FASTER Fixture Modification: Axial Tension-Compression

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16. Abstract

This technical note describes modifications made to the Full-Scale Aircraft Structural Test Evaluations and Research (FASTER) fixture for axial tension and compression loading capabilities. The original fixture was designed to apply axial tension loads only. The increased use of composite materials and bonded structures led to the realization that the fixture had to be modified to apply compression loads, a critical loading mode, to the test panels along with the axial tension loads. The new axial loading mechanism was designed for this purpose. Similar to the original axial loading mechanism, the actuators were installed on both sides of the level arm to provide both tension and compression loading capabilities. A splitter box was installed to change the negative load command to positive load command without increasing the number of control channels. An acceptance test was conducted using a calibration panel to verify to proper function of the new axial loading mechanism up to the maximum design loads and loading rates.

17. Key Words

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LIST OF ACRONYMS

FASTER	Full-Scale Aircraft Structural Test Evaluation and Research

EXECUTIVE SUMMARY

This technical note describes modifications made to the Full-Scale Aircraft Structural Test Evaluations and Research (FASTER) fixture for axial tension and compression loading capabilities. The original fixture was designed to apply axial tension loads only. The increased use of composite materials and bonded structures led to the realization that the fixture had to be modified to apply both tension and compression axial loads. The new axial loading mechanism was designed for this purpose. Similar to the original axial loading mechanism, the actuators were installed on both sides of the level arm to provide both tension and compression loading capabilities. A splitter box was installed to change the negative load command to positive load command without increasing the number of control channels. An acceptance test was conducted using a calibration panel to verify to proper function of the new axial loading mechanism up to the maximum design loads and loading rates.

INTRODUCTION

The Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) lab, located at the FAA William J. Hughes Technical Center, was developed for full-scale testing of fuselage structures under simulated flight conditions [1]. The fixture is capable of applying combined internal pressure and axial load with appropriate hoop reactions. In general, the hoop and axial stresses are simulated by the controlled application of distributed loads around the perimeter of the test panel. Hoop forces are distributed by seven individual loading mechanisms/whiffletree assemblies on each side of the specimen via 28 attachment points. A portion of the hoop loads are applied to the both ends of six frames via a separate frame loading system. At the end of each panel there are four load control devices that axial forces. Each control device is comprised of a whiffle tree arrangement that provides four attachment points.

In the original FASTER fixture configuration, axial loads were limited to the tension loads only. Testing to assess the structural integrity of airframe structures must consider critical and potentially damaging loading modes. In the case of composite materials and bonded structure, compression forces are a critical loading mode. With the increasing use of these advanced technologies, there is a need to have the testing capabilities to simulate these loading conditions.

To address this need, modifications were made to the FASTER fixture for axial tension and compression loading capabilities. Resources were leveraged with the Boeing Company under a Cooperative Research and Development Agreement to implement this modification.

In general, the fixture was designed to the following load specifications:

- The maximum axial design load is ±20000 lbs. per actuator. A level mechanism amplifies the actuator force by a ratio of four to one, thereby creating an output force of ±80 kip.
- A dynamic loading rate of 2 cycles per minute for tension-tension and compression-compression loading at load ratio (minimum load/maximum load) R = 0.1, up to 50% of the maximum design axial load.
- A dynamic loading rate of 1 cycle per minute for a fully reversible tension-compression-compression loading at load ratio R = -0.5, up to 50% of the maximum design axial load. An applied load tolerance of 5% of the nominal full scale values specified by the load control system.

This technical note is organized with a separate section for each portion of the modification as follows: fixture disassembly, axial loading mechanism modification, axial loading assembly installation, control system modification using splitter box, and the acceptance test using calibration panel. The engineering drawings are available in Appendix A.

FIXTURE DISASSEMBLY

As a first step, a disassembly effort was undertaken to prepare the fixture for the modifications. All axial loader assemblies, frame loaders, and hoop loaders were identified for placement in the same location for future tests and removed, as shown in Figure 1. Load cells were removed and recalibrated. The strain gage completion bridge board was relocated to clear the interference with the bottom of #4 axial loader assembly (AD8-4) and the new water dome valve bracket for compression bladders, as shown in Figure 2.

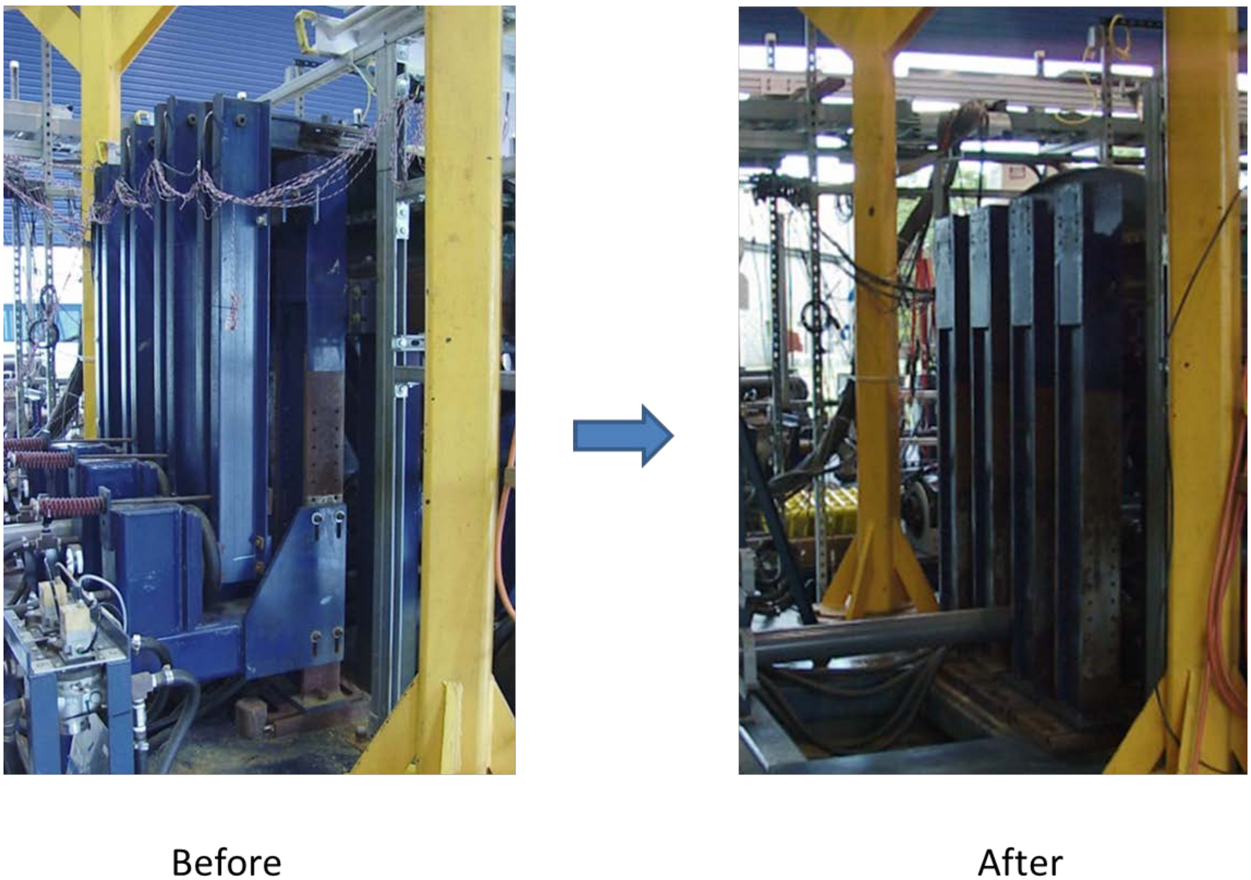


Figure 1. Photographs of Fixture Teardown – Axial Load Assembly Removal

Figure 2. Photographs of Strain Gage Completion Bridge Board Relocation

AXIAL LOADING MECHANISM MODIFICATION

A new axial loading mechanism was designed, fabricated, assembled and installed to provide both tension and compression capability as described in this section.

Similar to the original loading mechanism, it consists of two water actuators, lever arm, fulcrum pivot point, a load cell, a whiffle tree, and a push rod assembly as shown in Figure **3**. The axial load mechanism was designed to add the compression capability. To accomplish this, a set of water actuators was added on the other side of the lever arm. All water actuators were Firestone brand (item no. W01-358-8047). Inflation of the inside water actuator causes rotation of the lever arm about the fulcrum which in turn generates a compressive force on the load cells. The lever mechanism amplifies the actuator force by a ratio of four to one ($u_1 = 4*u_2$). Tensile forces are generated by the outside water actuator in a similar manner, as shown in Figure 3. Tension-compression load cells (Futek item no. FSH00712) have a maximum measurement capability up to ±20,000 lbs.

The new axial loading assemblies were fabricated per engineering drawings summarized in Table 1 and shown in Appendix A.

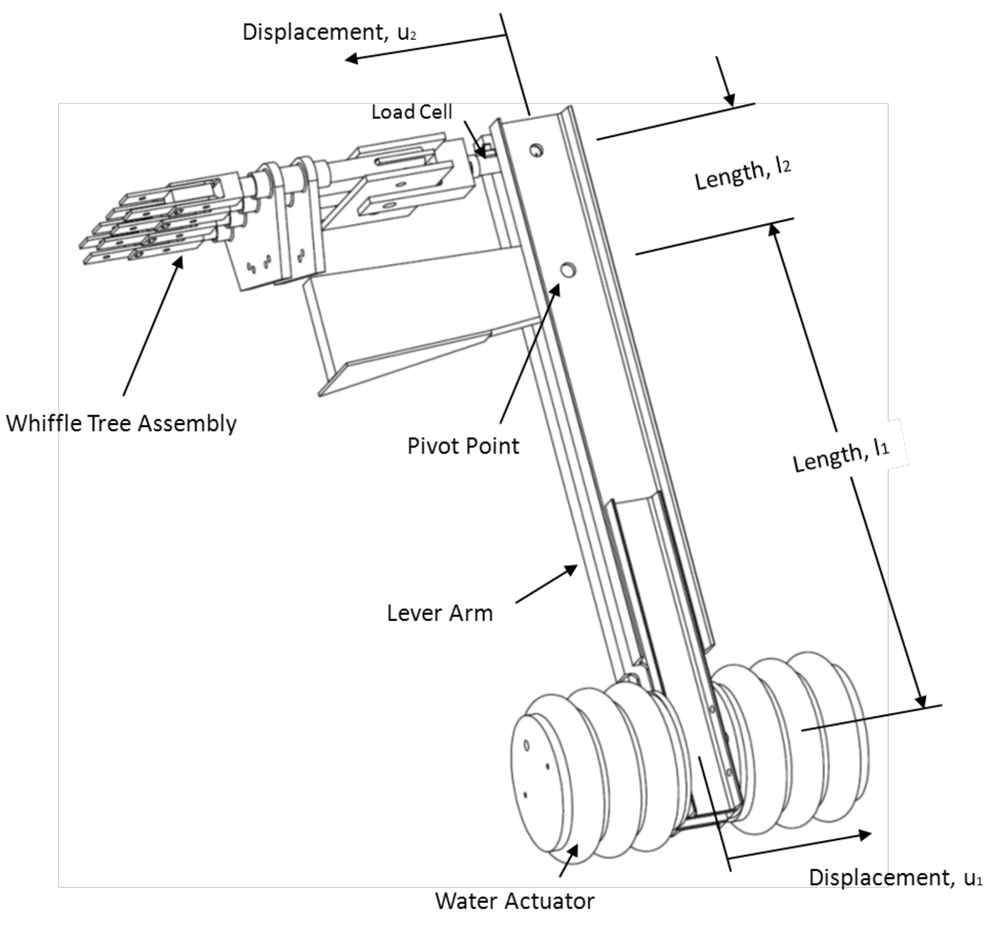


Figure 3. Schematic of the Axial Tension-Compression Load Mechanism

Table 1. Axial Loader Engineering Drawings

Drawing No.	Description	Quantity
GJK0001-1	Push Rod Assembly	32
GJK0001-3	Glide Tube Assembly	8
GJK0001-5	Pivot Assembly	8
GJK0001-7	Lever Assembly	8
GJK0001-9	Bottom End Assembly	8
GJK0001-51	Guide Rail Assembly	8

AXIAL LOADING ASSEMBLY INSTALLATION

The alignment of the axial loading assembly is critical to ensure the load transferred properly to the test panel as desired. To accomplish this, the axial load assembly was installed according to the following guidelines:

A. Adjust shims between axial loader support assembly (AD 9) column and the riser (AD 2) base – 8 places, as shown in Figure 4. When properly shimmed the new axial load assembly (AD 8) lever beam will be vertical with the fingers connected to the test panel and the bottom end positioned between the two (equal height) firestone actuators.

B. All bolts used in shear applications must not have the threads bearing on the parts. The bolts do not need to be shoulder bolt type but must have an unthreaded shank that extends through the entire joint, keeping the threads engaged only in the nut. All bolts shall fit into the linkage parts freely. It will not be necessary to use a hammer to install the bolts. A bullet nose adapter should be available for the end of shoulder bolts to facilitate bolt engagement. If bolts do not slide easily into the joint holes a reamer should be employed to fit the holes properly.

C. Loading mechanism alignment and shimming. All loading mechanisms (glide assemblies) shall be adjusted in the vertical and horizontal directions to achieve the following:

1. Fingers of the loading assembly shall be adjusted and shimmed to achieve balanced positioning first, as shown in Figure 5.

2. Glide assembly shall be free to move to accommodate finger shimming.

3. Pivot bearing assembly shall be adjusted vertically to accommodate 1 and 2 above.

4. Base assembly shall be adjusted vertically to allow the load cell to be horizontal (LEVEL) when 1, 2, and 3 are properly positioned.

5. The base of axial loader support assembly (AD 9) shall be adjusted laterally to achieve alignment of the loading mechanism with the acceptance test panel, as shown in Figure 5 .

New ½” diameter holes were drilled and tapped in the vertical columns of axial support assembly (AD-9) to install -5 pivot assemblies, as shown in Figure 7 . The original whiffle tree center plate was milled from 0.5 inch to 0.375 inch to provide 5 degree rotation freedom for the push rods, as shown in Figure 8. The second set of holes on the GJK0001-3 glide tube assembly is an adjustment fit for the test panel curvature as shown drawing GJK0002-19.

The edge of the test panel is approx. 0.5 inch with reinforcement doublers. The gap between load links is 1.0 inch. The shims were bonded to the test panel to fill the gap between GJK0001-11 load links, as shown in Figure 6. A plain fiberglass scrim cloth of 0.005 inch thickness (McMaster Carr p/n 9345K4) was used to both the shims on test panel.

In contrast to previous tests conducted on the FASTER fixture, in which push pins were used to fasten the axial loader fingers to the panel, bolts were used for the Curved Panel Bonded Repairs 2 test so that there was clamping force on the panel.

The water supply line has been rerouted to clear the interference with axial load assembly #2 (AD8-2) and axial load assembly #3 (AD8-3) water actuators, as shown in Figure 9.

It was found that the axial load assembly lever arm shifted from the center line at higher load during initial loading of the acceptance test. To address this issue, the guide rail assemblies were fabricated and installed per engineering drawing GJK0001-51. All guide rail center bars were raised to the same height to install a working platform, as shown in Figure 10.

