LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Advanced LIGO SEI/SUS Test Stand

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1) Introduction

The purpose of this document is to document the design criteria and installation of the LASTI test stand. The test stand will be used at LASTI and eventually at both the Hanford and Livingston facilities to assemble and test the Advanced Ligo seismic isolation and quad suspension systems.

2) Design Requirements

1. The test stand must be able to support the total load of the seismic isolation (ISI) and quad (SUS) assembly of 8820#s with minimal (<. 002) vertical deflection.
2. The dynamic stiffness of the structure shall be greater than the stiffness of the existing BSC crossbeam and support tube assembly, with the first mode no less than 50 Hz.
3. The stand must be able to match the mounting points of the advanced Ligo seismic isolation with bosses and tolerance similar to the current BSC support tube D972121.
4. The stand should have the versatility of being assembled at a convenient height for assembly of the ISI structure (~32”) and to be at a height to support both the ISI and Quad assemblies for testing prior to a cartridge installation.
5. The stand in its fully loaded state must be level to within .2 mrad (.010” over the 49” mounting area). Trim masses supplied with the ISI system can then be used for more accurate leveling.

3) Analysis Results

Figures 1-4 show the finite element model created, along with results of static deflection and the first three mode shapes.

Static deflection with 8820# load = .0012”

Natural Frequencies

Mode number	rad/sec	Hz
1	323.8	51.53
2	406.3	64.66
3	469.5	74.72
4	790.3	125.79
5	1170.5	186.29
6	1247.7	198.58

