very accurately. Indicator methods do a reasonable job of aligning the centers of the shafts but a poor job of making them parallel; large angular misalignments are common. By contrast, the S-680 provides the needed accuracy to reduce excess vibrations and heat so the motors last as long as the salesman says they should!

### PM Programs More Efficient with S-680

If you have a preventative maintenance program, you will be glad you have the S-680. Whether you are changing a worn-out motor or simply performing a PM check, the S-680 can be set up and displaying misalignment data in about 10 minutes, allowing you to know instantly whether you have to align a motor or not. And with our computer-based laser system, generating reports and saving alignment data has never been easier.

### Automatic Sweep Function Saves Even More Time

The S-680 uses an accelerometer to provide rotation angle measurements, eliminating the "clock method" many other systems still use today. This rotation sensor automatically detects "start" and "stop" points, and works with a sweep angle of as little as 60°, which is especially useful in cramped conditions.

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**Recommended System Configuration**

- **L-790 Laser w/Dual-Beam™ Technology**
- **T-1290 Bluetooth Wireless 5-Axis Shaft Alignment Target**
- **A-980A Upgraded Bracket Kit for 0.5" to 12" (25 mm to 300 mm) Shaft Diameters**
- **R-1342 Ruggedized Tablet Data Collector**
- **T-241 Backup Cable**
- **S-1396 Couple6 Software**
- **A-812 Shipping Case**

**Optional Accessories**

- **A-980B Small Shaft Adapter**
- **A-980C Extra Chain Set for 1" - 12" Shaft Diameter**
- **A-980-OF Offset Bracket**
- **A-980NRA-1 Non-rotating Shaft Bracket without chain**
- **A-980NRA-2 Non-rotating Shaft Bracket w/chain**
- **A-980NRA Non-rotating Large Shaft Bracket**
- **A-982 Magnetic Bracket Set**
S-680 Even Works in Direct Sunlight
With our new internal light meter, the S-680 actually provides a display of how sunlight is affecting the readings. In most cases, with the use of our optional light shield, the S-680 will actually work in direct sunlight without having to put up tarps or other shade devices.

Universal Brackets Eliminate Bulky Accessories
One set of mounting brackets is all that is needed to align 95% of the motors out in the field. The brackets accommodate shafts from 1" to 12", (25 mm to 300 mm) without modification, and the can be easily expanded to fit larger shafts to 18". They even have built-in magnets for extremely large shafts. About the only bracket accessories that are needed are offset brackets used for very short shafts.

How Couple6 Software Works

Step 1: In the MOTOR SETUP SCREEN, the motor’s foot dimensions, machine description and desired alignment tolerances are entered. Thermal grown offsets (the amount the motor grows from a cold start to operating temperature) are also entered at this stage.

Step 2: The LASER SETUP SCREEN displays and the laser and target are placed on the brackets and adjusted until the readings are within ±.030" (0.8 mm) of zero. Adjustments to the vertical center are made by moving the laser up or down on the brackets. Adjustments in the horizontal center are made by an adjustment knob on top of the laser. For new motor installations, this screen is used to “rough in” the motor’s large angular misalignment.

Step 3: After the laser and target setup and the motor rough-in, the SOFT FOOT SCREEN displays an easy-to-follow routine that finds potential soft-foot problems and recommends corrective action. The soft-foot routine is best used with the motor uncoupled to the driven unit. This is because a large pump and rigid coupling can prevent the laser from finding soft-foot problems. The laser measures shaft deflections caused by a soft foot, and if the shaft is rigidly coupled to a driven unit, it may not move much at all.
Step 4: Once the soft foot routine is completed, the DATA TAKING SCREEN displays. The laser and target are rotated for data collection and analysis of mounting errors. The S-680 system automatically senses when the laser and target are being rotated and when they stop. When rotation stops, the software automatically calculated the mounting errors and subtracts them from the misalignment readings. A coupled or uncoupled routine may be selected.

Step 5: The MISALIGNMENT SCREEN displays a graphic of the misalignment, including center and slope readings corrected for mounting errors and shim values in all 4 axes. The readings and motor graphics automatically update when moves are made or shims added. The data-updating speed (averaging) can be adjusted to smooth out fluctuations in the readings due to air turbulence or vibration. Shim value displays are replaced by IN TOLER when the alignment comes into tolerance. The DATA TAKING and MISALIGNMENT screens also show a light meter that warns the user if bright light, such as the sun, is affecting the readings.

For motors with large misalignment, Steps 4 and 5 may need to be repeated. In general, however, one set of shims and moves is all that is needed to perform the alignment.