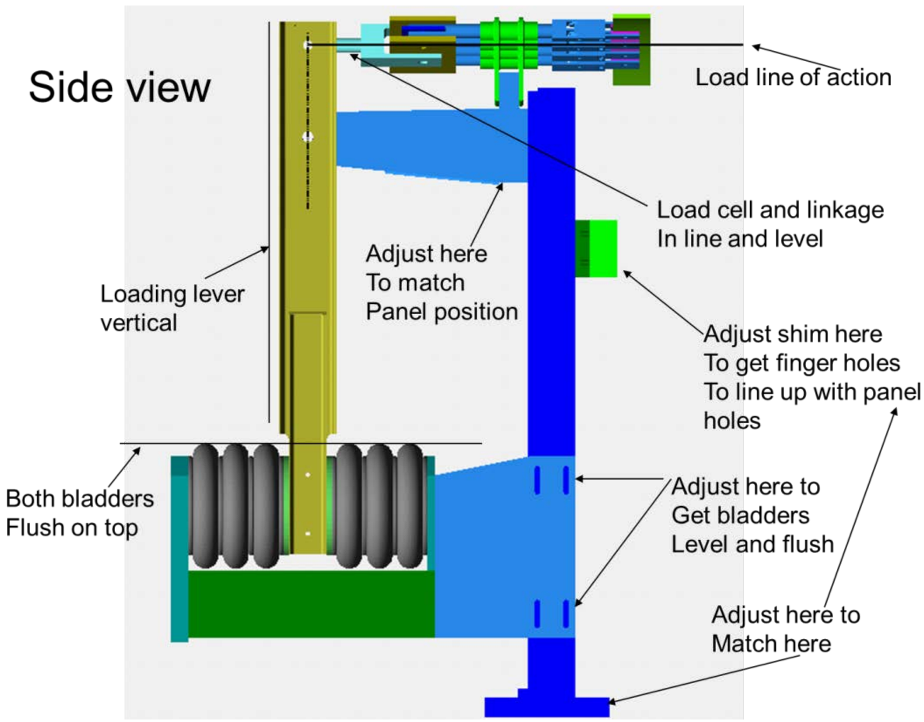


Figure 4. Alignment of Axial Load Assembly – Side View

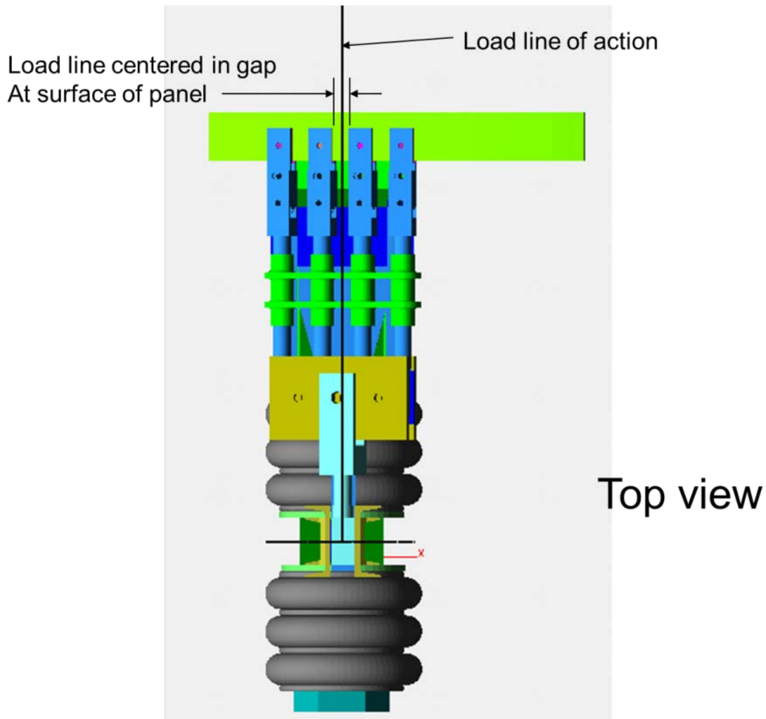


Figure 5. Alignment of Axial Load Assembly – Top View

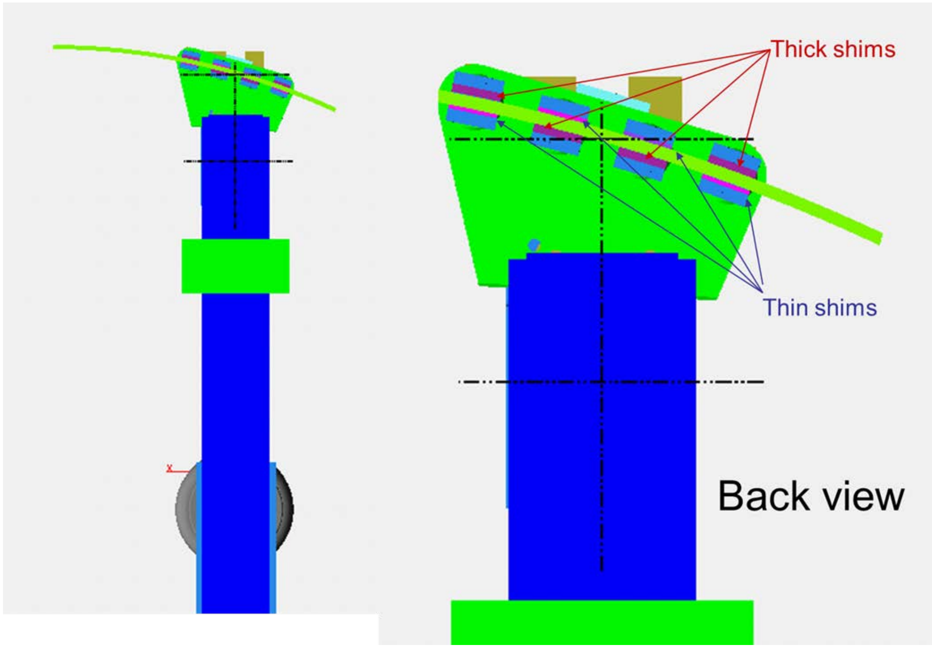


Figure 6. Shims for Whiffle Tree Fingers

Figure 7. Photo of New Hole Drilling on Axial Load Support Assembly Column Beam

Figure 8. Photo of Whiffle Tree Center Plate Milling

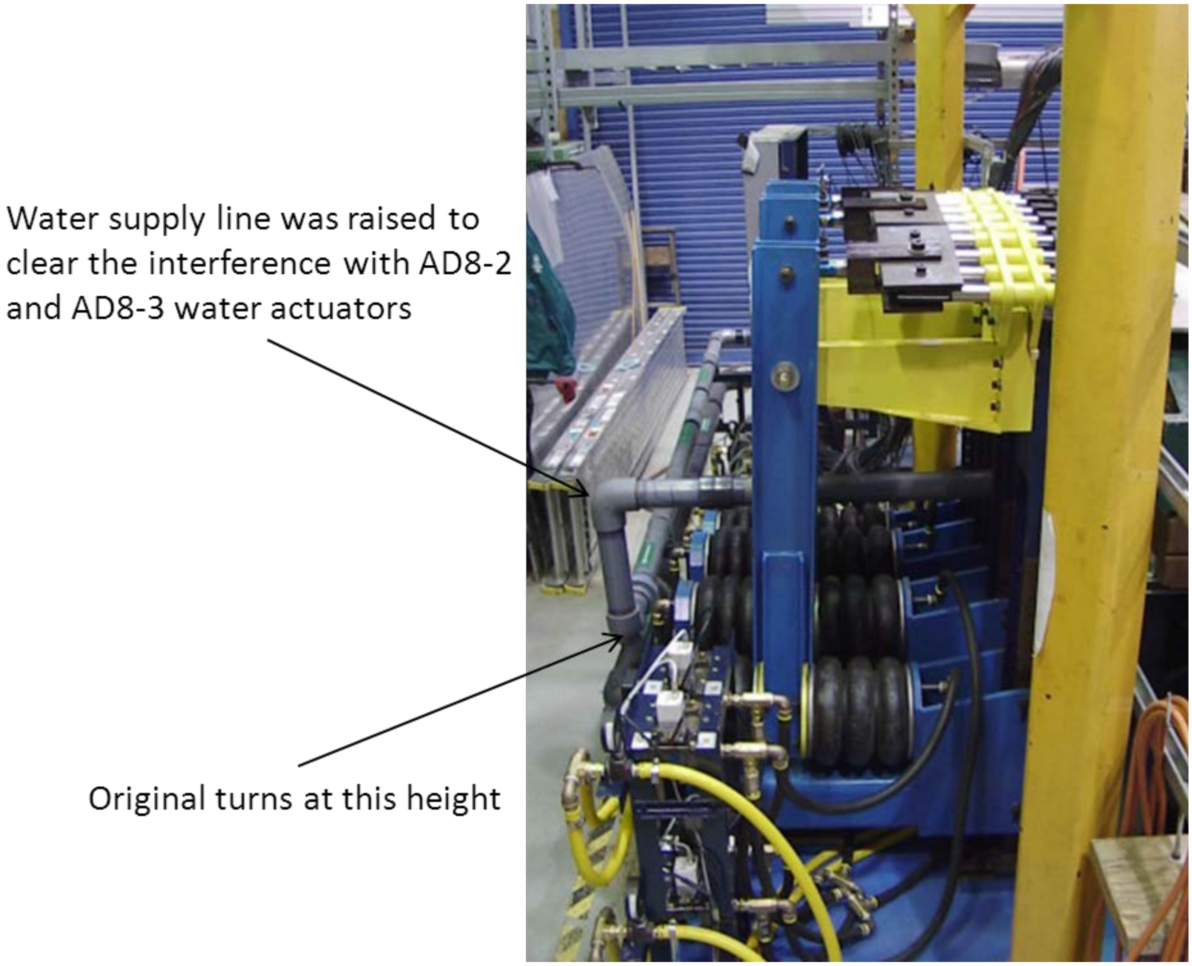


Figure 9. Photo of Adjustment of Water Supply PVC Piping

Figure 10. Photo of Guide Rail Assembly Final Configuration

AXIAL LOADING CONTROL MODIFICATION

A splitter box was used to control the compression load without adding additional control channels to the existing system. Each of the axial load channels is equipped with a signal splitter circuit, as shown in Figure 11. If the signal is positive, the splitter circuit outputs a voltage equal to the input on the tension E/P valve. If the signal is negative, the splitter circuit outputs voltage equal to the inverse of the negative voltage on the compression E/P valve, as shown in Figure 12. The signal splitter box combines the feedback from both E/P valves into a single signal which is checked and verified using the feedback from the load cells. Configuration of the splitter box with two E/P valves for one axial load assembly is shown in Figure 13. There is no change on control interface. However, the installation of the splitter box allows user to input negative numbers for compression loads without increasing the control channels.

Figure 14 shows a typical example of a servo loop control for an axial load mechanism, using water, where the input, output and channel number designations are specific to axial load assembly #1 (AD8-1). For each axial load mechanism there are two dome valves: one to apply tension load, AD8-1T, and the other for compressive loads, AD8-1C. These dome valves control the flow of water from the supply manifold into the actuators.

Channel 194 is used to send the servo channel command signal AD8-1CTL to a signal splitter. The signal splitter sends command to either a tension or a compression E/P valve to control the associated dome valves. The load cells are used (item no. FSH00712) having a maximum measurement capability up to ±20,000 lbs. The feedback and output from the tension-compression load cells (Futek Model FSH00712, ±20,000 lb) are routed via channel 246.

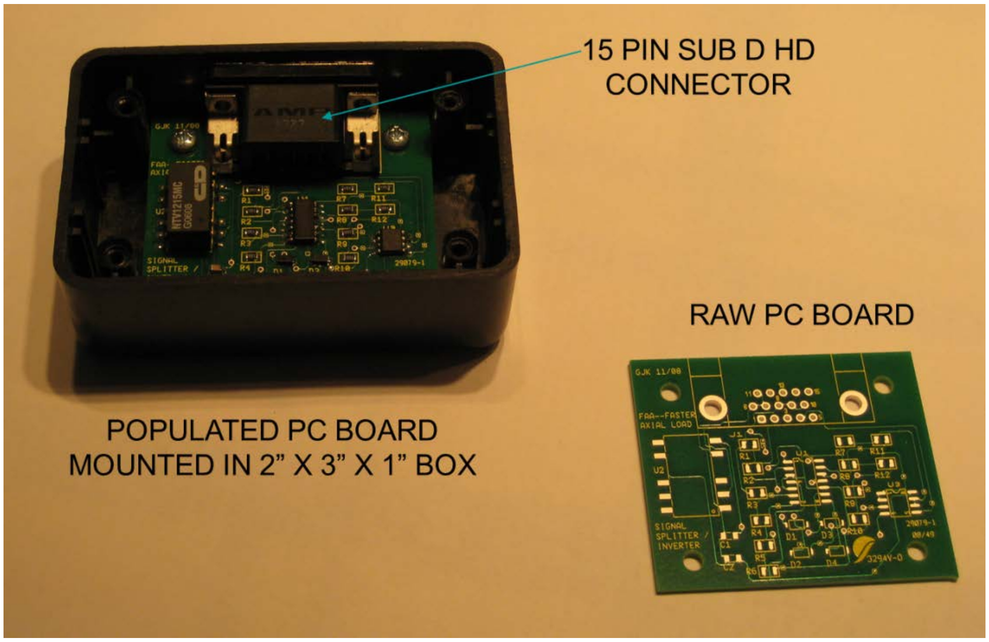


Figure 11. Signal Splitter Box for Axial Load Assembly

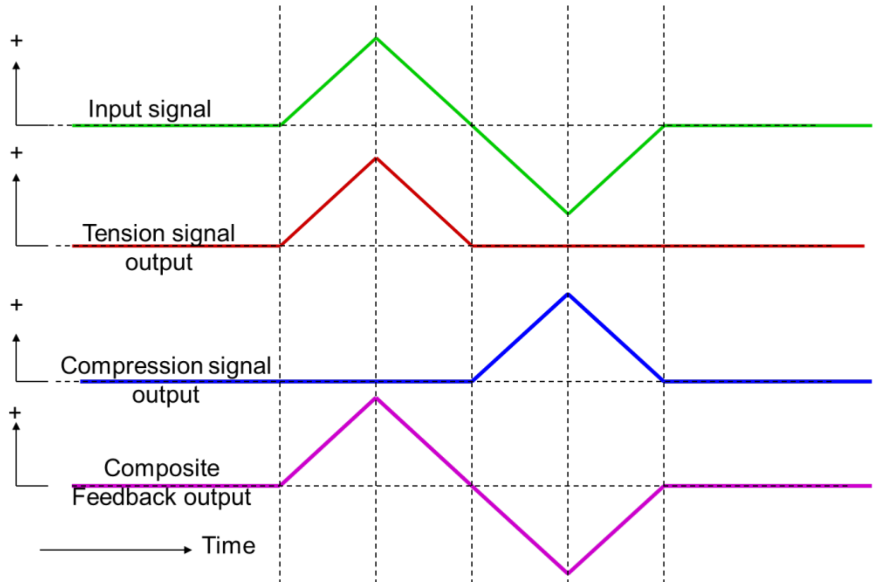


Figure 12. Schematic of Signal Splitter Box Processing Mechanism

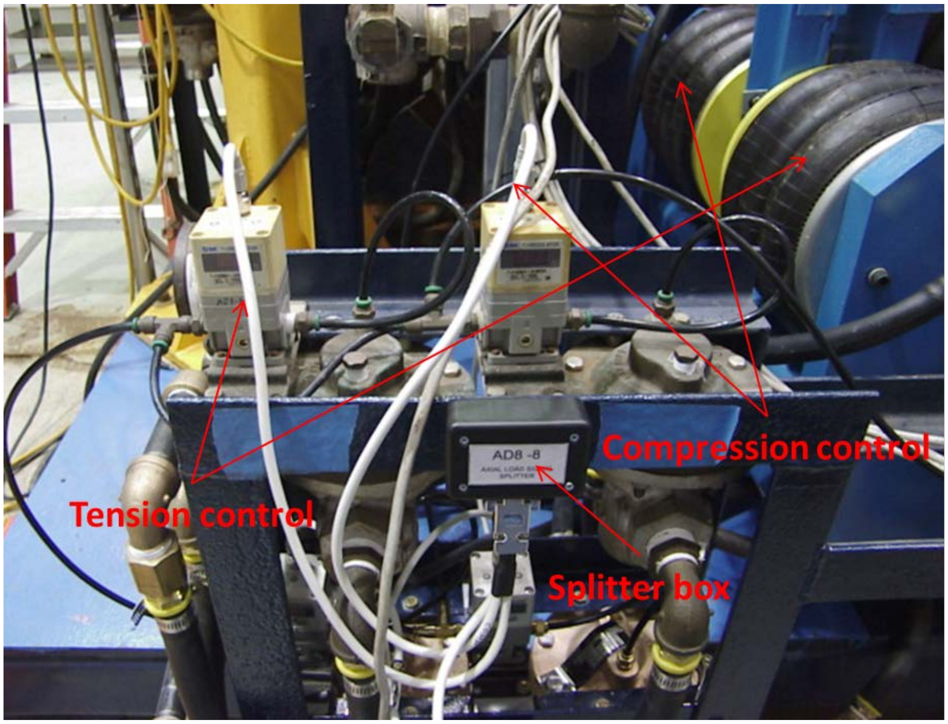


Figure 13. Photo of Axial Load Assembly Configuration with Splitter Box

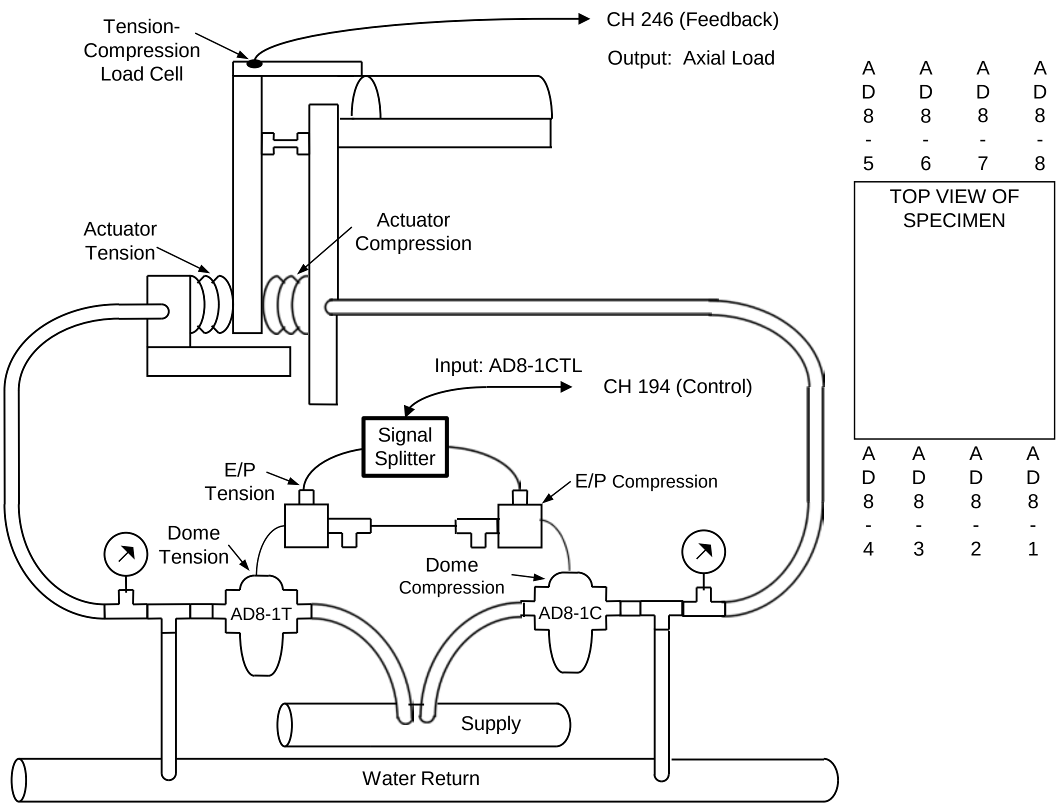


Figure 14. Axial load servo loop using water

Graphic User Interface

The graphic programming language, Agilent -Visual Engineering Environment (VEE) was used to develop the graphical user interface (GUI) for the control and DAQ system. The Agilent-VEE software is designed for use with the VXI-based instrumentation. It can access and load any driver for standard VXI instrument cards. The driver then provides a procedural interface to the instrument for programmatic control. The user-friendly GUI of HP-VEE allows a user to efficiently develop code necessary for controlling instruments, acquiring data, display data in real-time, analyze and reduce data in real time or store data to buffers and files for posttest analysis and data reduction. A graphical interface program developed using HP-VEE allows the operator to control the loads, speed, and type of test desired as shown, for example, in **Figure 15**. Data acquisition from strain transducers, load transducers, pressure transducers, etc., are displayed on color monitors in real time and stored for off-line analysis. The splitter box allows the addition of axial tension and compression without increasing the control channels, and also allows user to input negative numbers for axial compression loads for both static and fatigue tests without changing the GUI.

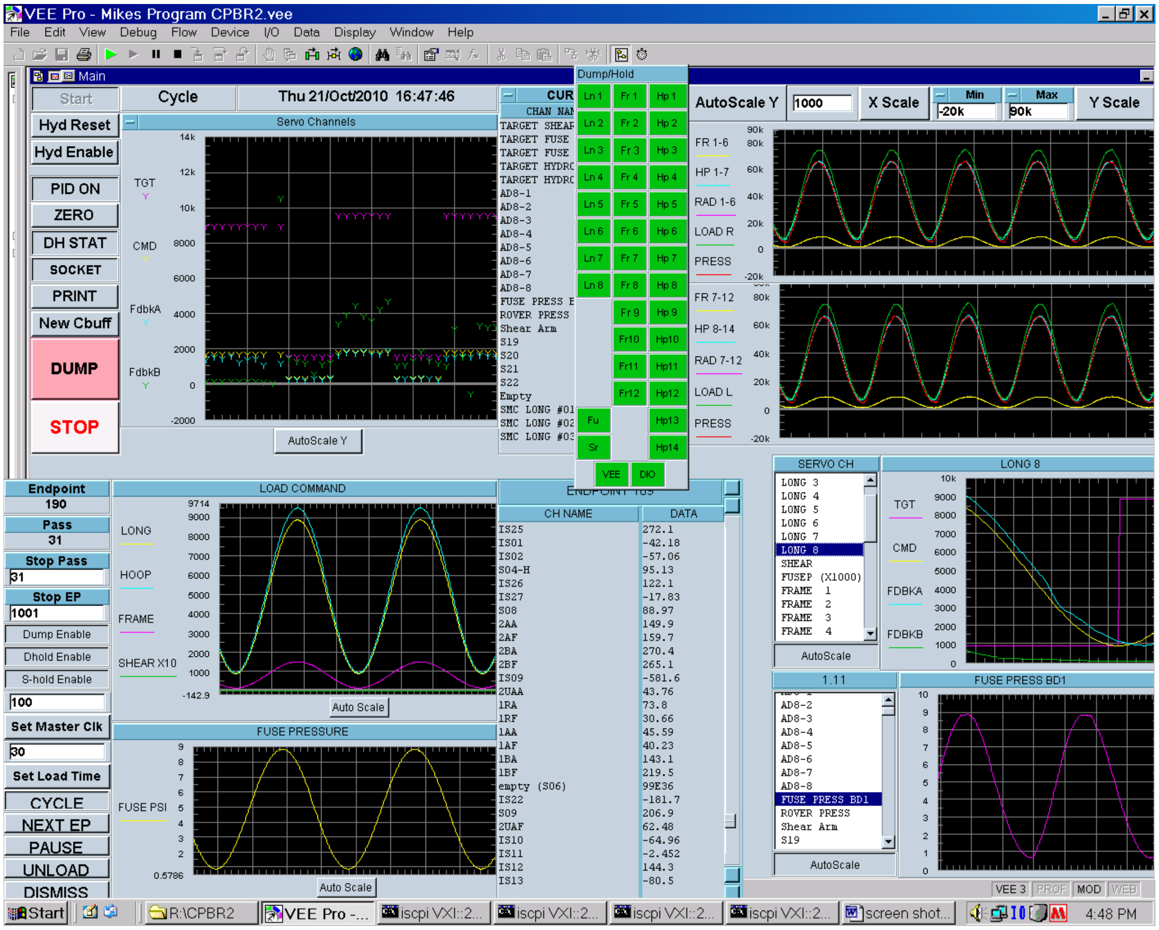


Figure 15. Photograph of the FASTER GUI

ACCEPTANCE TEST

An acceptance test where the axial loading mechanism was loaded to 100% capacity (25,000 lb) using a calibration panel was conducted to verify the system functioned properly.

The calibration panel was made of a 0.375 inch thick 2024-T3 Aluminum by the Rose Corporation per engineering drawing as shown in Figure 16.

The test setup and strain gages locations are shown in Figure 18, 19, 20 and 21. A total of 33 strain gages were installed on the calibration panel, including 19 external skin gages, 8 internal skin strain gages, and 6 strain gages on frames between BS 640 and BS 700.

Six tests were performed, as shown in Table 2. Axial load performances are shown in Figure 21. and Figure 22. Both static tension and static compression tests were conducted at 10% load increments. Performance during the loading was satisfactory with the feedback from load cell closely following the command up to the maximum load.

Some of the acceptance test results are shown in Figure 23 and Figure 24. The strain rate was linear up to maximum load. Load was distributed uniformly across the test section areas.