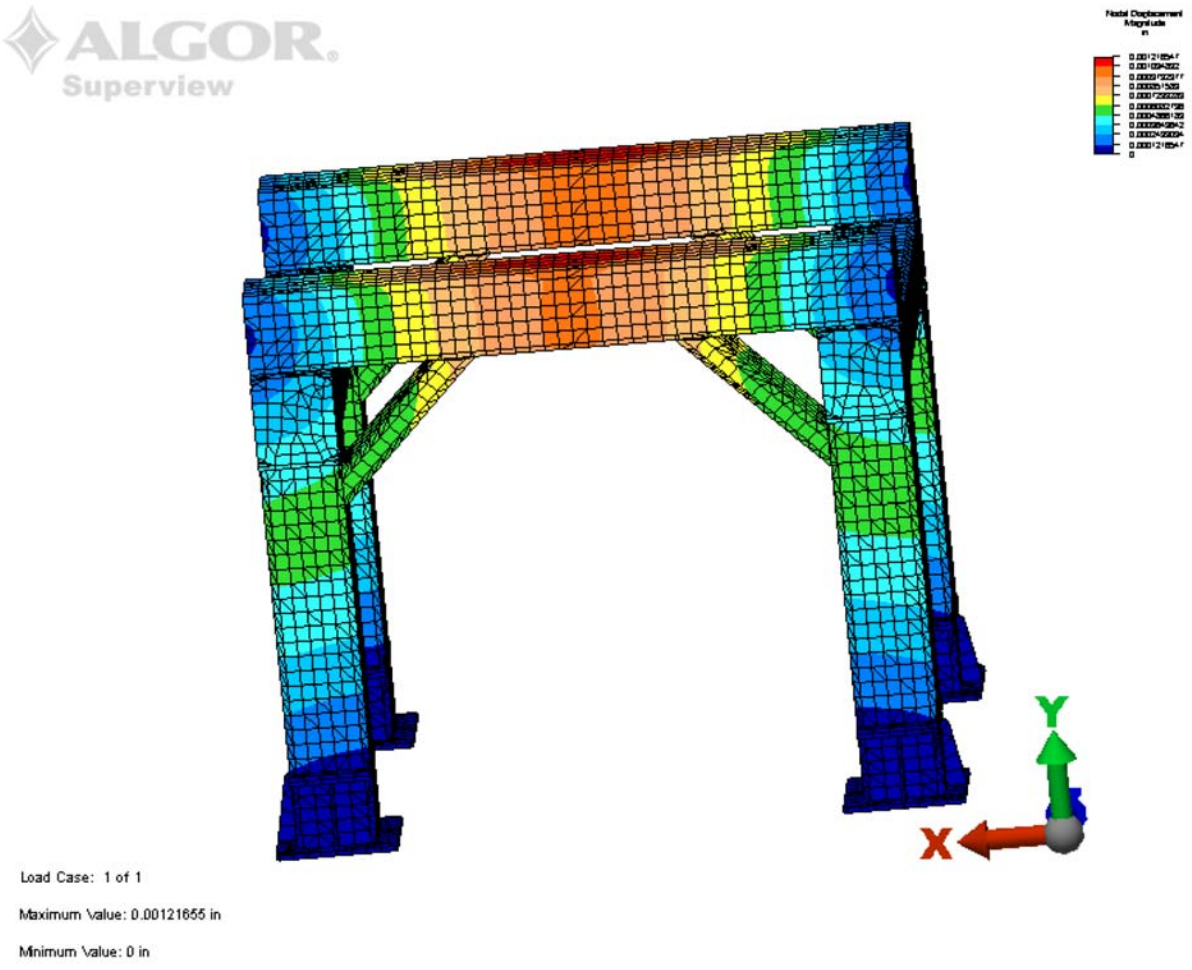

ALGOR
Superview
Y
X
Load Case: 1 of 1
Maximum Value: 0.00121655 in