Table 2 Acceptance Test Data Sheet

Test Sequence	Description	Panel Pressure (psi)	Longitudinal Load (lb)	Pass	Fail
1	Static Tension	0	0 to 25,000	√	
2	Static Compression	0	0 to -25,000	√	
3	Dura Tension	0	2,000 to 20,000	√	
4	Dura Compression	0	-2,000 to -25,000	√	
5	Dura Tension/Compression	8.0	+20,000 to -20,000	√	
6	Dura Ten/Compression	0	+20,000 to -20,000	√	

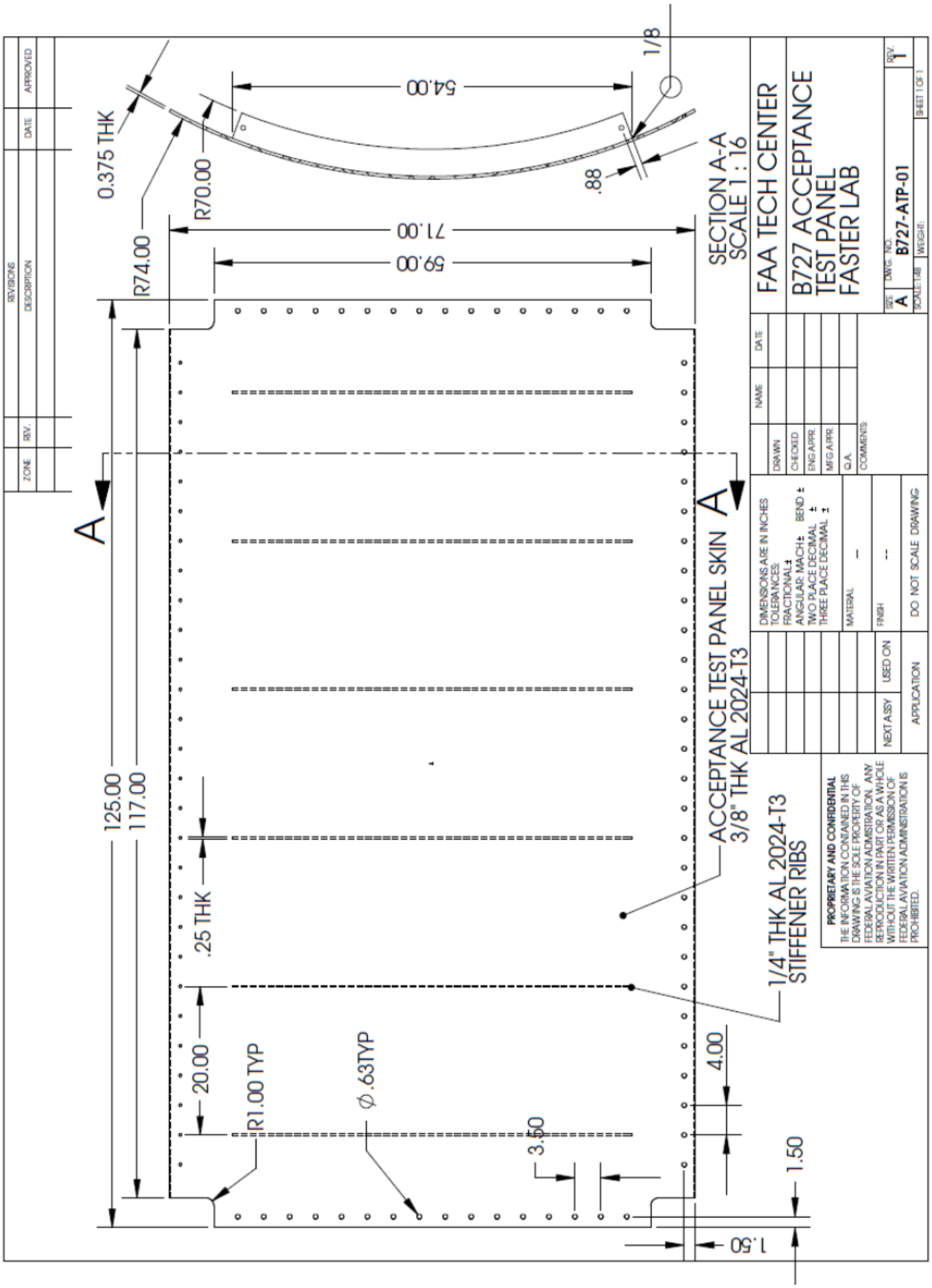


Figure 16. Acceptance Test Panel Engineering Drawing

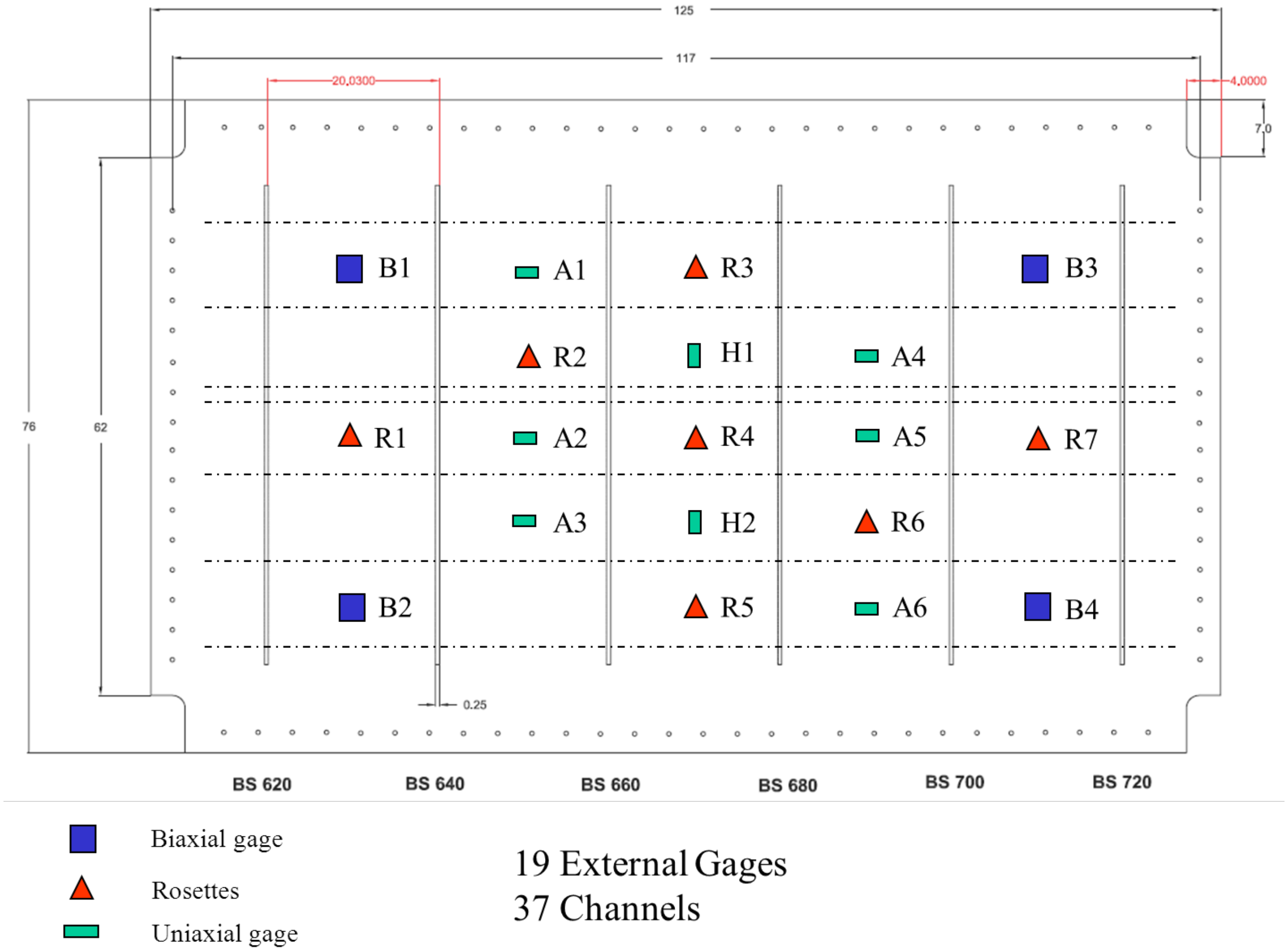


Figure 17. Acceptance Test Setup – External Strain Gages

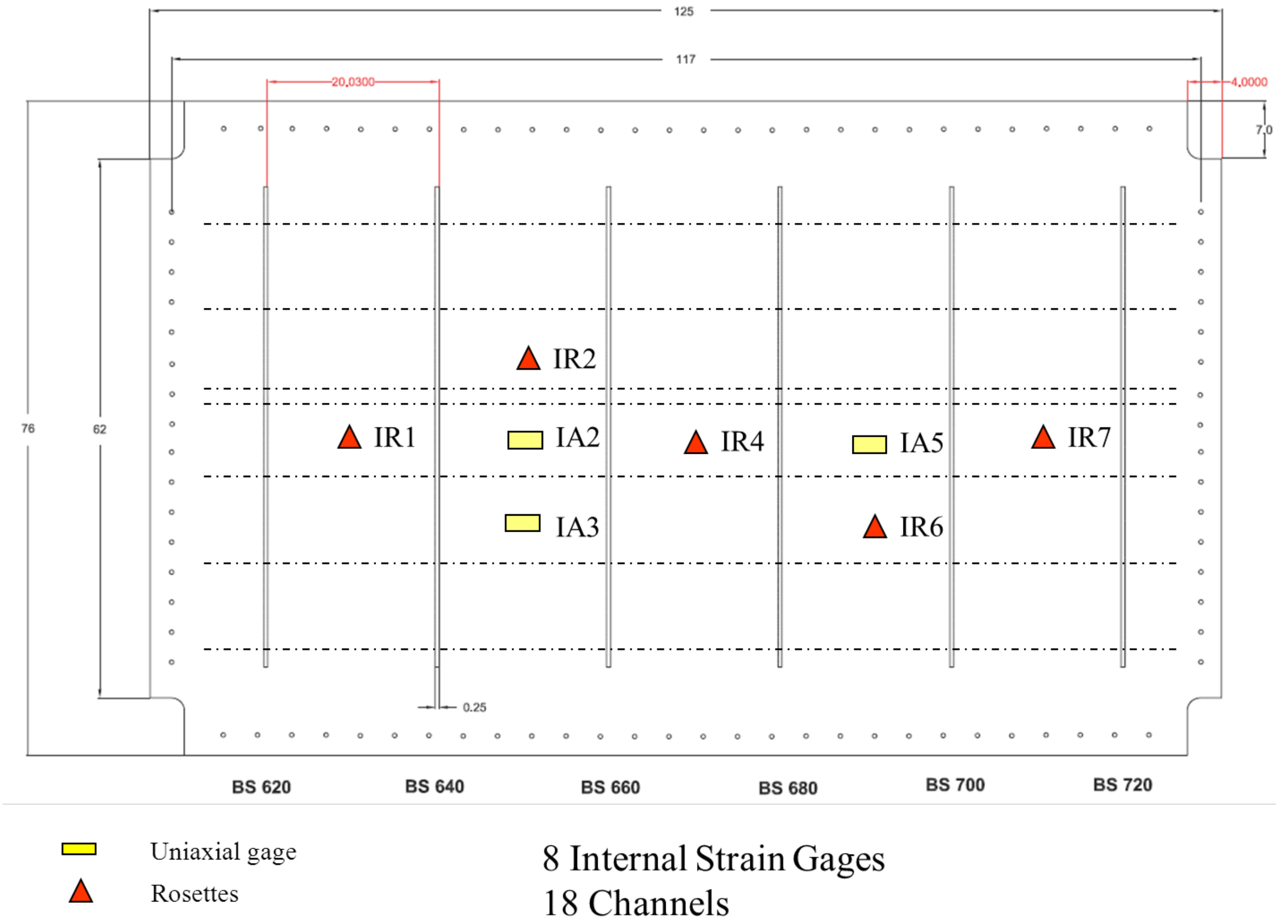


Figure 18. Acceptance Test Setup – Internal Stain Gages

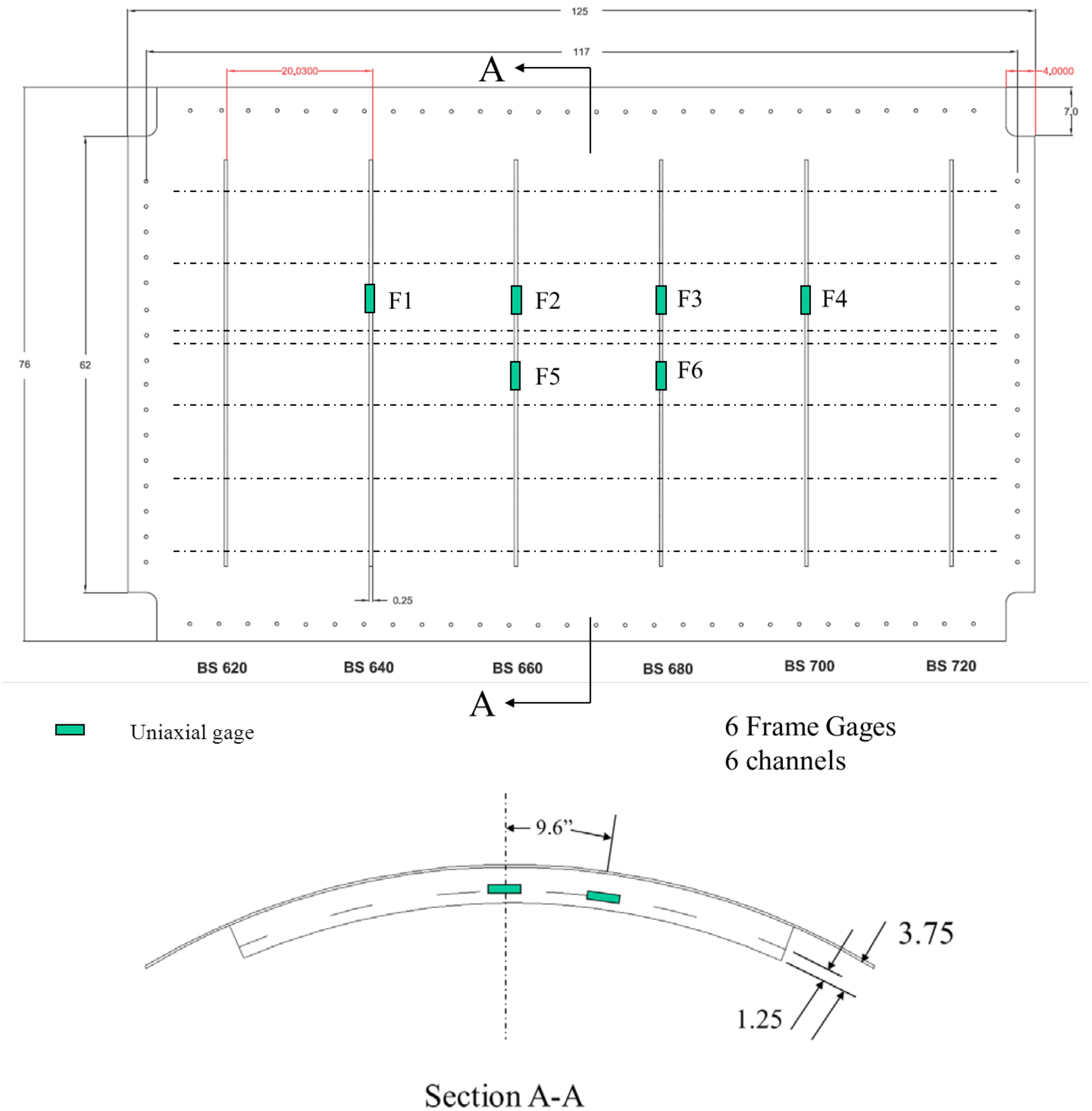


Figure 19. Acceptance Test Setup – Frame Strain Gages

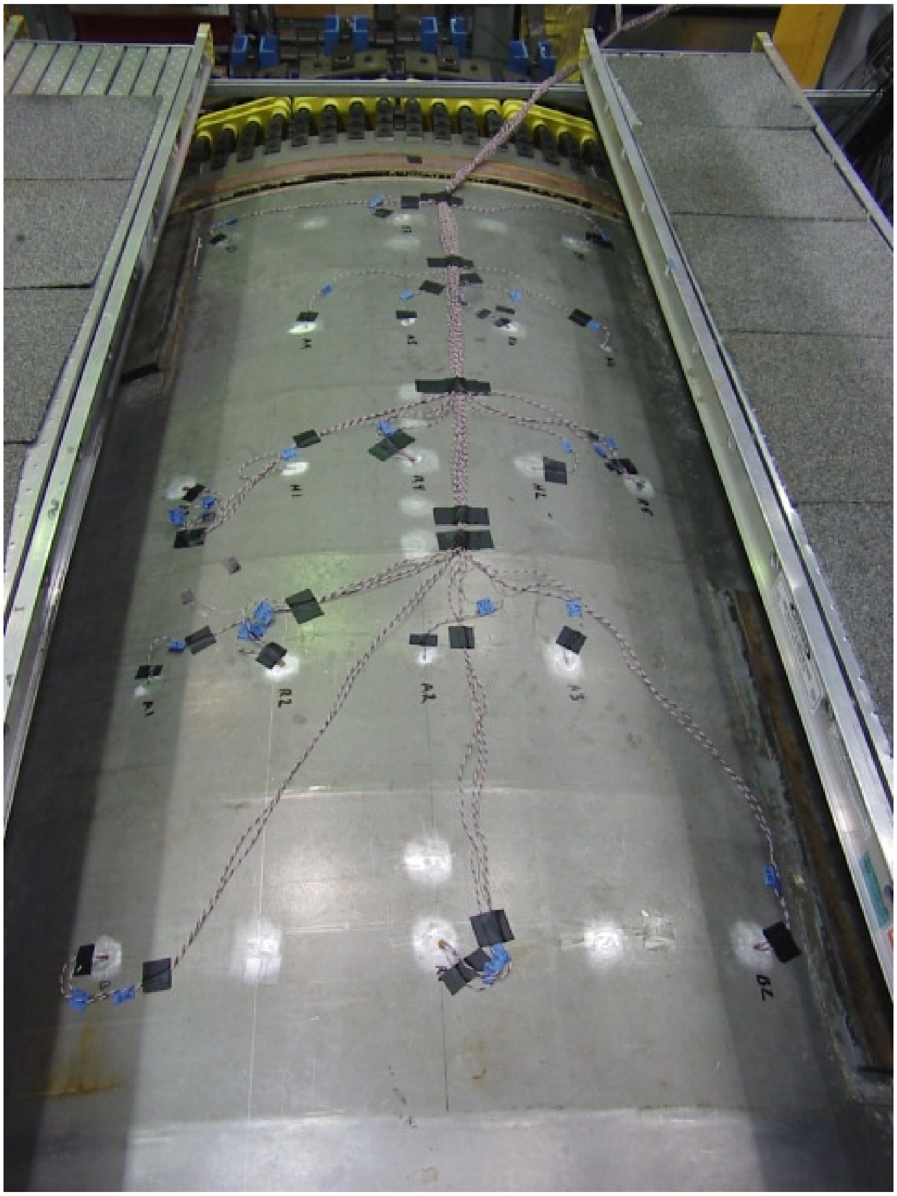


Figure 20. Photo of Acceptance Test Setup

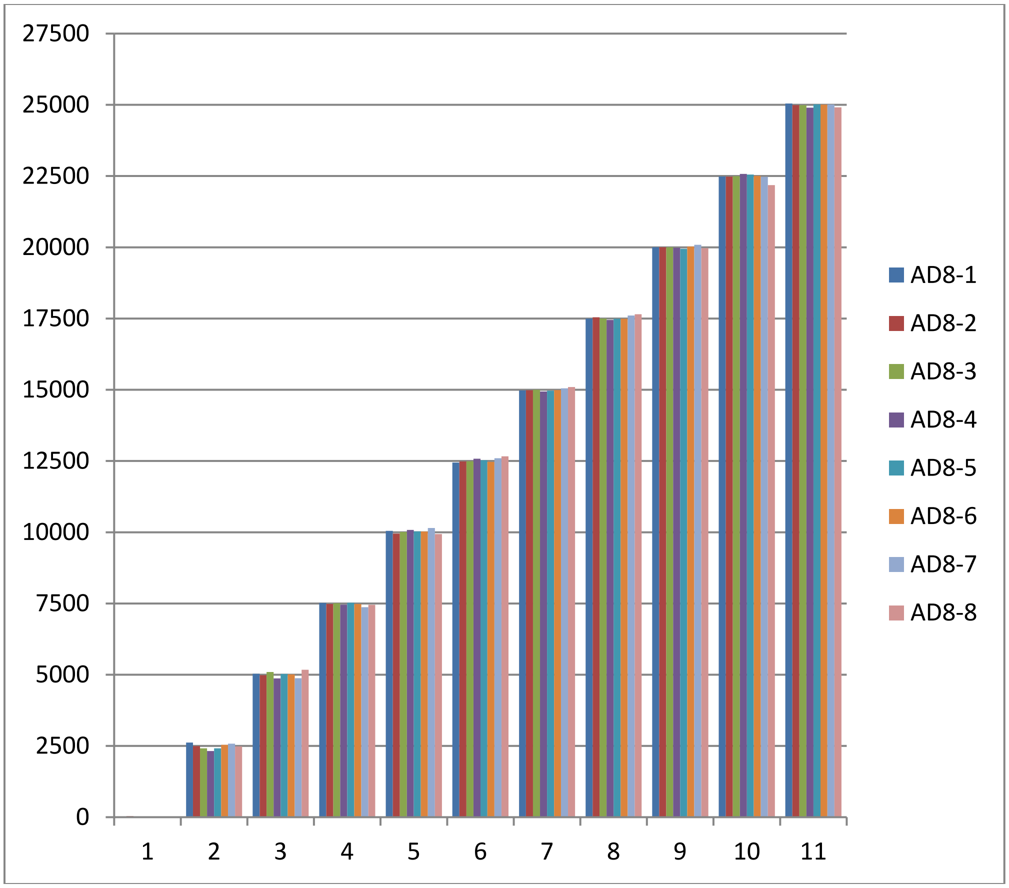


Figure 21. Static Axial Tension Load Performance

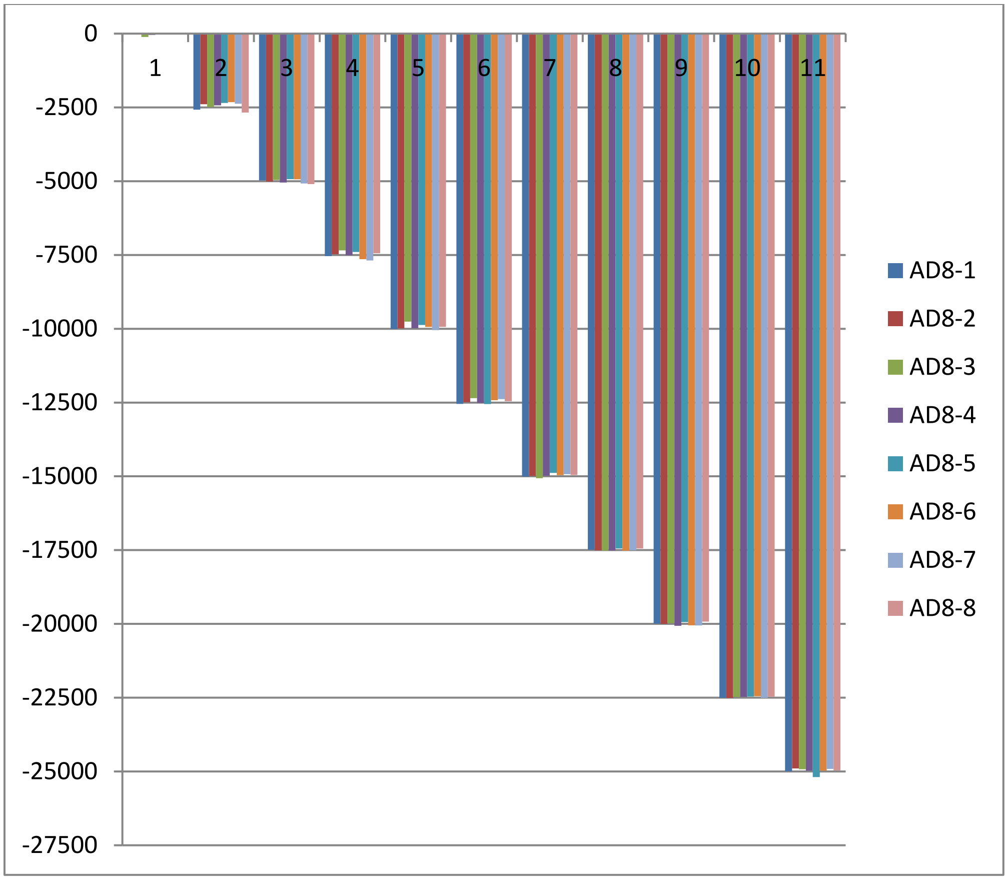


Figure 22. Static Axial Compression Load Performance

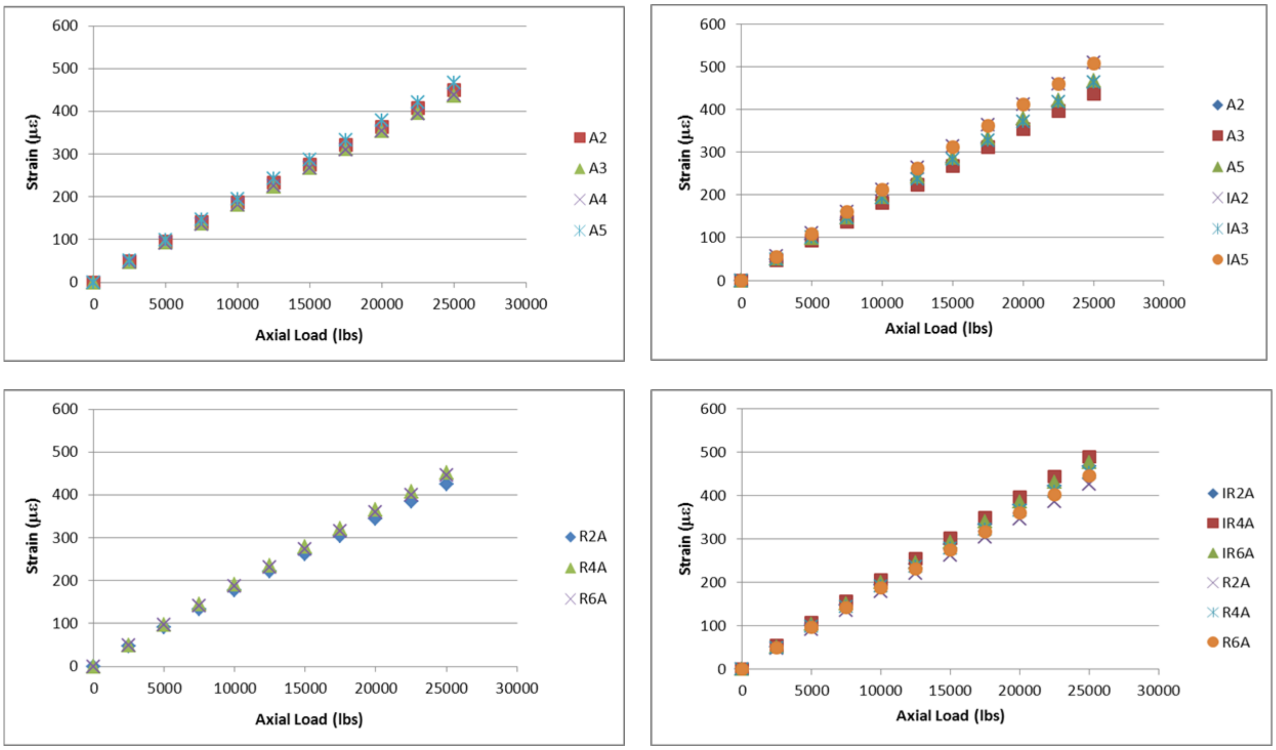


Figure 23. Static Tension Test Results