Minimum Value: 0 in

Fig. 1

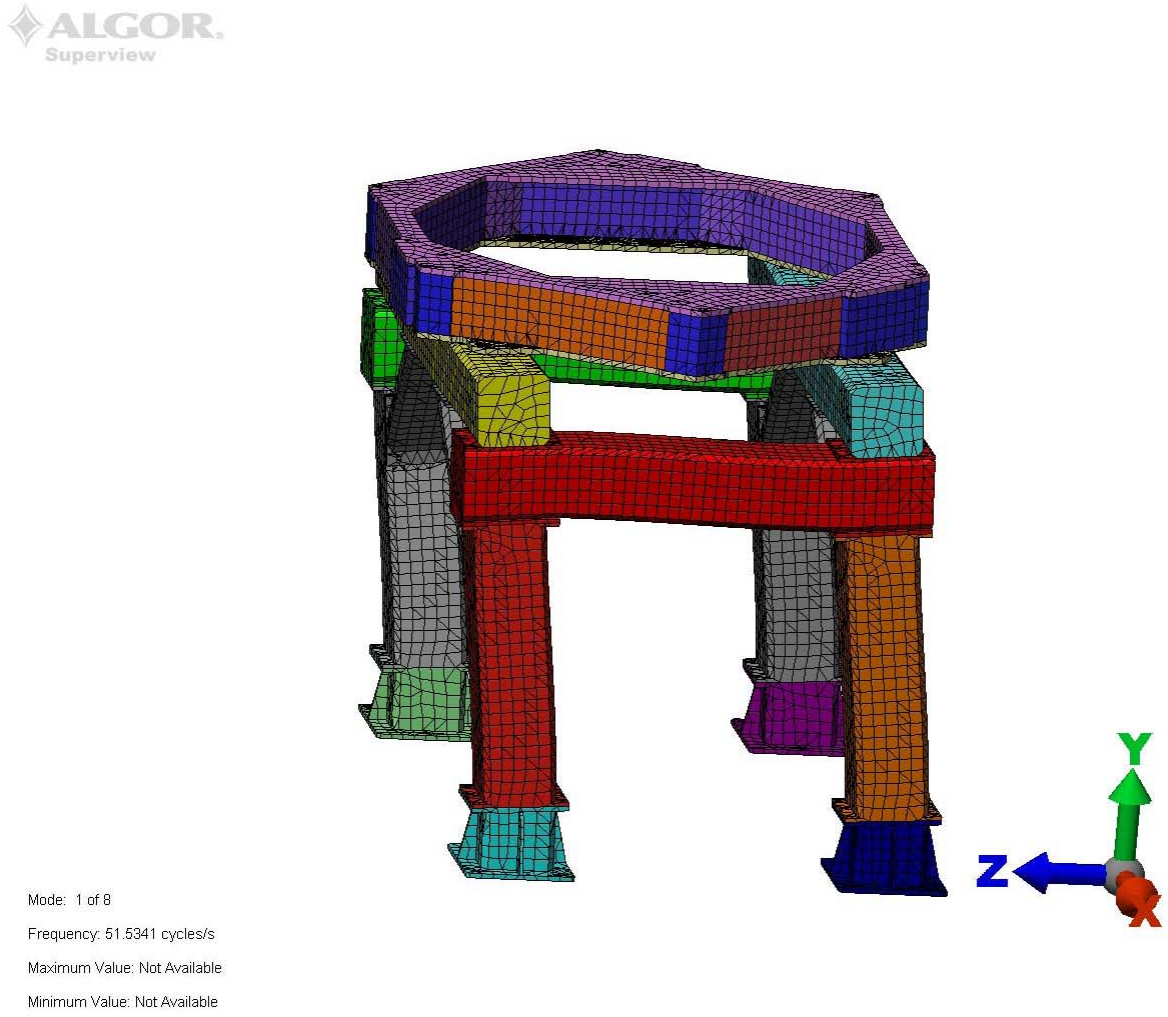
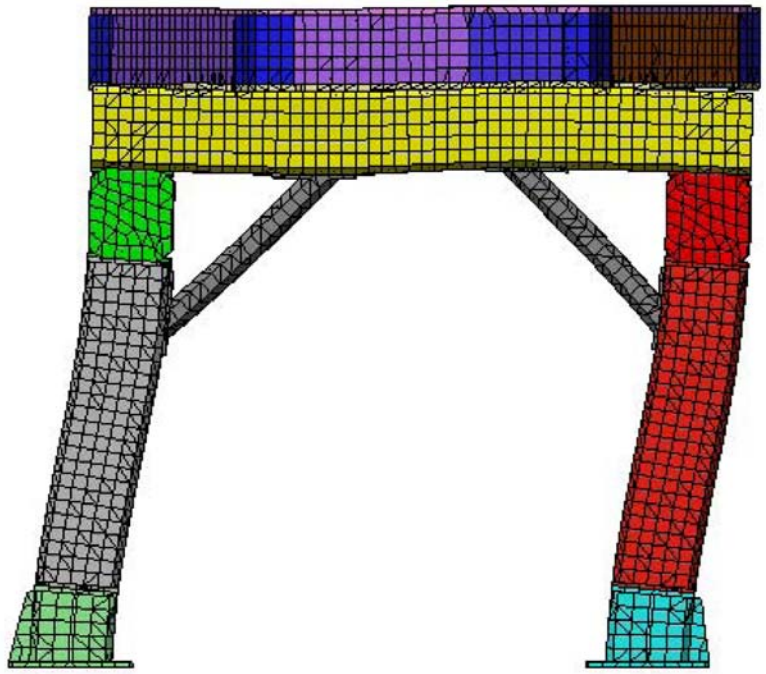