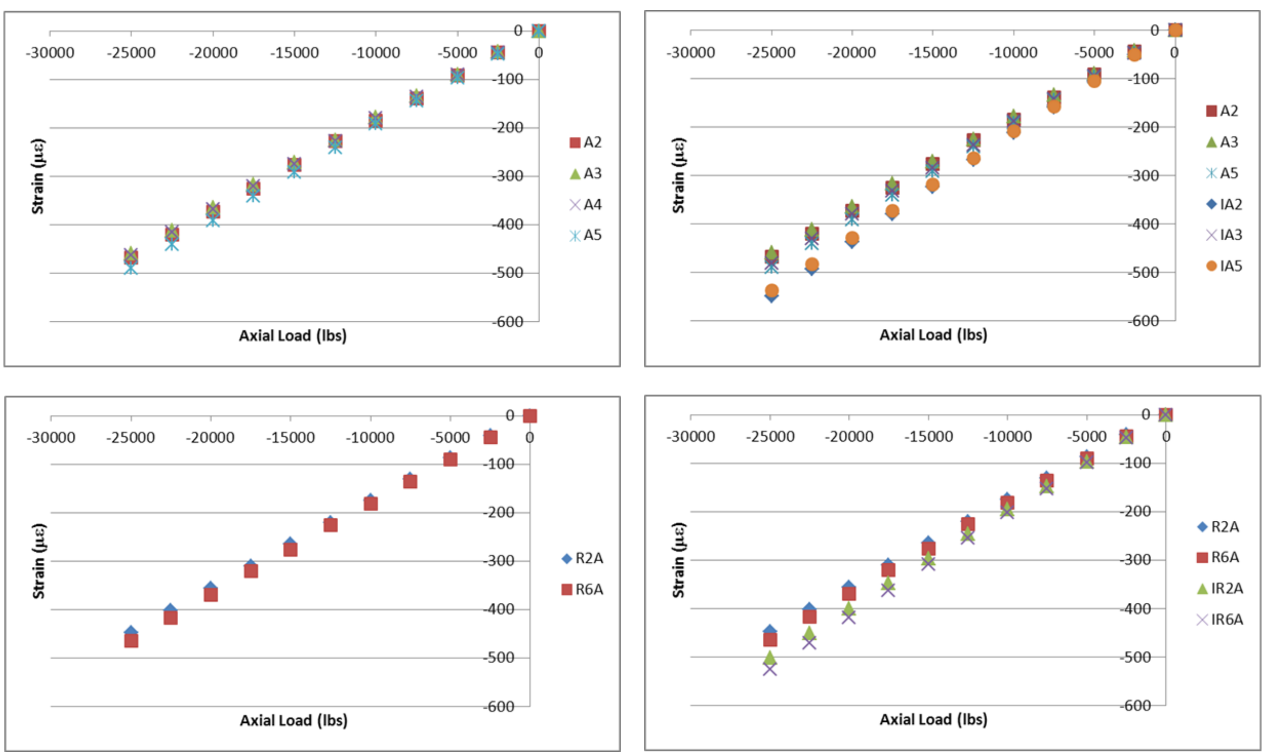
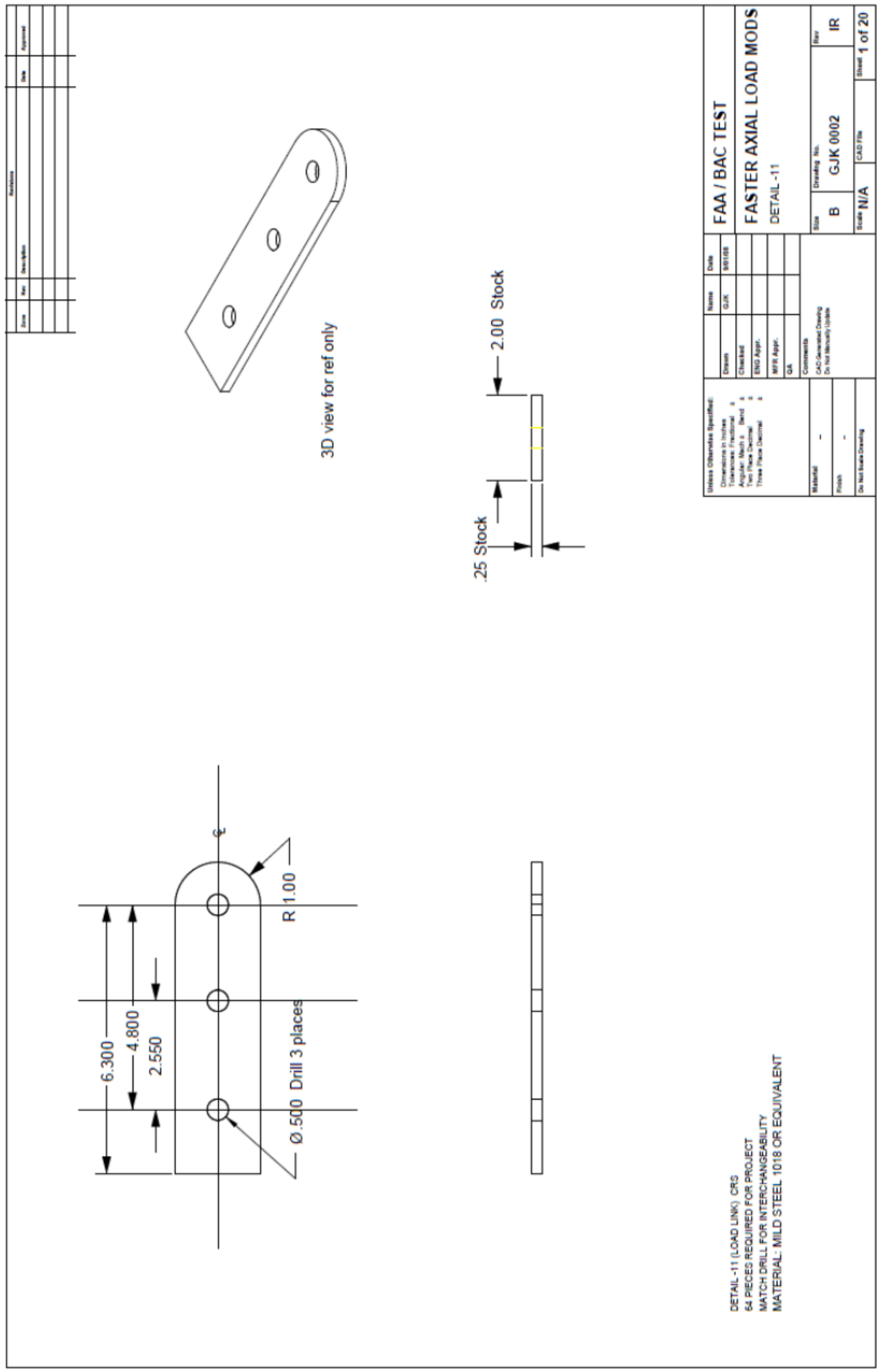


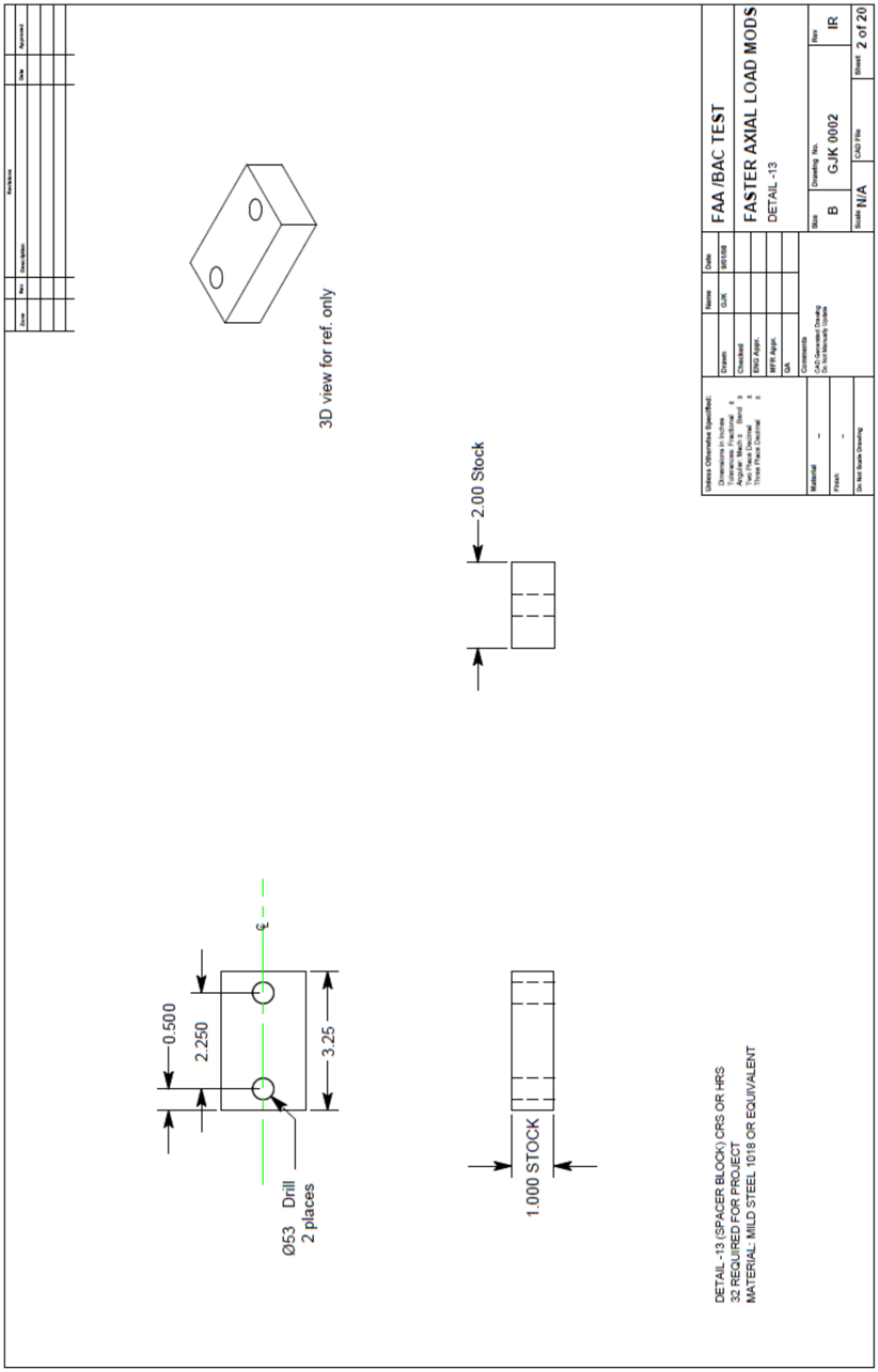
Figure 24. Static Compression Test Results

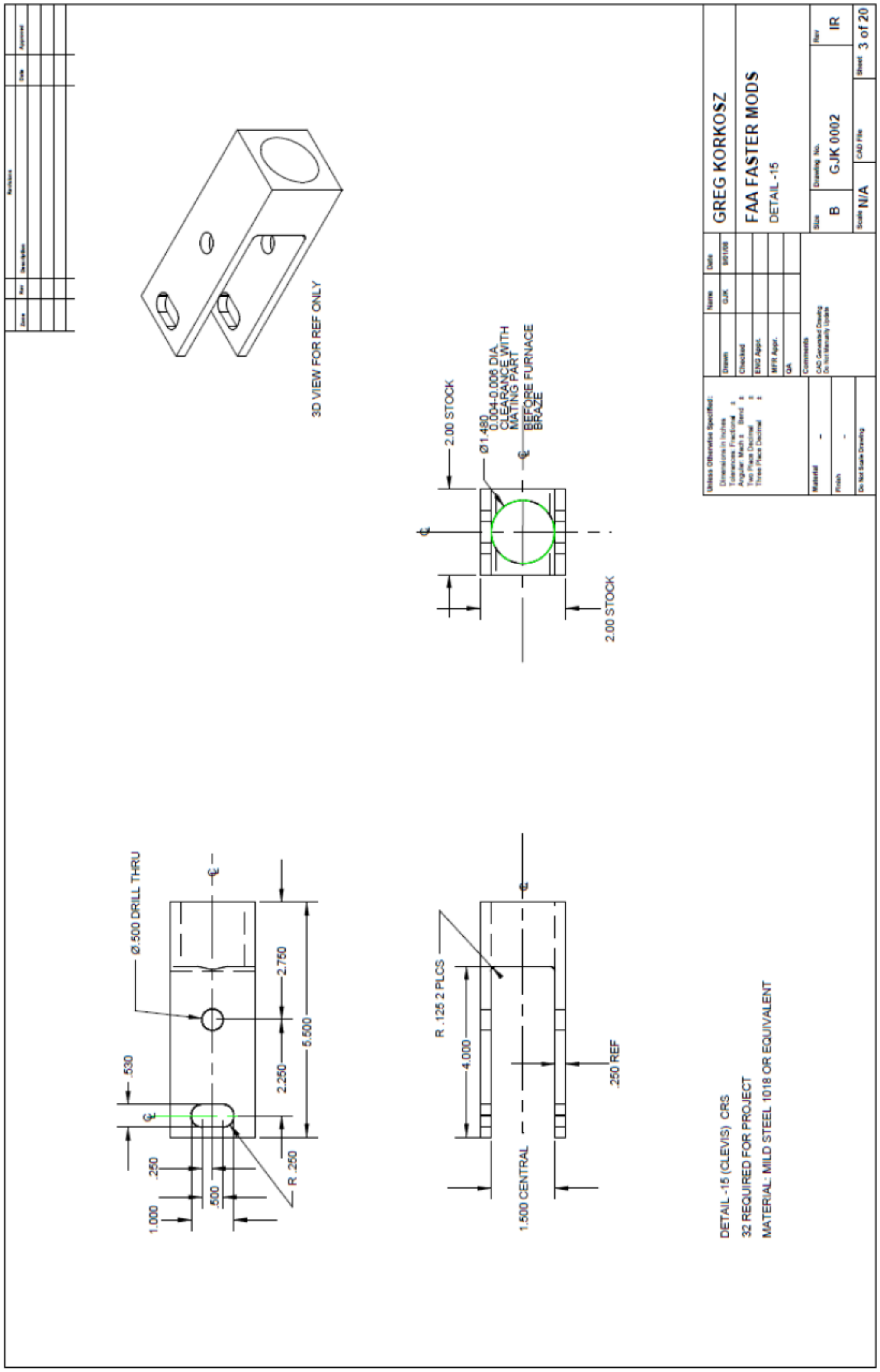
REFERENCES

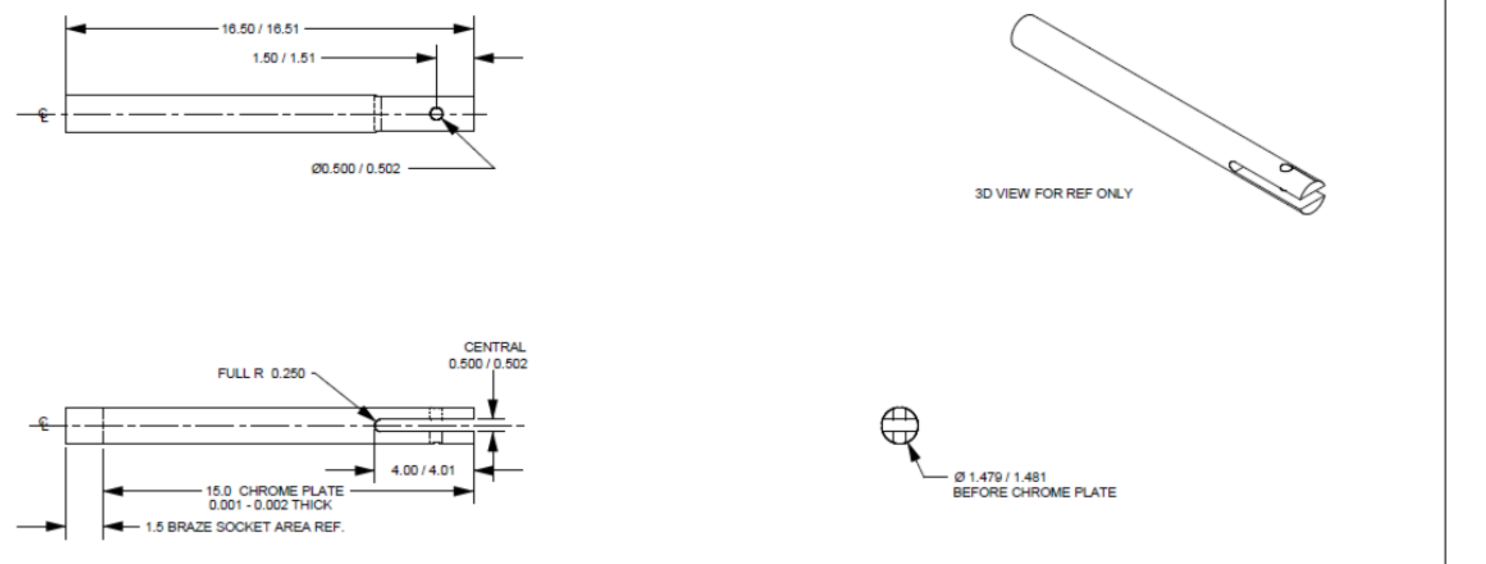
1. Bakuckas, J. G., “Full-Scale Testing and Analysis of Fuselage Structure Containing Multiple Cracks”, DOT/FAA/AR-01/46, July 2002

APPENDIX A: ENGINEERING DRAWINGS FOR AXIAL LOAD MECHANISMS




0.500
2.250
Ø53 Drill
2 places
3.25
1.000 STOCK
2.00 Stock
3D view for ref. only
DETAIL -13 (SPACER BLOCK) CRS OR HRS
32 REQUIRED FOR PROJECT
MATERIAL: MILD STEEL 1018 OR EQUIVALENT
FAA /BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -13
Drawn GJK 9/01/08
Size B
Drawing No. GJK 0002
Rev IR
Scale N/A
Sheet 2 of 20


GREG KORKOSZ
FAA FASTER MODS
DETAIL -15
B
GJK 0002
IR
N/A
3 of 20
3D VIEW FOR REF ONLY
2.00 STOCK
Ø1.480
0.004-0.006 DIA.
CLEARANCE WITH
MATING PART
BEFORE FURNACE
BRAZE
2.00 STOCK
Ø.500 DRILL THRU
.530
2.750
2.250
5.500
R .250
.250
.500
1.000
R .125 2 PLCS
4.000
.250 REF
1.500 CENTRAL
DETAIL -15 (CLEVIS) CRS
32 REQUIRED FOR PROJECT
MATERIAL: MILD STEEL 1018 OR EQUIVALENT



DETAIL -17 (PUSH ROD) MAKE FROM STOCK

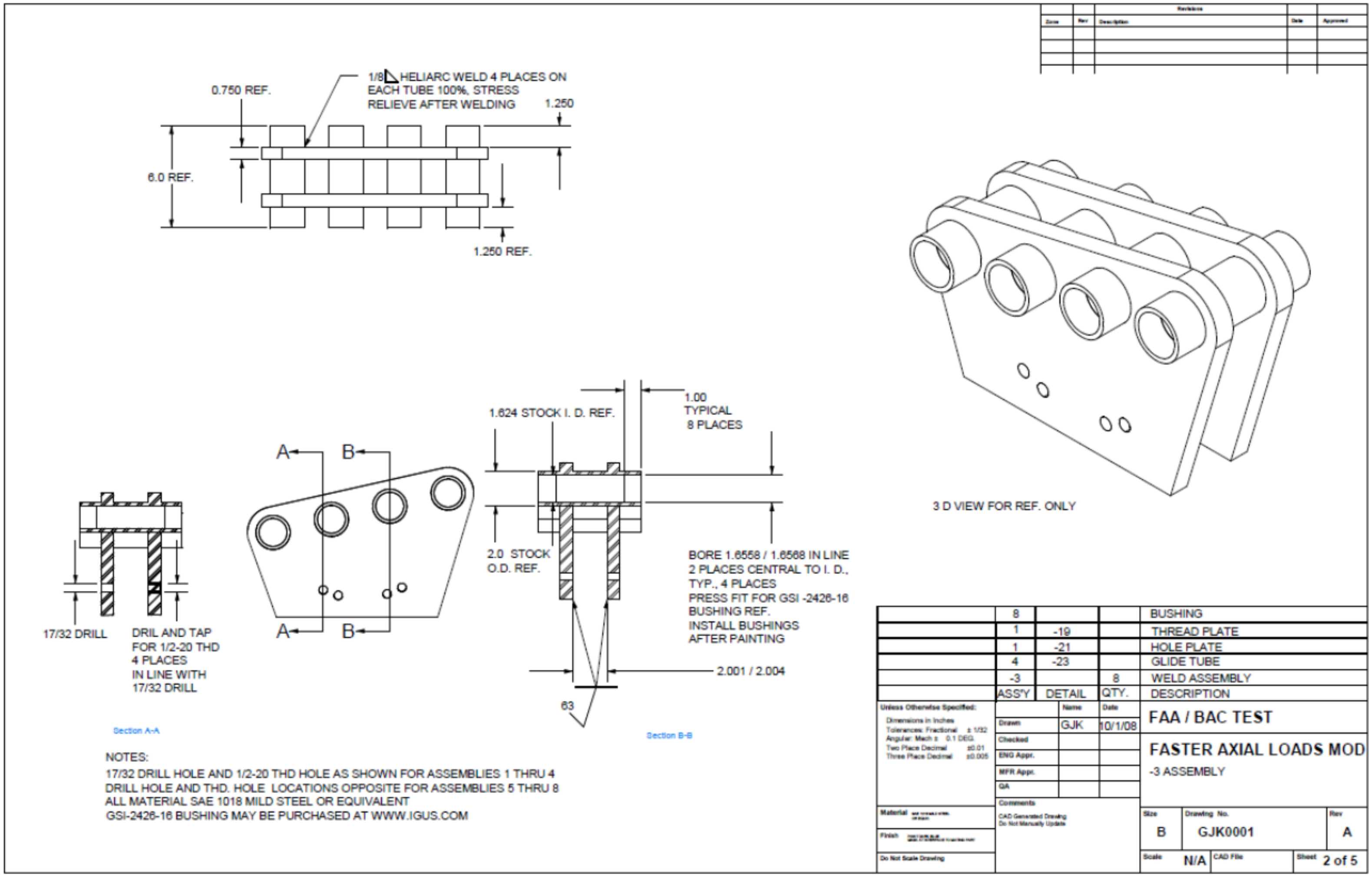
STEEL DRILL ROD

32 REQUIRED FOR PROJECT

IMBRITTLEMENT RELIEVE (BAKE) AFTER PLATING

POLISH CHROME PLATED AREA O. D.

Unless Otherwise Specified:		Name	Date	
Dimensions in Inches Tolerances: Fractional ± Angular: Mach ± Bend ± Two Place Decimal ± Three Place Decimal ±	Drawn	GJK	9/01/08	FAA / BAC TEST
	Checked			FASTER AXIAL LOAD MODS
	ENG Appr.			DETAIL -17
	MFR Appr.			
	QA			
Material –	Comments: CAD Generated Drawing Do Not Manually Update			Size B · Drawing No. GJK 0002 · Rev IR
Finish –				
Do Not Scale Drawing				Scale N/A · CAD File · Sheet 4 of 20


1/8 HELIARC WELD 4 PLACES ON EACH TUBE 100%, STRESS RELIEVE AFTER WELDING
0.750 REF.
1.250
6.0 REF.
1.250 REF.
3 D VIEW FOR REF. ONLY
A
B
17/32 DRILL
DRIL AND TAP FOR 1/2-20 THD 4 PLACES IN LINE WITH 17/32 DRILL
Section A-A
1.624 STOCK I. D. REF.
1.00 TYPICAL 8 PLACES
2.0 STOCK O.D. REF.
BORE 1.6558 / 1.6568 IN LINE 2 PLACES CENTRAL TO I. D., TYP., 4 PLACES PRESS FIT FOR GSI -2426-16 BUSHING REF. INSTALL BUSHINGS AFTER PAINTING
2.001 / 2.004
63
Section B-B
NOTES:
17/32 DRILL HOLE AND 1/2-20 THD HOLE AS SHOWN FOR ASSEMBLIES 1 THRU 4
DRILL HOLE AND THD. HOLE LOCATIONS OPPOSITE FOR ASSEMBLIES 5 THRU 8
ALL MATERIAL SAE 1018 MILD STEEL OR EQUIVALENT
GSI-2426-16 BUSHING MAY BE PURCHASED AT WWW.IGUS.COM
Revisions
Zone
Rev
Description
Date
Approved
8 | | | BUSHING
1 | -19 | | THREAD PLATE
1 | -21 | | HOLE PLATE
4 | -23 | | GLIDE TUBE
-3 | | 8 | WELD ASSEMBLY
ASS'Y | DETAIL | QTY. | DESCRIPTION
Unless Otherwise Specified:
Name
Date
Drawn
GJK
10/1/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
Material
Finish
Do Not Scale Drawing
FAA / BAC TEST
FASTER AXIAL LOADS MOD
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Size
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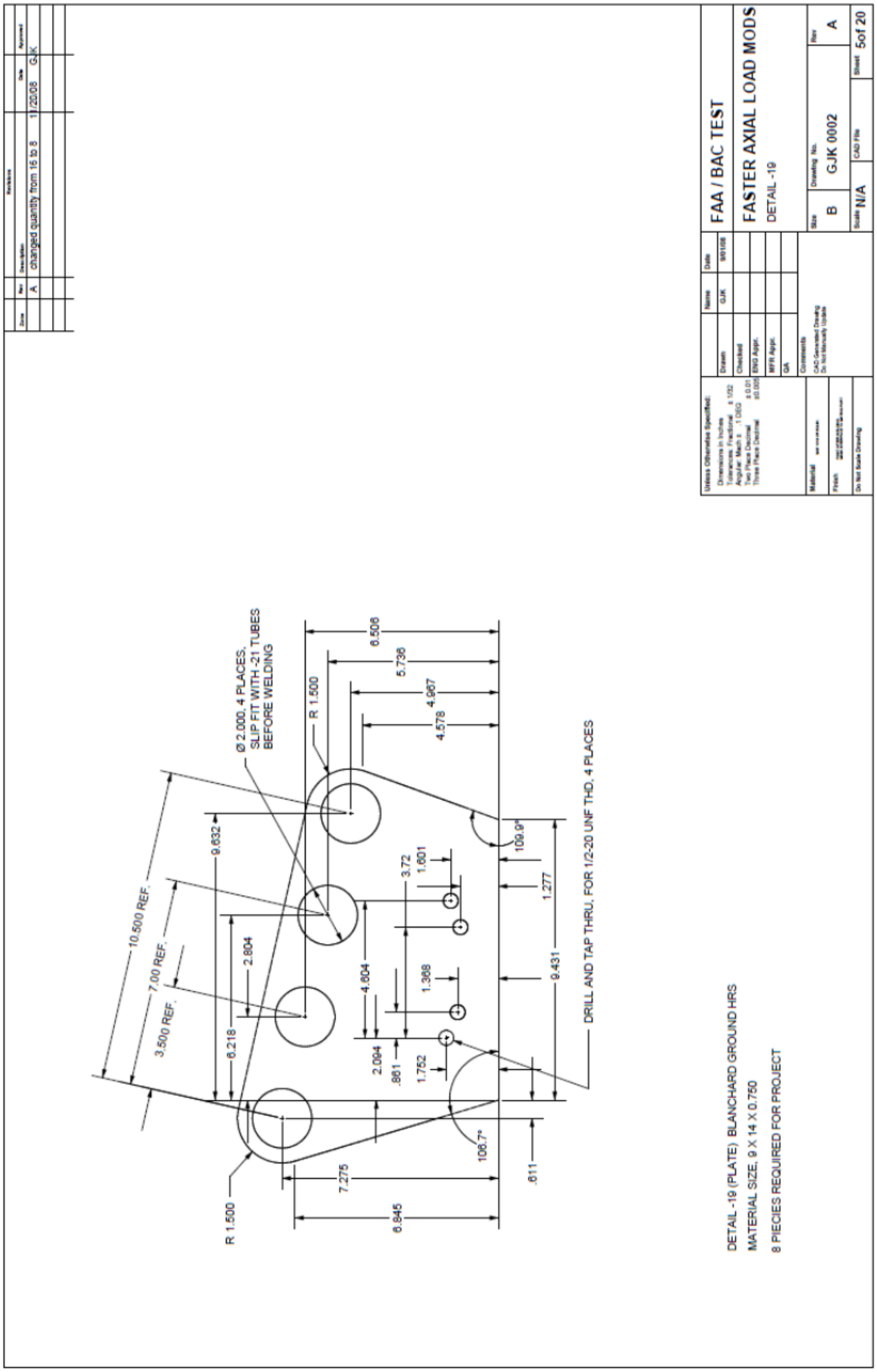
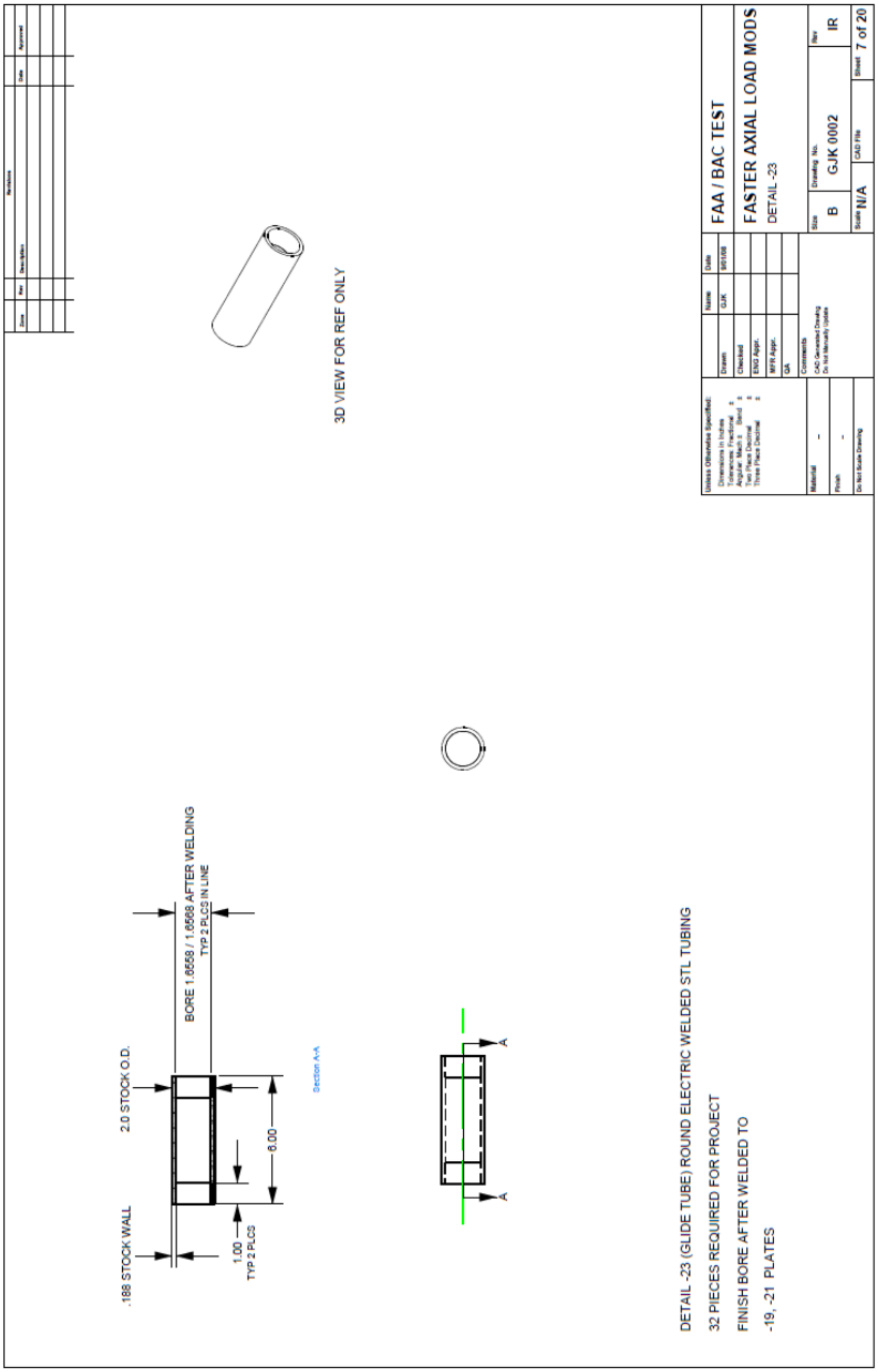
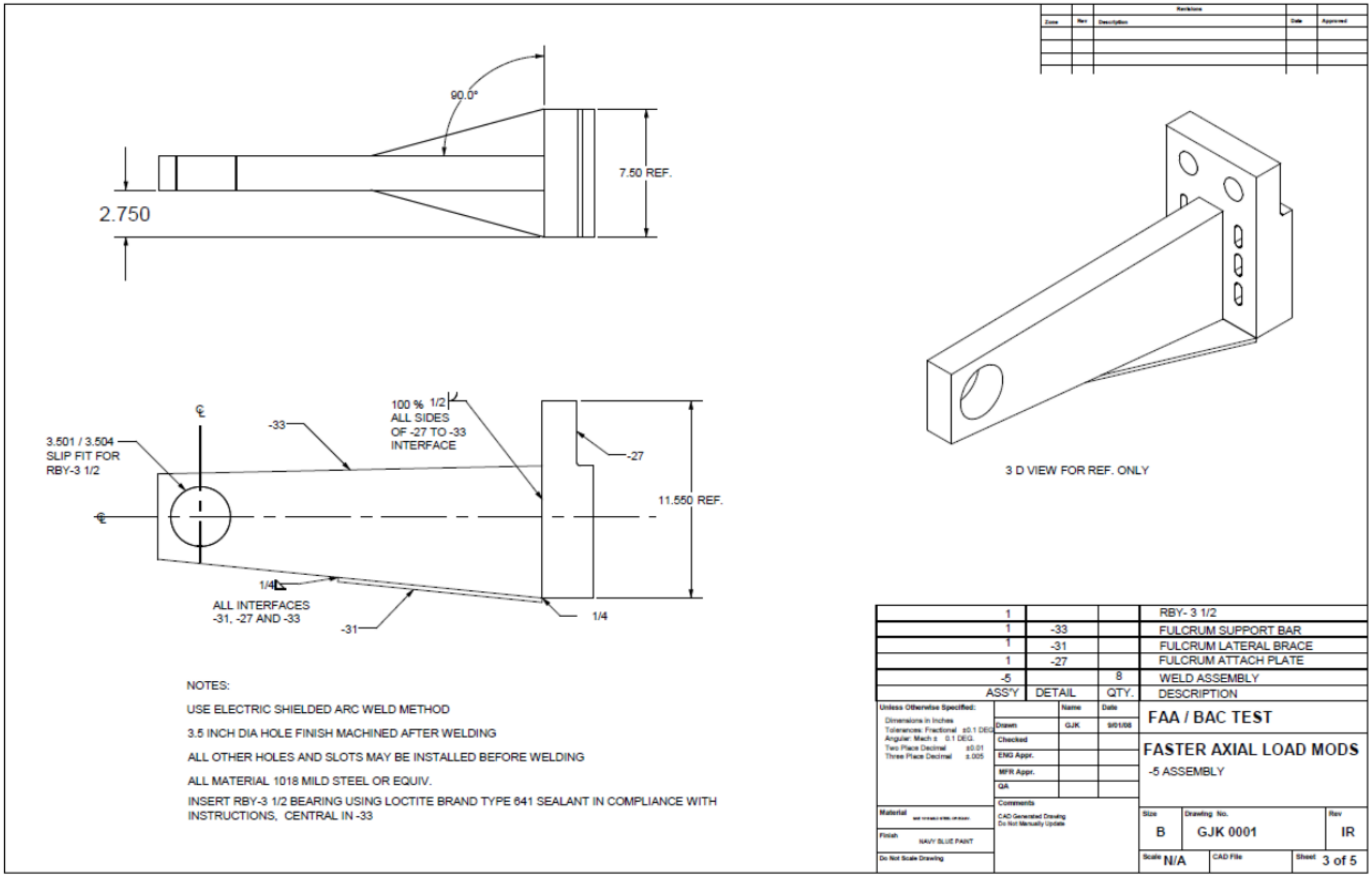
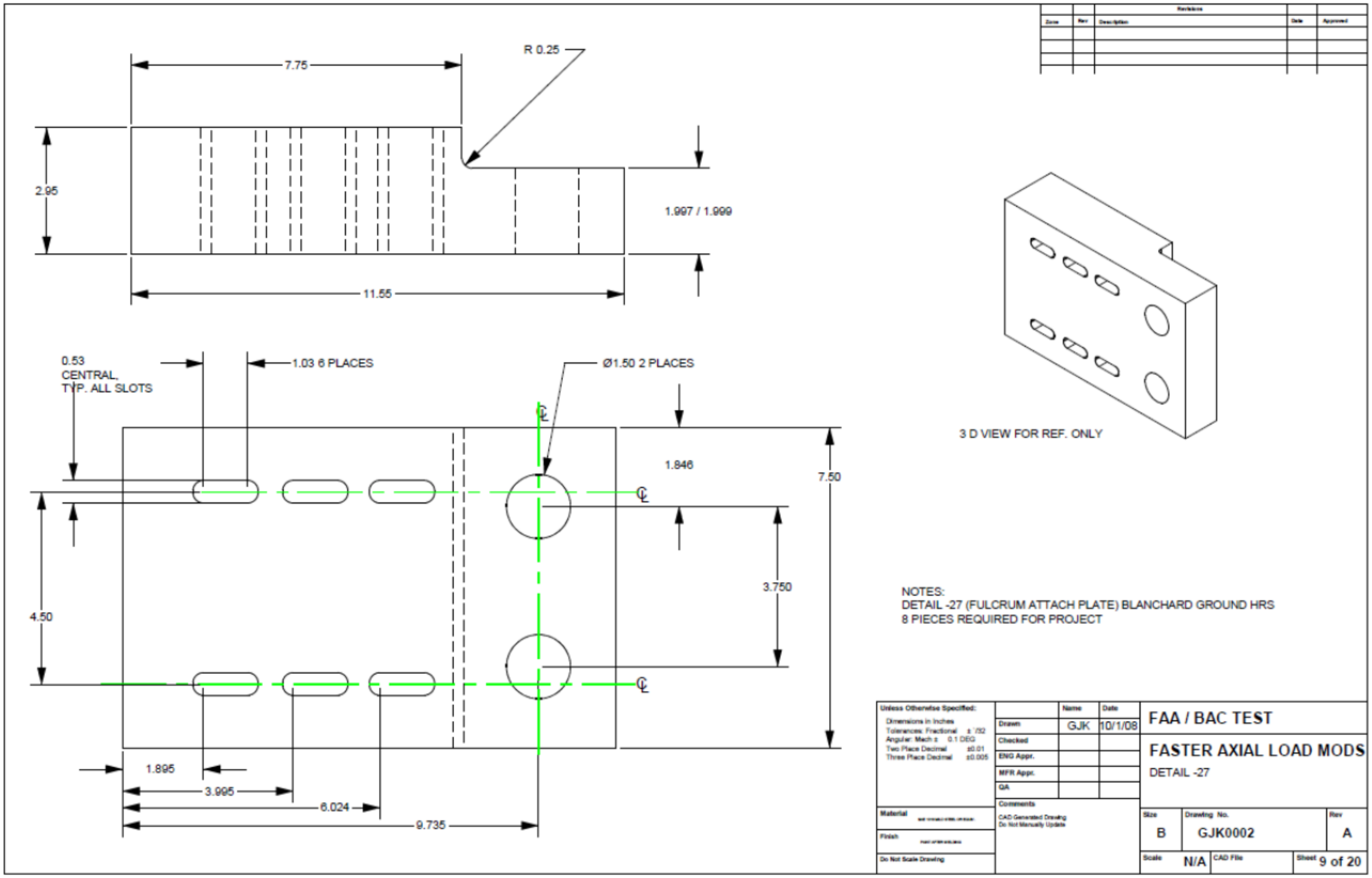
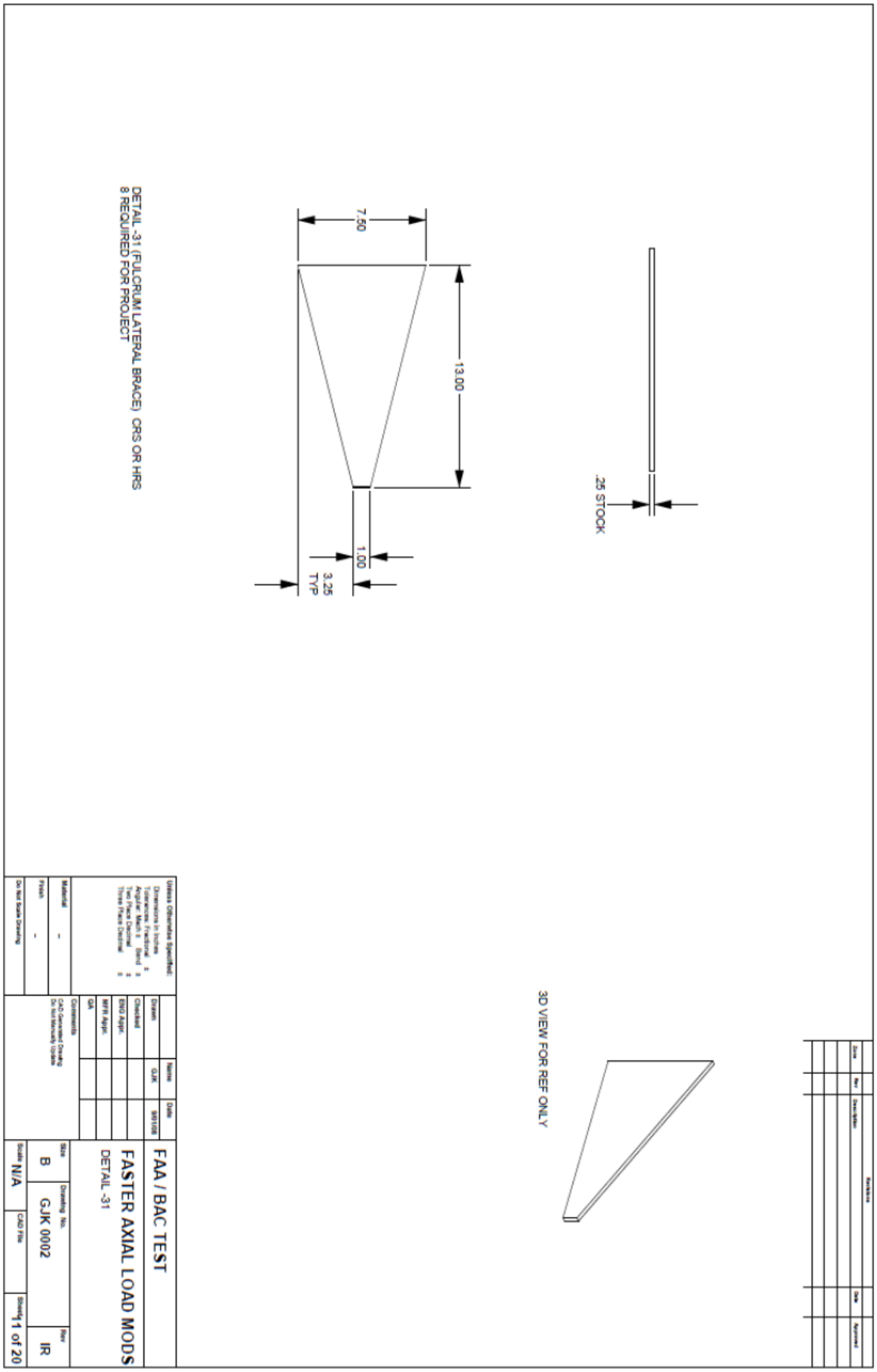