ALGOR
Superview
Y
Z
X
Mode: 1 of 8
Frequency: 51.5341 cycles/s
Maximum Value: Not Available
Minimum Value: Not Available

Fig. 2



Mode: 2 of 8

Frequency: 64.6649 cycles/s

Maximum Value: Not Available

Minimum Value: Not Available

Fig. 3

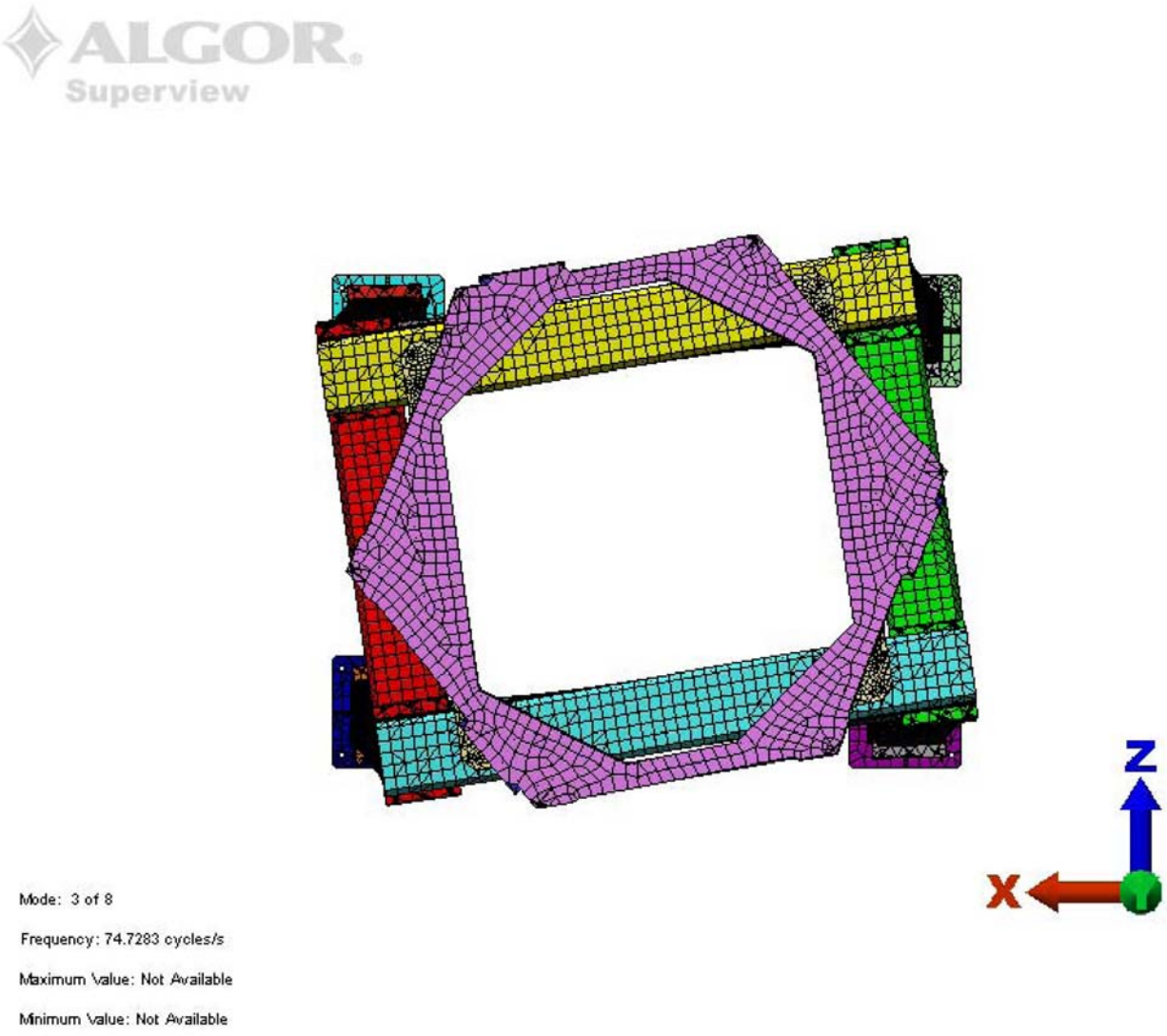

ALGOR
Superview
Z
X
Mode: 3 of 8
Frequency: 74.7283 cycles/s
Maximum Value: Not Available
Minimum Value: Not Available

Fig. 4

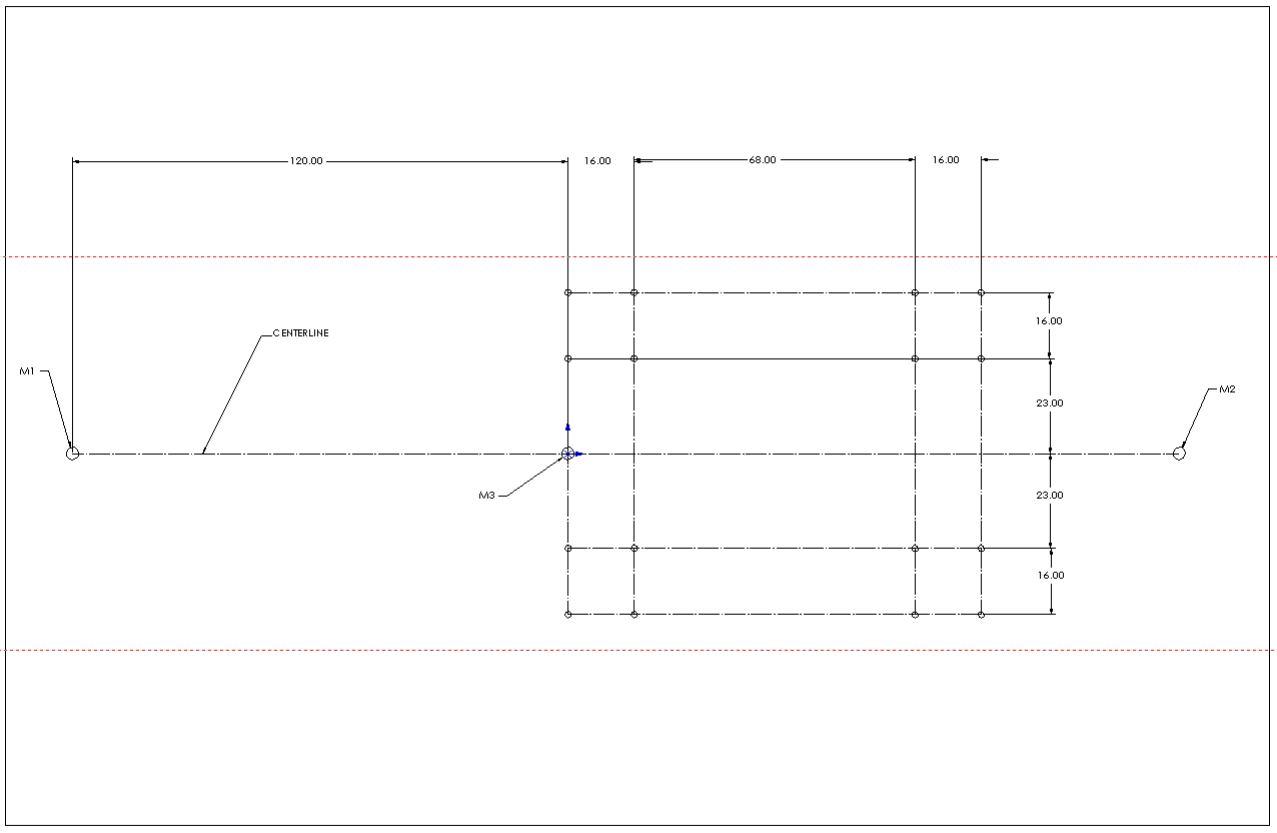
4) Alignment Methods

Equipment Required

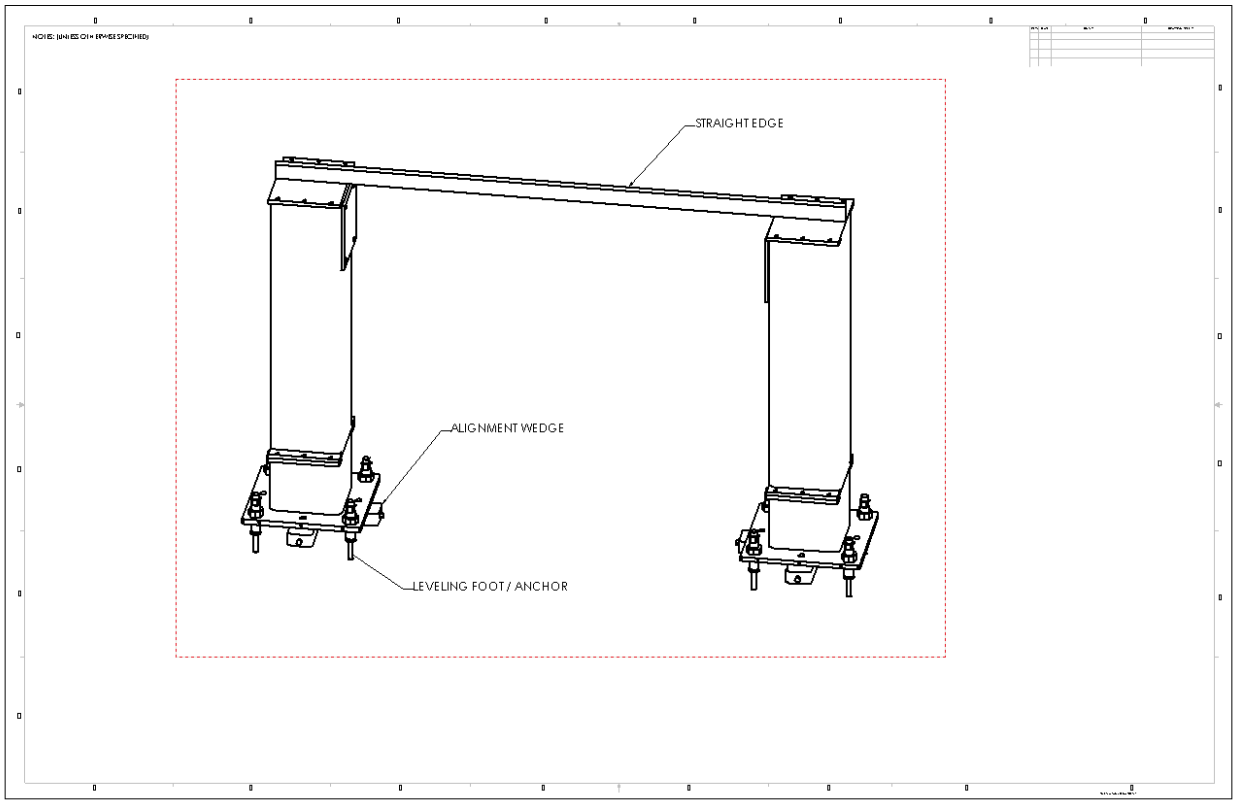
1. Brunson model 75-H optical transit square with micrometer eyepiece, instrument stand 230-HC, and coincidence level.
2. (6) Unisorb RK1 Alignment wedges.
3. 96” x 3¼ precision beveled edge straightedge, McMaster Carr part # 2265AZ or equivalent.
4. 24” Combination Square, plumb bob, plumb bob stand, and (16) ¾” Hilti anchors.
5. Precision cross level - .001/10” sensitivity, McMaster Carr part # 21665A31 or equivalent.