Zone
Rev
Description
Date
Approved
A
changed quantity from 16 to 8
11/20/08
GJK
Ø 2.000, 4 PLACES, SLIP FIT WITH -21 TUBES BEFORE WELDING
R 1.500
10.500 REF.
7.00 REF.
3.500 REF.
9.832
6.218
2.804
4.604
2.094
.861
1.752
1.368
3.72
1.601
6.508
5.736
4.967
4.578
109.9°
1.277
9.431
106.7°
.611
7.275
6.845
R 1.500
DRILL AND TAP THRU, FOR 1/2-20 UNF THD, 4 PLACES
DETAIL -19 (PLATE) BLANCHARD GROUND HRS
MATERIAL SIZE, 9 X 14 X 0.750
8 PIECIES REQUIRED FOR PROJECT
Unless Otherwise Specified:
Drawn
Checked
ENG Appr.
MFR Appr.
QA
Comments
Material
Finish
Do Not Scale Drawing
Name
GJK
Date
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -19
Size
B
Drawing No.
GJK 0002
Rev
A
Scale N/A
CAD File
Sheet
5of 20

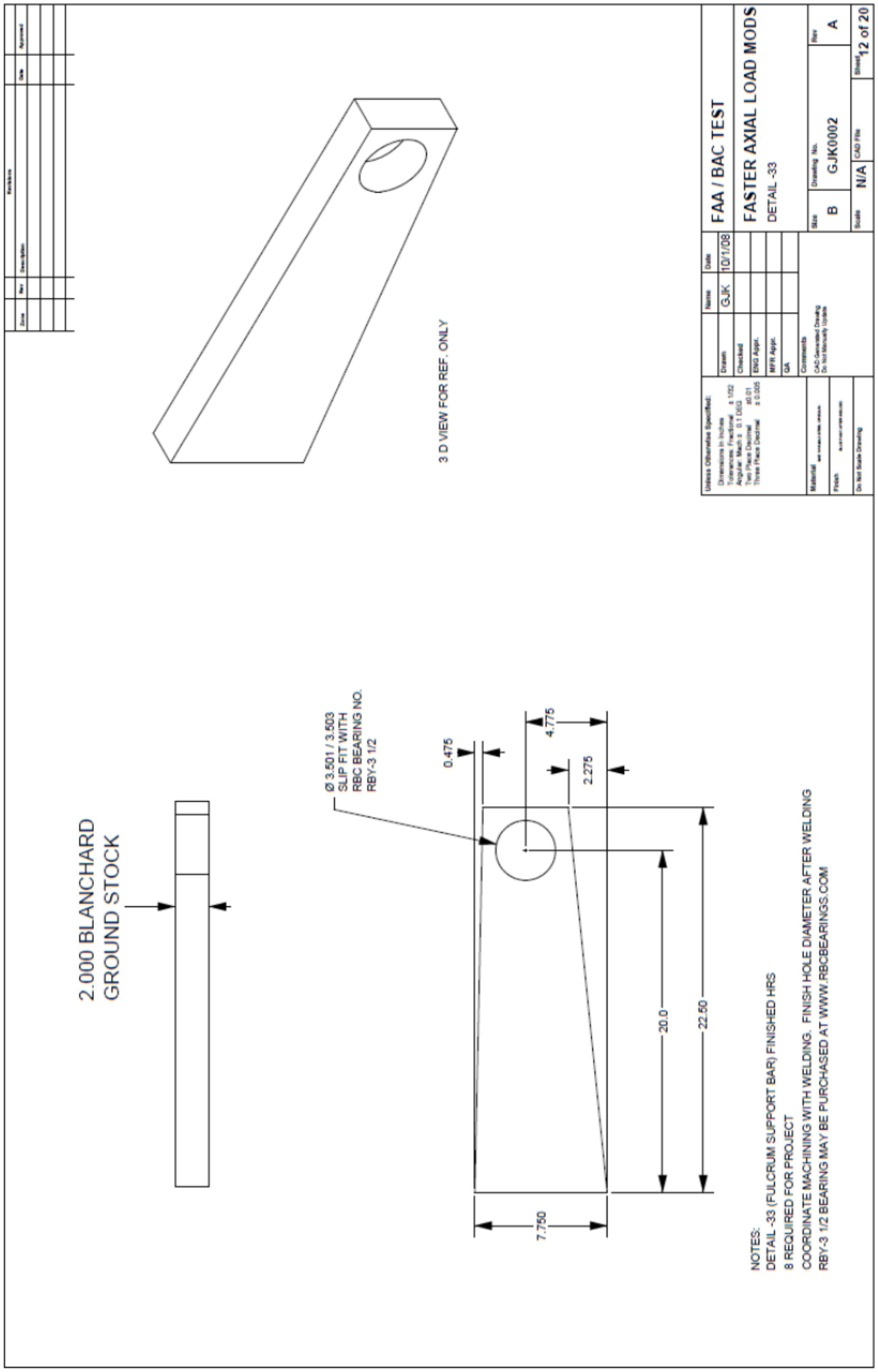

.188 STOCK WALL
2.0 STOCK O.D.
BORE 1.6558 / 1.6568 AFTER WELDING
TYP 2 PLCS IN LINE
1.00
TYP 2 PLCS
6.00
Section A-A
A
A
3D VIEW FOR REF ONLY
DETAIL -23 (GLIDE TUBE) ROUND ELECTRIC WELDED STL TUBING
32 PIECES REQUIRED FOR PROJECT
FINISH BORE AFTER WELDED TO
-19, -21 PLATES
Unless Otherwise Specified:
Dimensions In Inches
Tolerances: Fractional ±
Angular: Mach ± Bend ±
Two Place Decimal ±
Three Place Decimal ±
Material -
Finish -
Do Not Scale Drawing
Name
Date
Drawn
GJK
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -23
Size
B
Drawing No.
GJK 0002
Rev
IR
Scale N/A
CAD File
Sheet 7 of 20

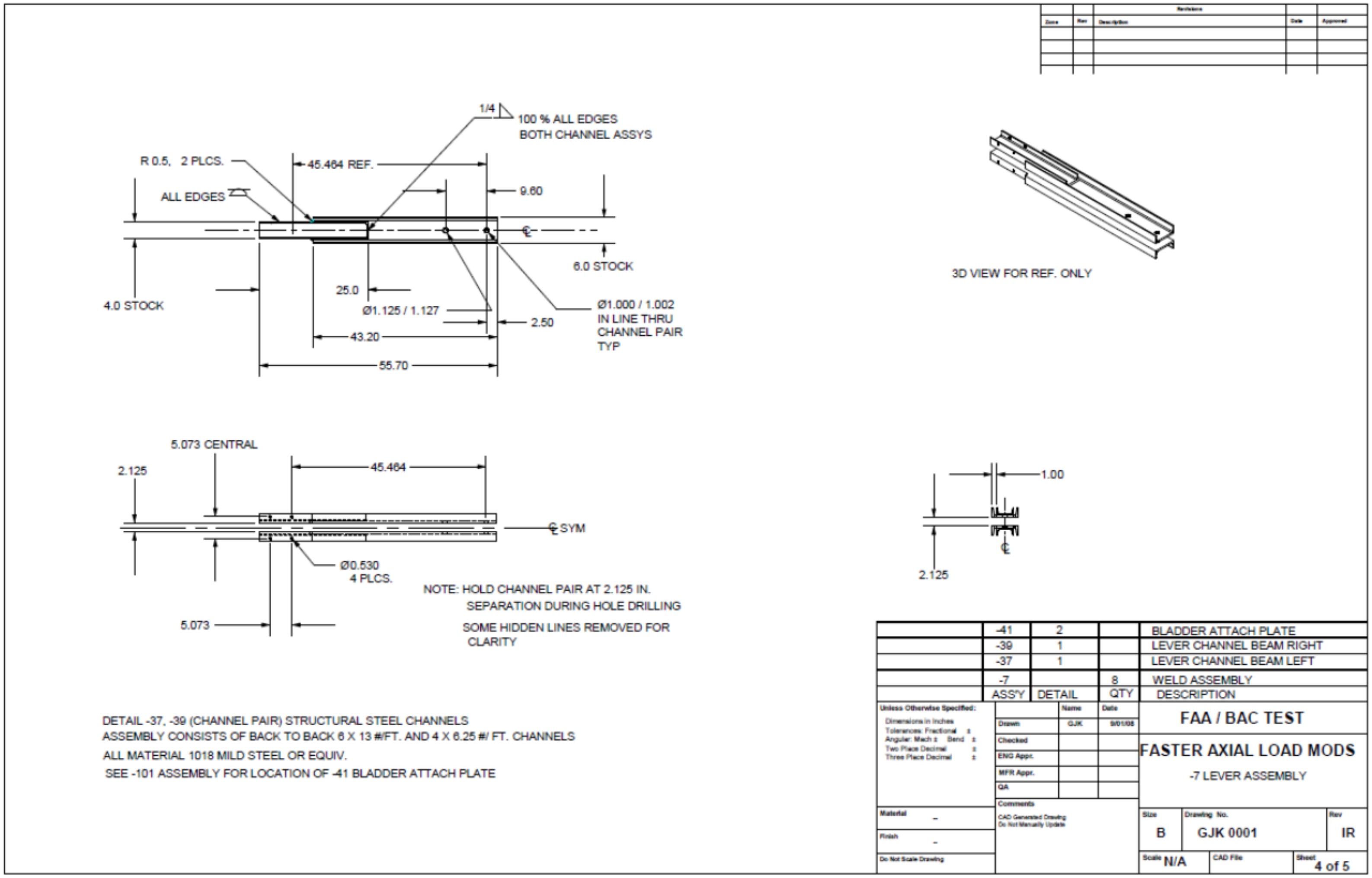

90.0°
7.50 REF.
2.750
3.501 / 3.504
SLIP FIT FOR
RBY-3 1/2
-33
100 % 1/2
ALL SIDES
OF -27 TO -33
INTERFACE
-27
11.550 REF.
1/4
ALL INTERFACES
-31, -27 AND -33
-31
1/4
3 D VIEW FOR REF. ONLY
NOTES:
USE ELECTRIC SHIELDED ARC WELD METHOD
3.5 INCH DIA HOLE FINISH MACHINED AFTER WELDING
ALL OTHER HOLES AND SLOTS MAY BE INSTALLED BEFORE WELDING
ALL MATERIAL 1018 MILD STEEL OR EQUIV.
INSERT RBY-3 1/2 BEARING USING LOCTITE BRAND TYPE 641 SEALANT IN COMPLIANCE WITH INSTRUCTIONS, CENTRAL IN -33
1 RBY- 3 1/2
1 -33 FULCRUM SUPPORT BAR
1 -31 FULCRUM LATERAL BRACE
1 -27 FULCRUM ATTACH PLATE
-5 8 WELD ASSEMBLY
ASS'Y DETAIL QTY. DESCRIPTION
FAA / BAC TEST
FASTER AXIAL LOAD MODS
-5 ASSEMBLY
Drawn GJK 9/01/08
B GJK 0001 IR
N/A
3 of 5
NAVY BLUE PAINT
CAD Generated Drawing
Do Not Manually Update
Do Not Scale Drawing


R 0.25
7.75
2.95
1.997 / 1.999
11.55
0.53
CENTRAL,
TYP. ALL SLOTS
1.03 6 PLACES
Ø1.50 2 PLACES
1.846
7.50
3.750
4.50
1.895
3.995
6.024
9.735
3 D VIEW FOR REF. ONLY
NOTES:
DETAIL -27 (FULCRUM ATTACH PLATE) BLANCHARD GROUND HRS
8 PIECES REQUIRED FOR PROJECT
Unless Otherwise Specified:
Drawn GJK 10/1/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
Material
Finish
Do Not Scale Drawing
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -27
Size B
Drawing No. GJK0002
Rev A
Scale N/A
Sheet 9 of 20

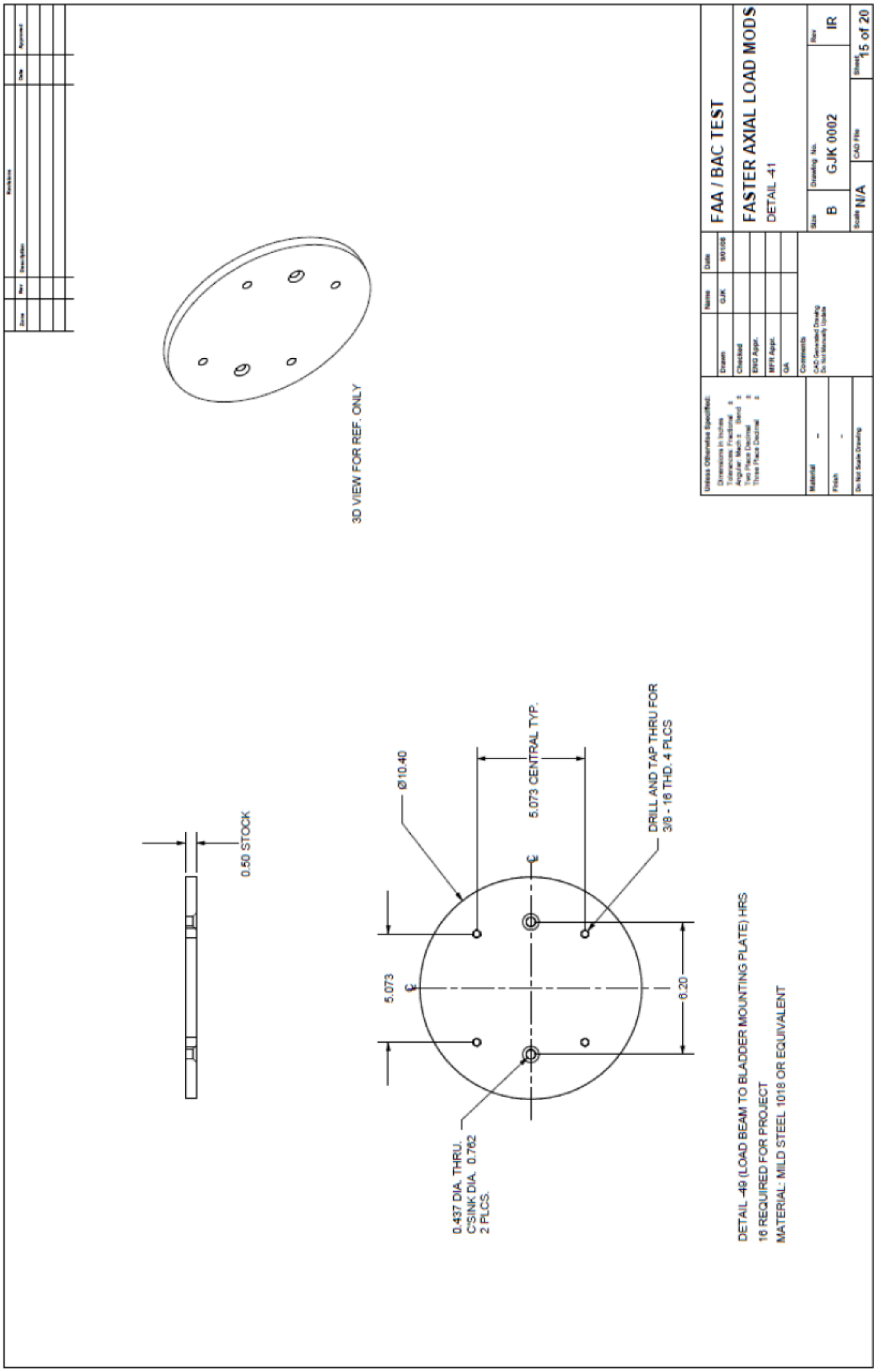


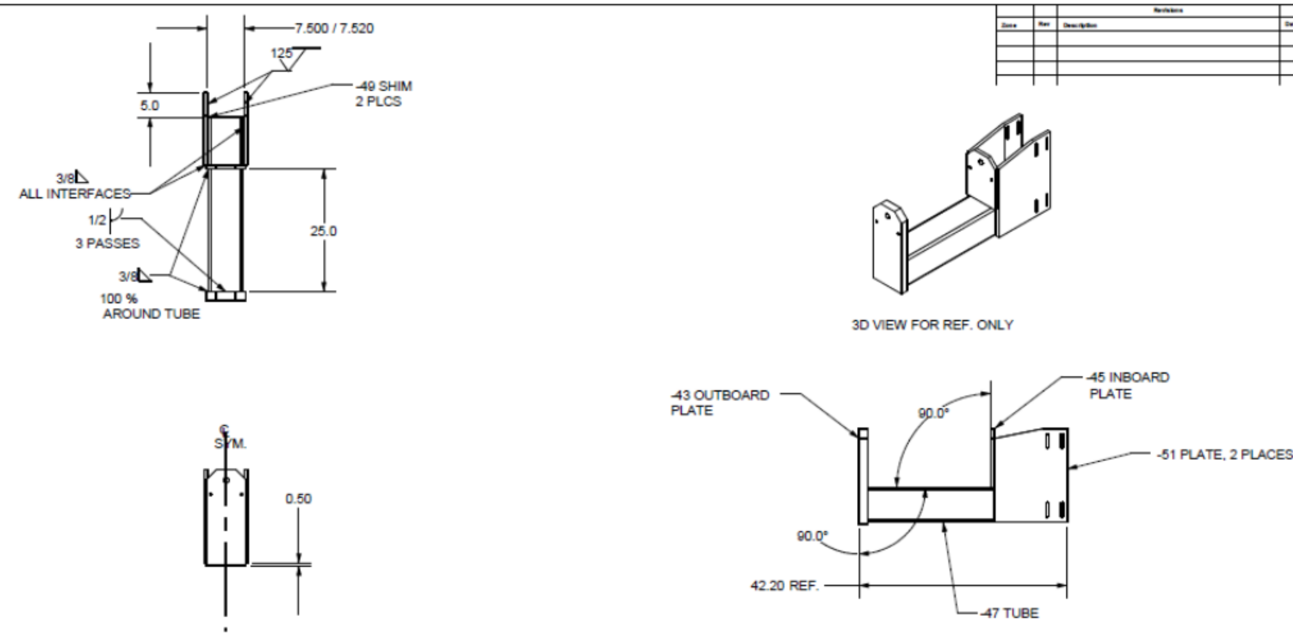
.25 STOCK
3D VIEW FOR REF ONLY
13.00
7.50
1.00
3.25
TYP
DETAIL -31 (FULCRUM LATERAL BRACE) CRS OR HRS
8 REQUIRED FOR PROJECT
Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ±
Angular: Mach ± Bend ±
Two Place Decimal ±
Three Place Decimal ±
Material -
Finish -
Do Not Scale Drawing
Name
Date
Drawn
GJK
9/01/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -31
Size
B
Drawing No.
GJK 0002
Rev
IR
Scale N/A
CAD File
Sheet 11 of 20
Revisions
Zone
Rev
Description
Date
Approved