Assembly and Alignment Procedures

1. Create a centerline and place monuments at positions M1, M2, and M3 per figure 6. With a 24” combination square and steel rule, locate the 16 anchor positions also shown in the figure below. Drill and place ¾” Hilti anchors in each of these positions.



2. Position leg 1 (D050261) and base (D050262) over 3 Fixator alignment wedges per figure 7. Anchor bolts should be loosely installed to maintain location and prevent tipping.
3. Level leg 1 with the precision cross level to within .001”/ 10”.
4. Position leg 2 (D050261) and base (D050262) over 3 Fixator alignment wedges. Anchor bolts should be loosely installed to maintain location and prevent legs from tipping.
5. Place the straight edge beveled side up across the top of the two legs and roughly position and level the second leg.
6. Install the Brunson transit square with micrometer head at a convenient location such that you can rotate the transit to view both legs. Raise the transit to the height of the straight edge over leg 1 and level the transit as described in T970151-C appendix 2.
7. Rotate the transit to leg 2 and measure the height difference. Adjust the height and level leg 2 to match leg 1.
8. Install and tighten the anchor bolts on each leg and remove the alignment wedges.



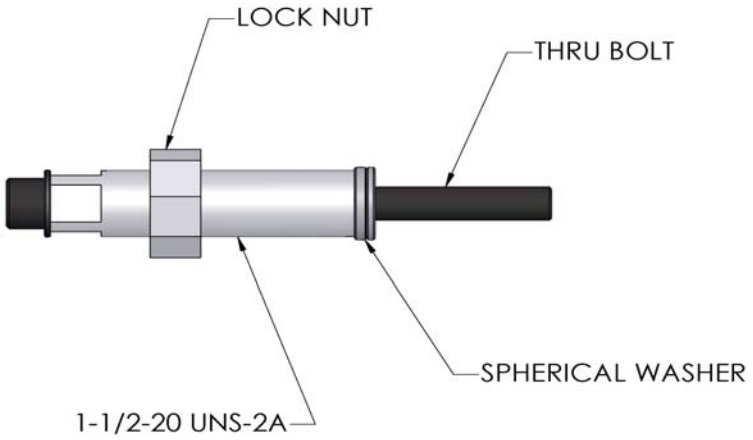


Fig. 6 & 7

9. Install, set height, and level legs 3 and 4 using the procedure described in steps 2 thru 8 above.
10. Install the two cross braces (D050260) onto the top of the legs. Raise the Brunson transit to check that the top of the cross braces are at the same height. It may be necessary to re-install the alignment wedges to make slight adjustments.
11. Install the support tubes (D050259) and gussets (D050263). Do not tighten bolts.
12. Install the (3) support tube alignment jigs between the support tubes. Add pusher assemblies and push the support tubes if necessary to align with the jigs. The bolts must be able to easily screw in and out without rubbing.
13. Torque all bolts to 47 ft/lbs and remove alignment jigs. Grout in place.

Maximum Tolerance Stackup

Leveling of 4 legs and crossbrace using straightedge	.004”
Flatness of support tubes	.004
Static deflection under load	.0012
Total	.0092

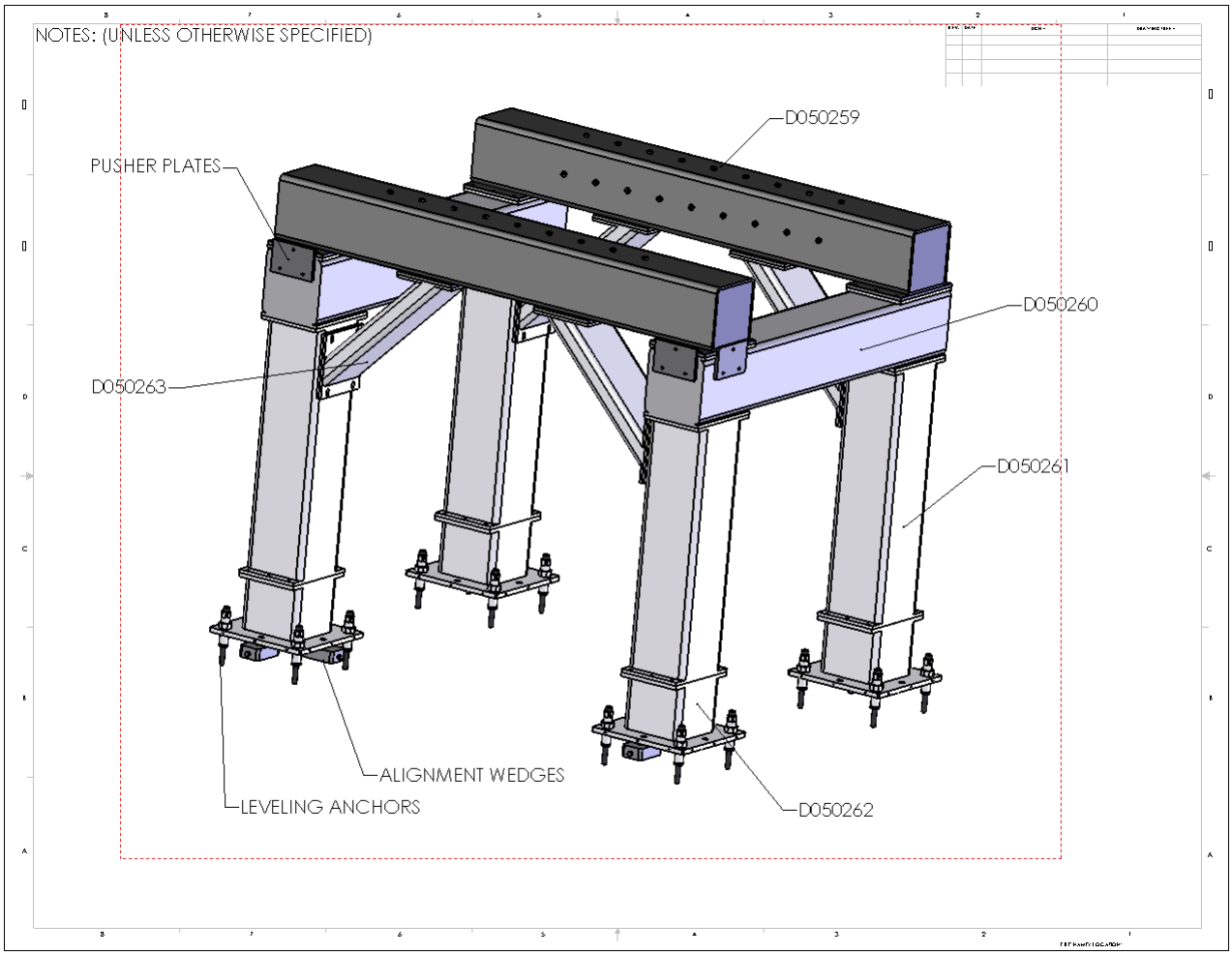

NOTES: (UNLESS OTHERWISE SPECIFIED)
D050259
PUSHER PLATES
D050260
D050263
D050261
ALIGNMENT WEDGES
LEVELING ANCHORS
D050262