2.000 BLANCHARD GROUND STOCK
Ø 3.501 / 3.503 SLIP FIT WITH RBC BEARING NO. RBY-3 1/2
0.475
4.775
2.275
20.0
22.50
7.750
3 D VIEW FOR REF. ONLY
NOTES:
DETAIL -33 (FULCRUM SUPPORT BAR) FINISHED HRS
8 REQUIRED FOR PROJECT
COORDINATE MACHINING WITH WELDING. FINISH HOLE DIAMETER AFTER WELDING
RBY-3 1/2 BEARING MAY BE PURCHASED AT WWW.RBCBEARINGS.COM
Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ± 1/32
Angular: Mach ± 0.1 DEG
Two Place Decimal ±0.01
Three Place Decimal ± 0.005
Material
Finish
Do Not Scale Drawing
Name
Date
Drawn
GJK
10/1/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -33
Size
B
Drawing No.
GJK0002
Rev
A
Scale
N/A
CAD File
Sheet
12 of 20



1/4
100 % ALL EDGES
BOTH CHANNEL ASSYS
R 0.5, 2 PLCS.
45.464 REF.
9.60
ALL EDGES
4.0 STOCK
6.0 STOCK
25.0
Ø1.125 / 1.127
Ø1.000 / 1.002
IN LINE THRU
CHANNEL PAIR
TYP
2.50
43.20
55.70
3D VIEW FOR REF. ONLY
5.073 CENTRAL
2.125
45.464
SYM
Ø0.530
4 PLCS.
5.073
NOTE: HOLD CHANNEL PAIR AT 2.125 IN.
SEPARATION DURING HOLE DRILLING
SOME HIDDEN LINES REMOVED FOR
CLARITY
1.00
2.125
DETAIL -37, -39 (CHANNEL PAIR) STRUCTURAL STEEL CHANNELS
ASSEMBLY CONSISTS OF BACK TO BACK 6 X 13 #/FT. AND 4 X 6.25 #/ FT. CHANNELS
ALL MATERIAL 1018 MILD STEEL OR EQUIV.
SEE -101 ASSEMBLY FOR LOCATION OF -41 BLADDER ATTACH PLATE
-41 2 BLADDER ATTACH PLATE
-39 1 LEVER CHANNEL BEAM RIGHT
-37 1 LEVER CHANNEL BEAM LEFT
-7 8 WELD ASSEMBLY
ASS'Y DETAIL QTY DESCRIPTION
FAA / BAC TEST
FASTER AXIAL LOAD MODS
-7 LEVER ASSEMBLY
B GJK 0001 IR
N/A
4 of 5


3D VIEW FOR REF. ONLY
0.50 STOCK
Ø10.40
5.073 CENTRAL TYP.
DRILL AND TAP THRU FOR
3/8 - 16 THD. 4 PLCS
5.073
6.20
0.437 DIA. THRU.
C'SINK DIA. 0.762
2 PLCS.
DETAIL -49 (LOAD BEAM TO BLADDER MOUNTING PLATE) HRS
16 REQUIRED FOR PROJECT
MATERIAL: MILD STEEL 1018 OR EQUIVALENT
Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ±
Angular: Mach ± Bend ±
Two Place Decimal ±
Three Place Decimal ±
Material -
Finish -
Do Not Scale Drawing
Name
Date
Drawn
GJK
9/01/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -41
Size
B
Drawing No.
GJK 0002
Rev
IR
Scale N/A
CAD File
Sheet 15 of 20



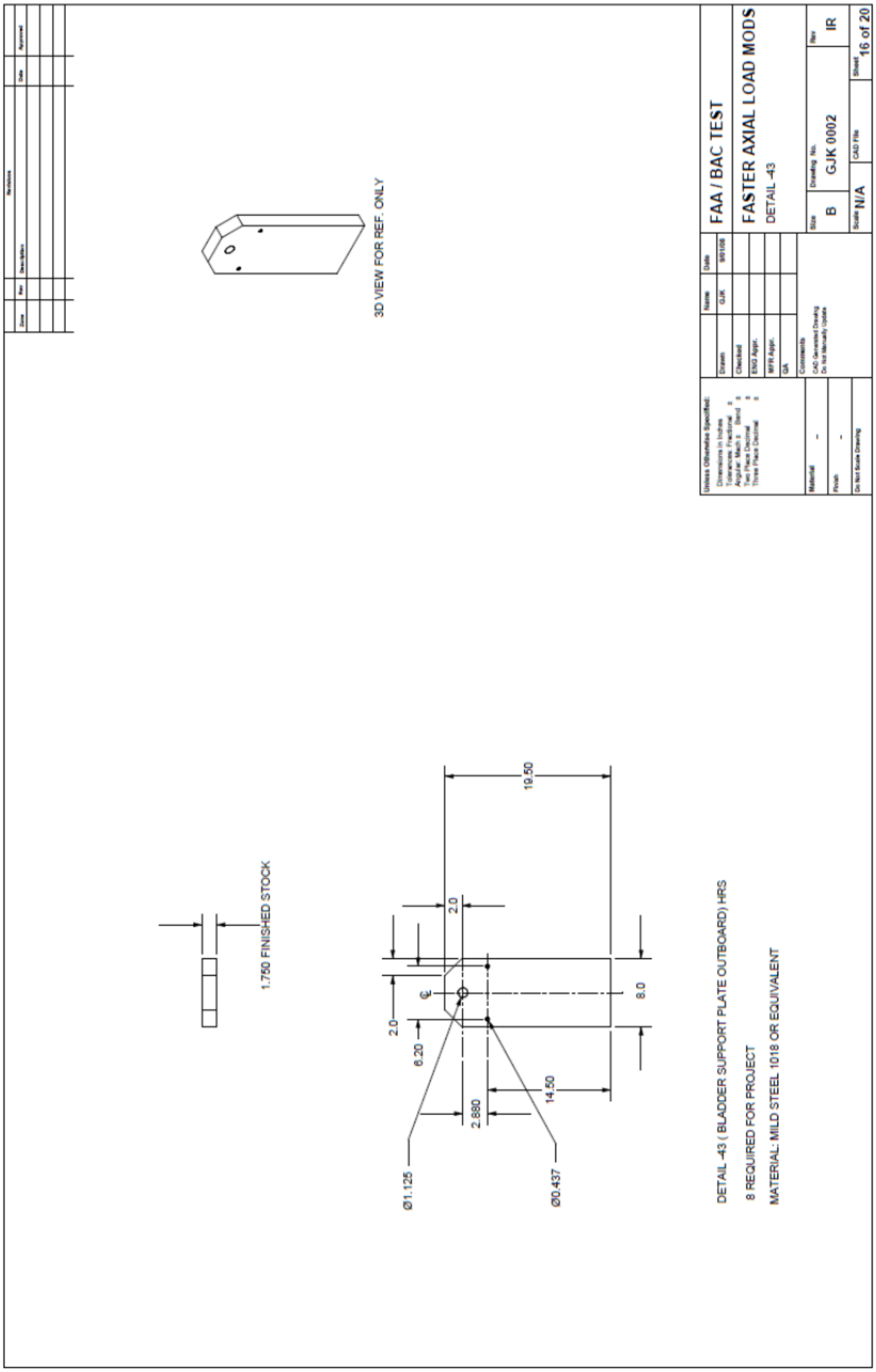
ASSEMBLY NOTES:

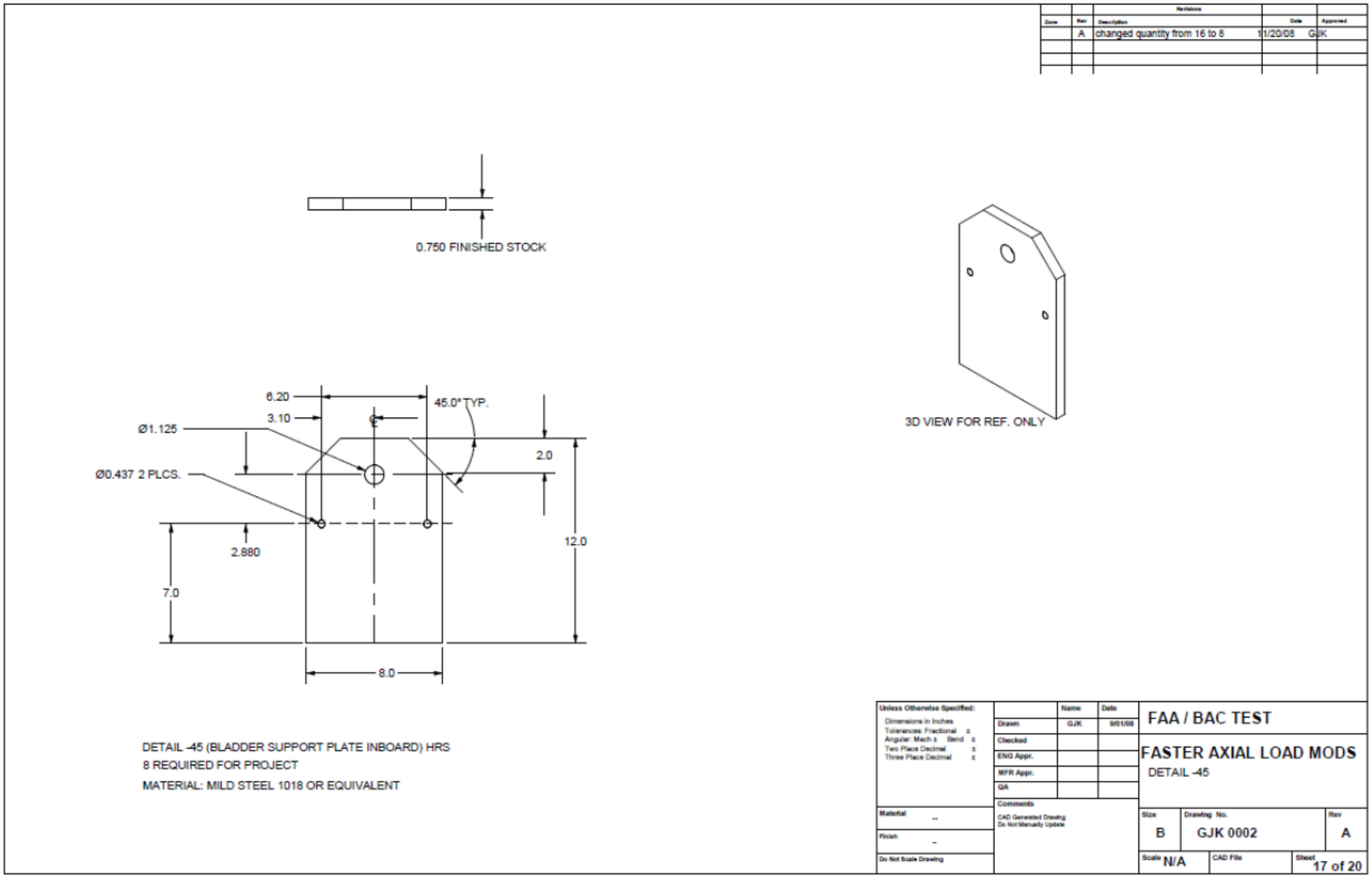
1. ALL HOLE AND SLOT PATTERNS MUST ALLIGN WITHIN .01 AFTER WELDING
2. HOLES AND SLOTS MAY BE INSTALLED AFTER WELDING. SHOP PRACTICE OPTIONAL
3. STRESS RELEIVE AFTER WELDING TO MINIMIZE PRESTRESSES.
4. USE SHIELDED ARC ELECTRIC WELD METHOD
5. BREAK ALL SHARP EDGES .02
6. ALL MATERIAL 1018 MILD STEEL OR EQUIV.

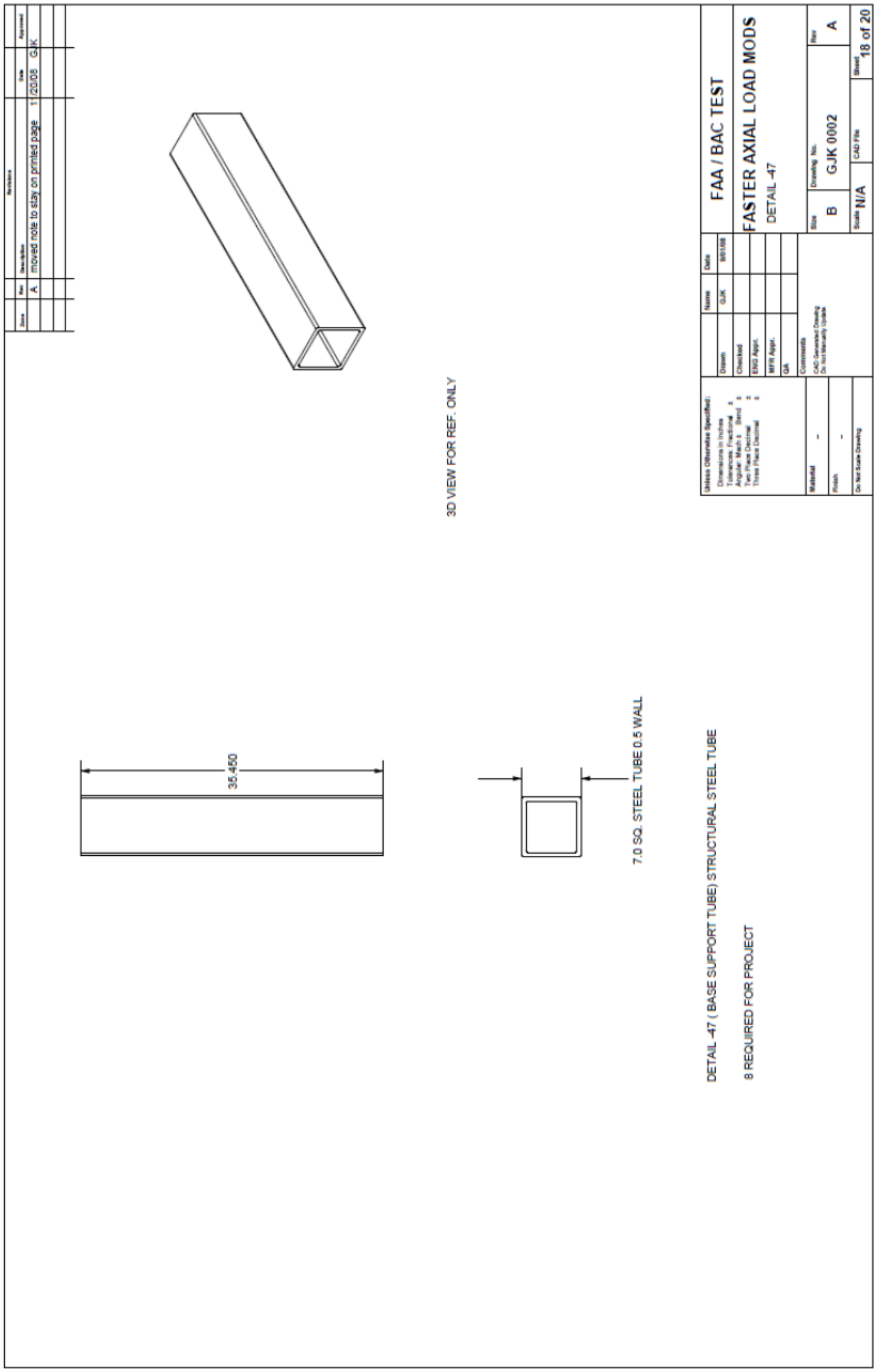
ASS'Y	DETAIL	QTY	DESCRIPTION
2	-51		SIDE PLATE
2	-49		SHIM
1	-47		REACTION SUPPORT TUBE
1	-45		BLADDER INBOARD PLATE
1	-43		BLADDER OUTBOARD PLATE
-9		8	WELD ASSEMBLY

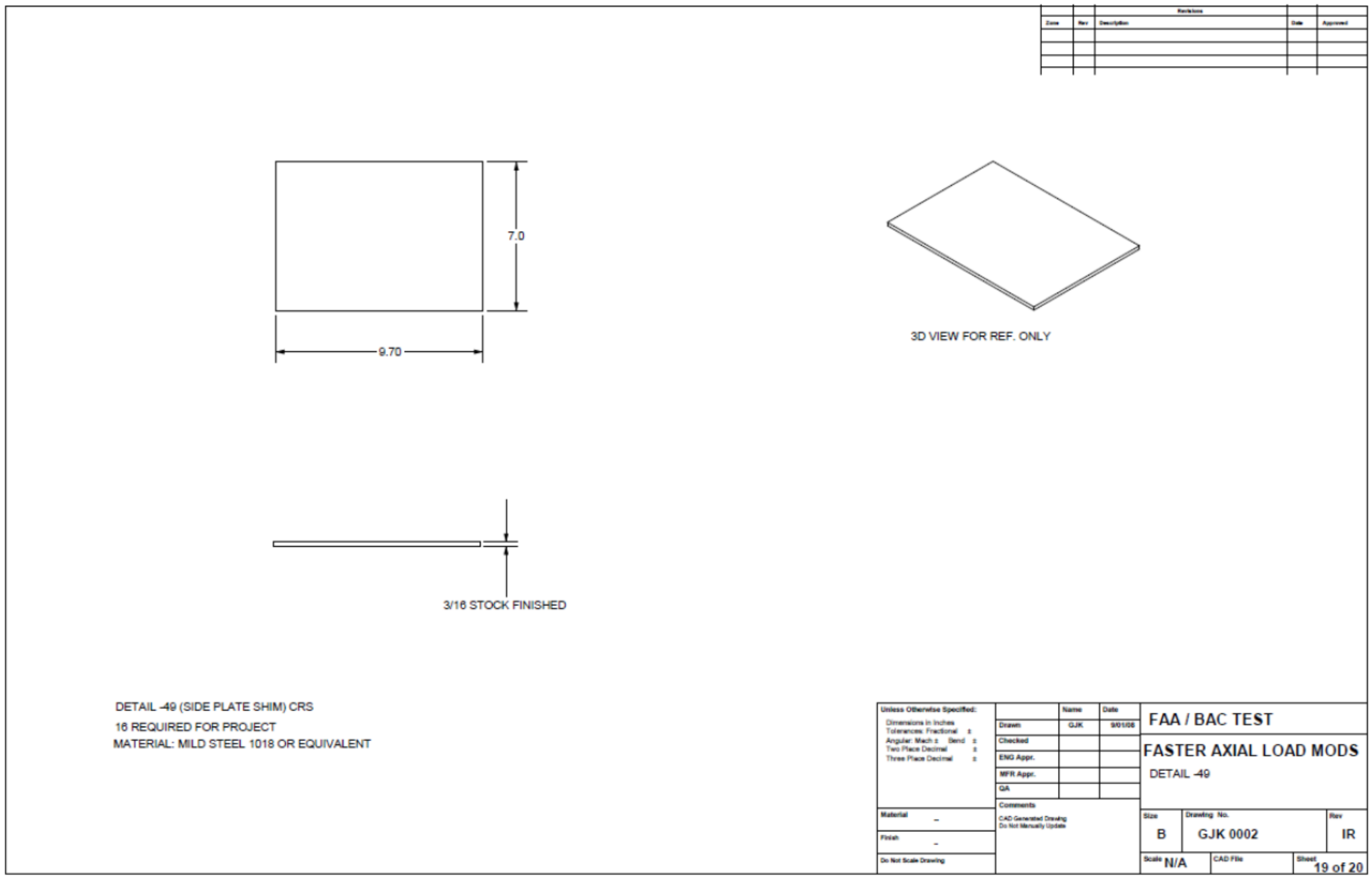
Unless Otherwise Specified:		Name	Date	
Dimensions in Inches Tolerances: Fractional ± Angular: Mach ± Bend ± Two Place Decimal ± Three Place Decimal ±	Drawn	GJK	9/01/08	FAA / BAC TEST
	Checked			FASTER AXIAL LOAD MODS
	ENG Appr.			-9 ASSEMBLY
	MFR Appr.			
	QA			
Material -	Comments: CAD Generated Drawing Do Not Manually Update			Size B · Drawing No. GJK 0001 · Rev IR
Finish -				Scale N/A · CAD File · Sheet 5 of 5
Do Not Scale Drawing				