Fig. 8

UNISORB® RK FIXATOR® ANCHORING/ALIGNMENT SYSTEM

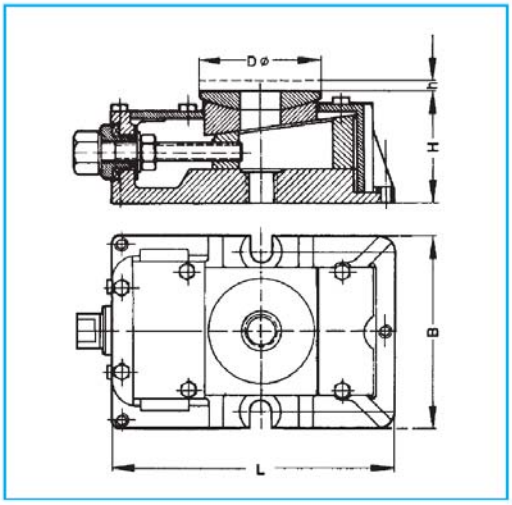
NOTE: All Fixator information in this catalog pertains to machine tool applications. Call UNISORB about the use of Fixators for Power Generation equipment.

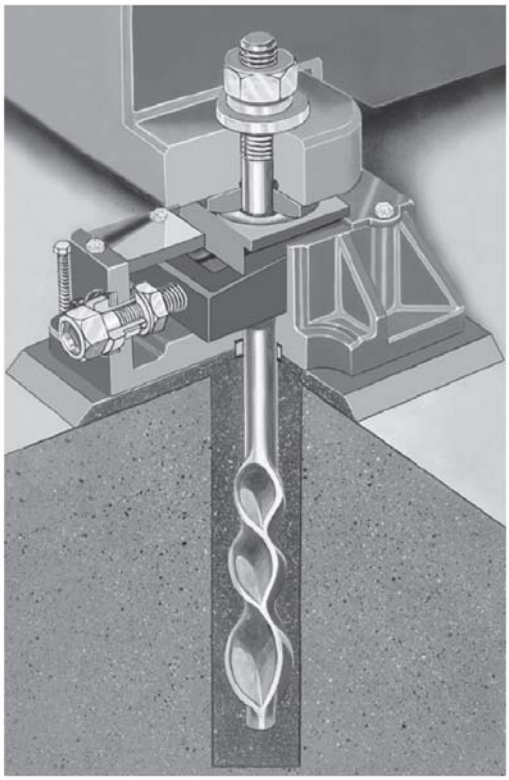
RK FIXATOR SYSTEMS level and align machinery to tolerances of one ten thousandth (0.0001") and make it possible to vary adjustments at any time, even under maximum loads requiring only a small hand wrench to adjust. Time consuming work and production losses normally associated with alignments are eliminated.

While affording **the most rigid machine-to-foundation connection available,** other benefits include built-in compensation for uneven areas in foundations and machine bases. True vertical lift, made possible by a 3-piece wedge design to eliminate lateral movement as machines are raised or lowered, makes the RK FIXATOR the "state-of-the-art" anchoring/alignment system.

INTEGRATED SYSTEM DESIGN

Though similar in appearance to conventional wedge-type leveling equipment, RK FIXATOR SYSTEMS differ significantly in concept and application. The RK FIXATOR is not a conventional wedge system and should not be treated as one. **Alignment adjustments are made after anchor nuts have been tightened.** In this way, the anchor bolts are tightened uniformly to predictable stress levels by adjusting the RK FIXATOR basic unit upward prior to the final alignment procedure eliminating the customary torquing of anchor nuts. This gives substantial savings in time and effort normally required for the installation of sophisticated machine tools.





RK FIXATORS SAVE MONEY BY:

- Allowing faster completion of new installations.
- Decreasing frequency of, and shorten time required for future realignments.
- Maintaining machine accuracy for longer time periods.
- Decreasing required maintenance.
- Ensuring maximum machine productivity.

BASIC DIMENSIONS

Dimension	RK I	RK II	RK III	RK IV	RK V
Dø	2.36	2.95	3.54	4.33	5.91
L	6.89	7.01	8.66	10.83	13.58
B	4.13	4.72	5.91	7.09	9.06
H	2.17	2.95	3.74	4.53	5.31
h	.20	.20	.24	.32	.40

LOAD RANGES (PER MOUNT)

MODEL NO.	*RECOMMENDED MACHINE STATIC WEIGHT	MAXIMUM ALLOWABLE LIFTING LOAD
RK I	2,200 lbs.	20,000 lbs.
RK II	4,400 lbs.	26,500 lbs.
RK III	8,800 lbs.	53,000 lbs.
RK IV	13,200 lbs.	80,000 lbs.
RK V	26,400 lbs.	155,000 lbs.

**Contact Unisorb Engineering for application assistance.*

BSC Support Tube Alignment Fixture