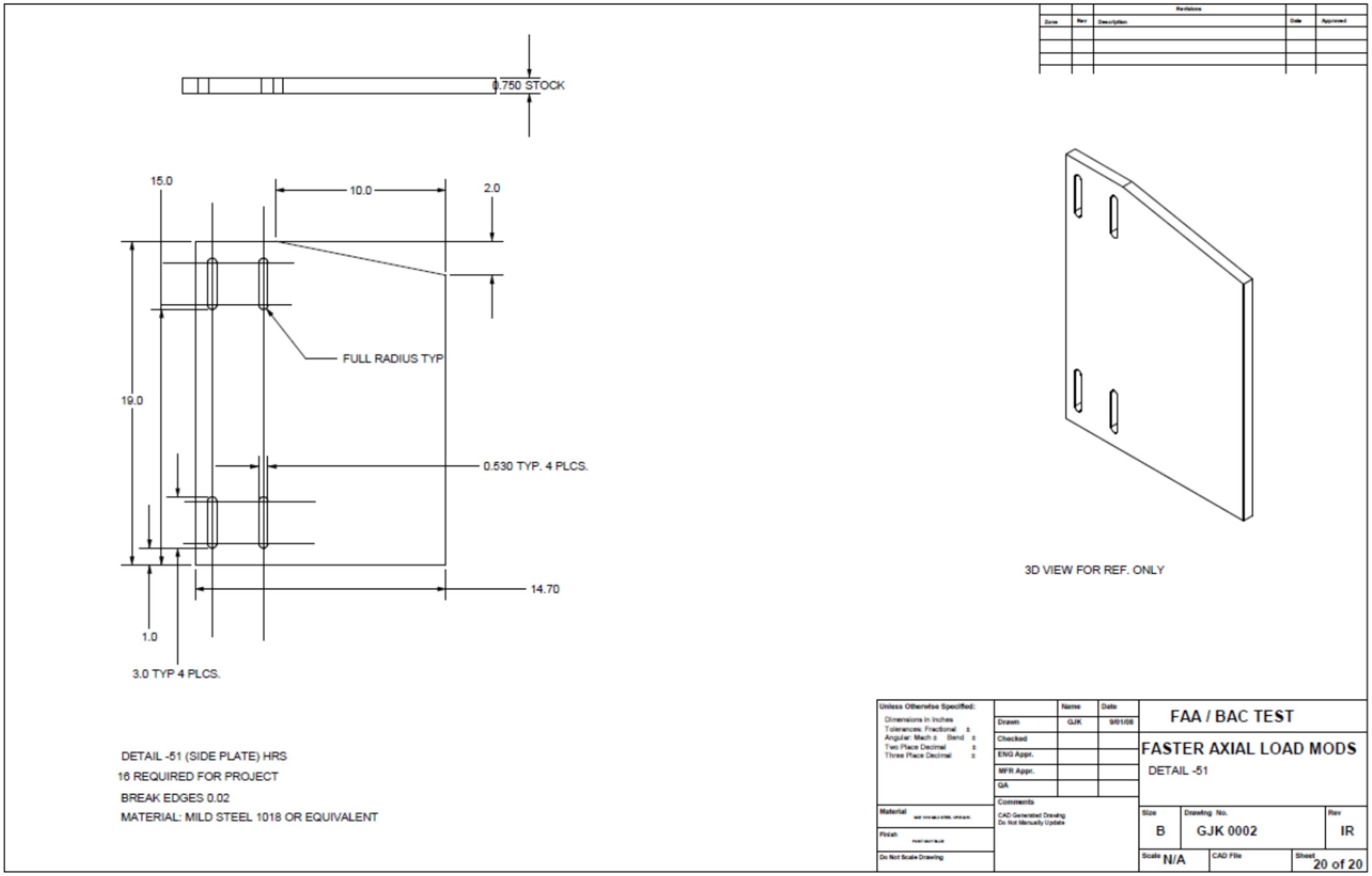
Zone	Rev	Description	Date	Approved


3D VIEW FOR REF. ONLY
1.750 FINISHED STOCK
19.50
2.0
2.0
6.20
8.0
14.50
2.880
Ø1.125
Ø0.437
DETAIL -43 (BLADDER SUPPORT PLATE OUTBOARD) HRS
8 REQUIRED FOR PROJECT
MATERIAL: MILD STEEL 1018 OR EQUIVALENT
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -43
Drawn
GJK
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
Unless Otherwise Specified:
Dimensions in Inches
Material
Finish
Do Not Scale Drawing
Size
B
Drawing No.
GJK 0002
Rev
IR
Scale
N/A
Sheet
16 of 20

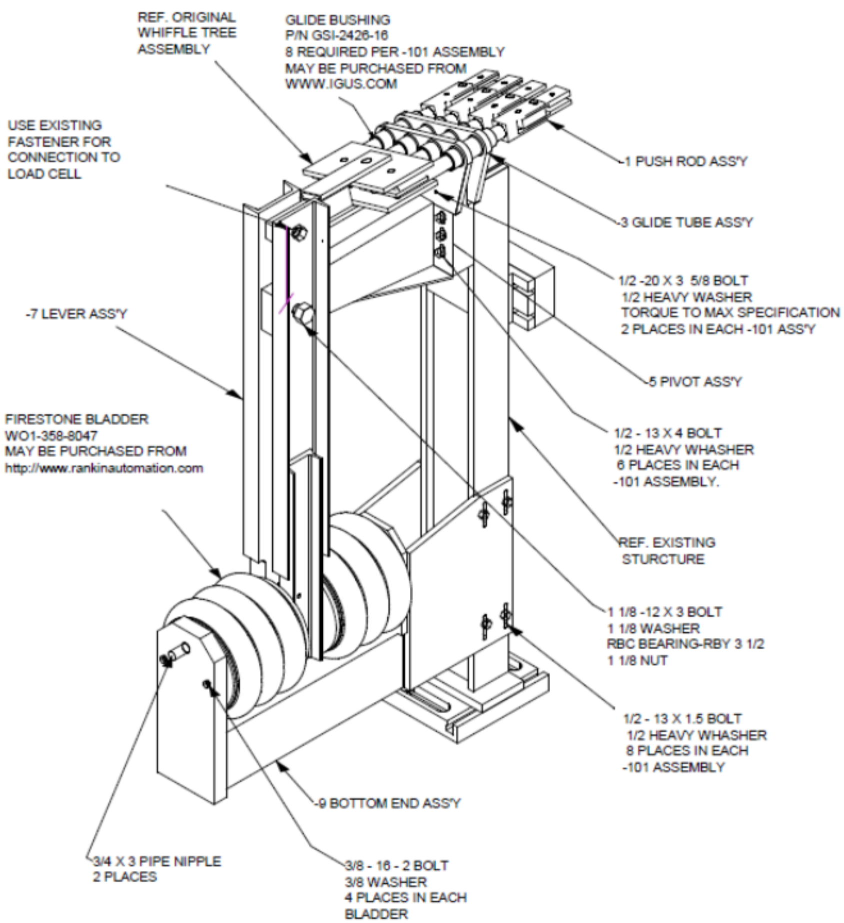

Revisions
Zone
Rev
Description
Date
Approved
A
changed quantity from 16 to 8
11/20/08
GJK
0.750 FINISHED STOCK
3D VIEW FOR REF. ONLY
6.20
3.10
45.0° TYP.
Ø1.125
Ø0.437 2 PLCS.
2.0
2.880
12.0
7.0
8.0
DETAIL -45 (BLADDER SUPPORT PLATE INBOARD) HRS
8 REQUIRED FOR PROJECT
MATERIAL: MILD STEEL 1018 OR EQUIVALENT
Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ±
Angular: Mach ± Bend ±
Two Place Decimal ±
Three Place Decimal ±
Material
Finish
Do Not Scale Drawing
Name
Date
Drawn
GJK
9/01/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -45
Size
B
Drawing No.
GJK 0002
Rev
A
Scale N/A
CAD File
Sheet 17 of 20


moved note to stay on printed page
11/20/08
GJK
35.450
7.0 SQ. STEEL TUBE 0.5 WALL
3D VIEW FOR REF. ONLY
DETAIL -47 (BASE SUPPORT TUBE) STRUCTURAL STEEL TUBE
8 REQUIRED FOR PROJECT
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -47
B
GJK 0002
A
N/A
18 of 20


7.0
9.70
3D VIEW FOR REF. ONLY
3/16 STOCK FINISHED
DETAIL -49 (SIDE PLATE SHIM) CRS
16 REQUIRED FOR PROJECT
MATERIAL: MILD STEEL 1018 OR EQUIVALENT
Revisions
Zone
Rev
Description
Date
Approved
Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ±
Angular: Mach ± Bend ±
Two Place Decimal ±
Three Place Decimal ±
Material
Finish
Do Not Scale Drawing
Name
Date
Drawn
GJK
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -49
Size
B
Drawing No.
GJK 0002
Rev
IR
Scale N/A
CAD File
Sheet 19 of 20



0.750 STOCK
15.0
10.0
2.0
19.0
FULL RADIUS TYP
0.530 TYP. 4 PLCS.
14.70
1.0
3.0 TYP 4 PLCS.
3D VIEW FOR REF. ONLY
DETAIL -51 (SIDE PLATE) HRS
16 REQUIRED FOR PROJECT
BREAK EDGES 0.02
MATERIAL: MILD STEEL 1018 OR EQUIVALENT
Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ±
Angular: Mach ± Bend ±
Two Place Decimal ±
Three Place Decimal ±
Material
Finish
Do Not Scale Drawing
Name
Date
Drawn
GJK
9/01/08
Checked
ENG Appr.
MFR Appr.
QA
Comments
CAD Generated Drawing
Do Not Manually Update
FAA / BAC TEST
FASTER AXIAL LOAD MODS
DETAIL -51
Size
B
Drawing No.
GJK 0002
Rev
IR
Scale
N/A
CAD File
Sheet
20 of 20



Zone	Rev	Description	Date	Approved

GENERAL NOTES:

1. BREAK ALL EDGES 0.04 - .06.
2. ALL STEEL SHALL BE SAE 1018 OR EQUIVALENT.
3. ALL WELDING SHALL BE PERFORMED IN ACCORDANCE WITH THE QUALITY STANDARDS OF THE AWS.
4. MATERIAL CUTS THAT ARE NOT CONTROLLED BY SURFACE FINISH MAY BE FLAME CUT AND GROUND / SANDED TO SIZE.
5. HOLES MAY BE DRILLED TO SIZE.
6. PRECISION HOLES SHALL BE BORED TO SIZE.
7. SLOTS SHALL BE FINISHED WITH A MILLING OPERATION SUCH AS END MILLING TO SIZE.
8. ALL WELDS SHALL BE STRUCTURALLY SOUND AND STRESS RELIEVED AFTER COMPLETE.
9. INSTALL PIPE FITTINGS WITH TEFLON TAPE SEALANT
10. ALL EXISTING STRUCTURES SHALL BE MOUNTED IN ACCORDANCE WITH THE ORIGINAL DESIGN REQUIREMENTS.

ASS'Y NO.	QUANTITY	STOCK SIZE AND / OR DESCRIPTION
	64	BUSHING, GSI- 2426-16
	16	BLADDER, WO1-358-0847
	8	BEARING, RBY - 3 1/2
-9	8	BOTTOM END ASSEMBLY
-7	8	LEVER ASSEMBLY
-5	8	PIVOT ASSEMBLY
-3	8	GLIDE TUBE ASSEMBLY
-1	32	PUSH ROD ASSEMBLY
-101	8	TENSION / COMPRESSION AXIAL LOAD ASS'Y

Unless Otherwise Specified:
Dimensions in Inches
Tolerances: Fractional ±1/32
Angular: Mach ± .1 DEG
Two Place Decimal ±.007
Three Place Decimal ±.005

	Name	Date
Drawn	GJK	9/29/08
Checked		
ENG Appr.		
MFR Appr.		
QA		

Material: ALL STEEL PARTS SAE 1018 OR EQUIV.
Finish: POWDER COAT ALL EXPOSED SURFACES
Do Not Scale Drawing
Comments: CAD Generated Drawing Do Not Manually Update

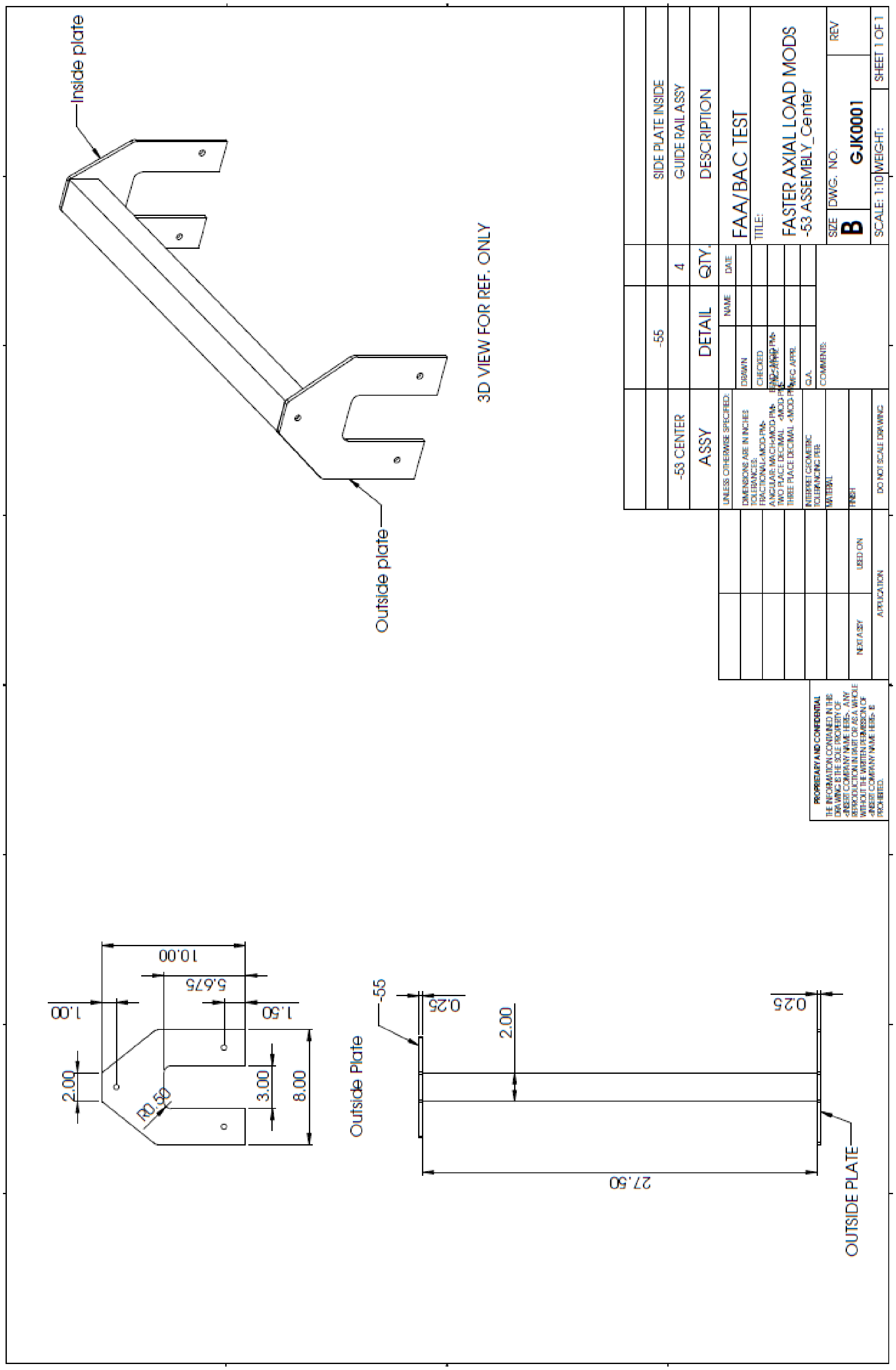
FAA / BAC TEST

FASTER AXIAL LOAD MODS

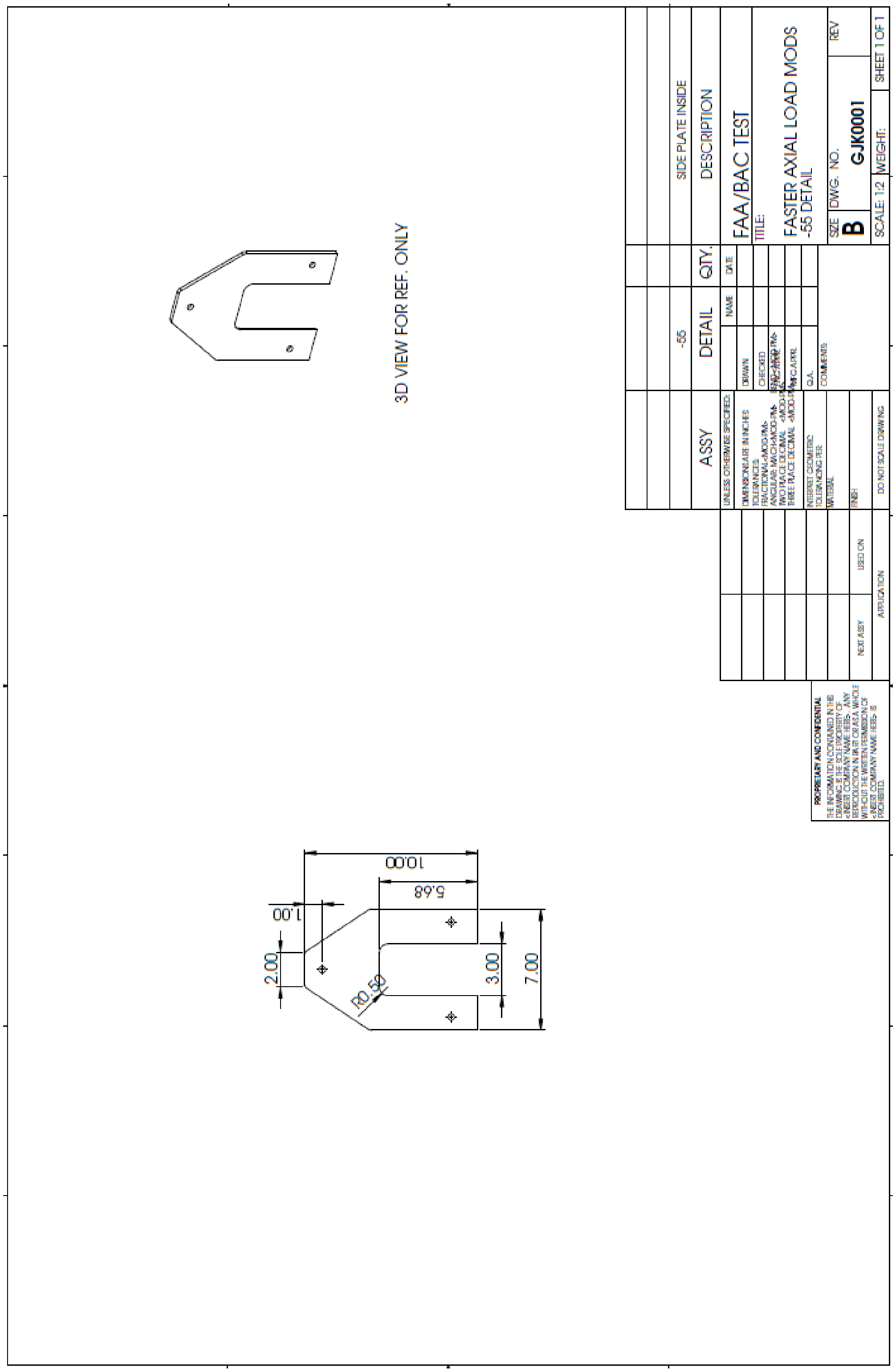
-101 ASSEMBLY

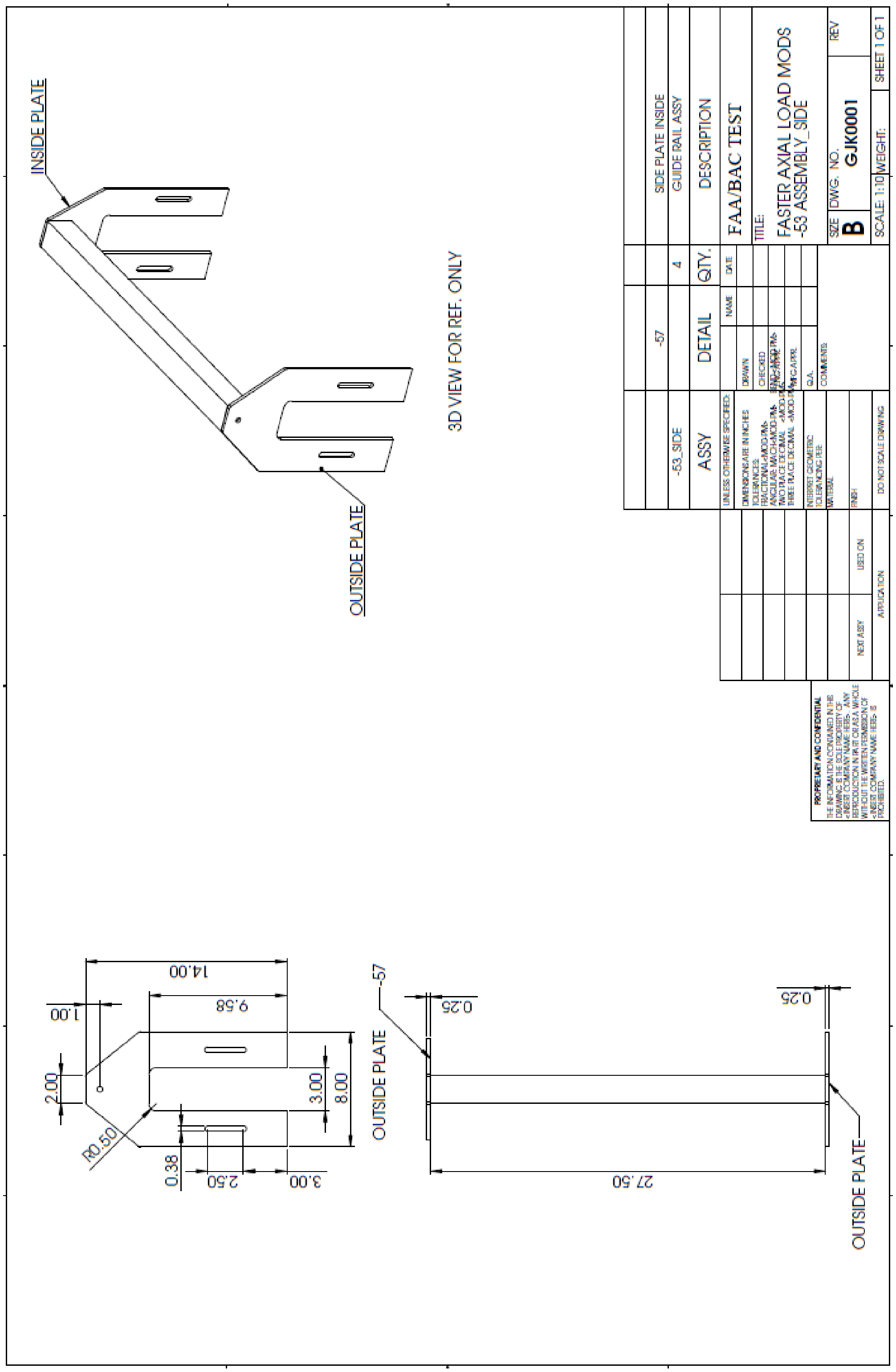
Size	Drawing No.	Rev
B	GJK0003	A

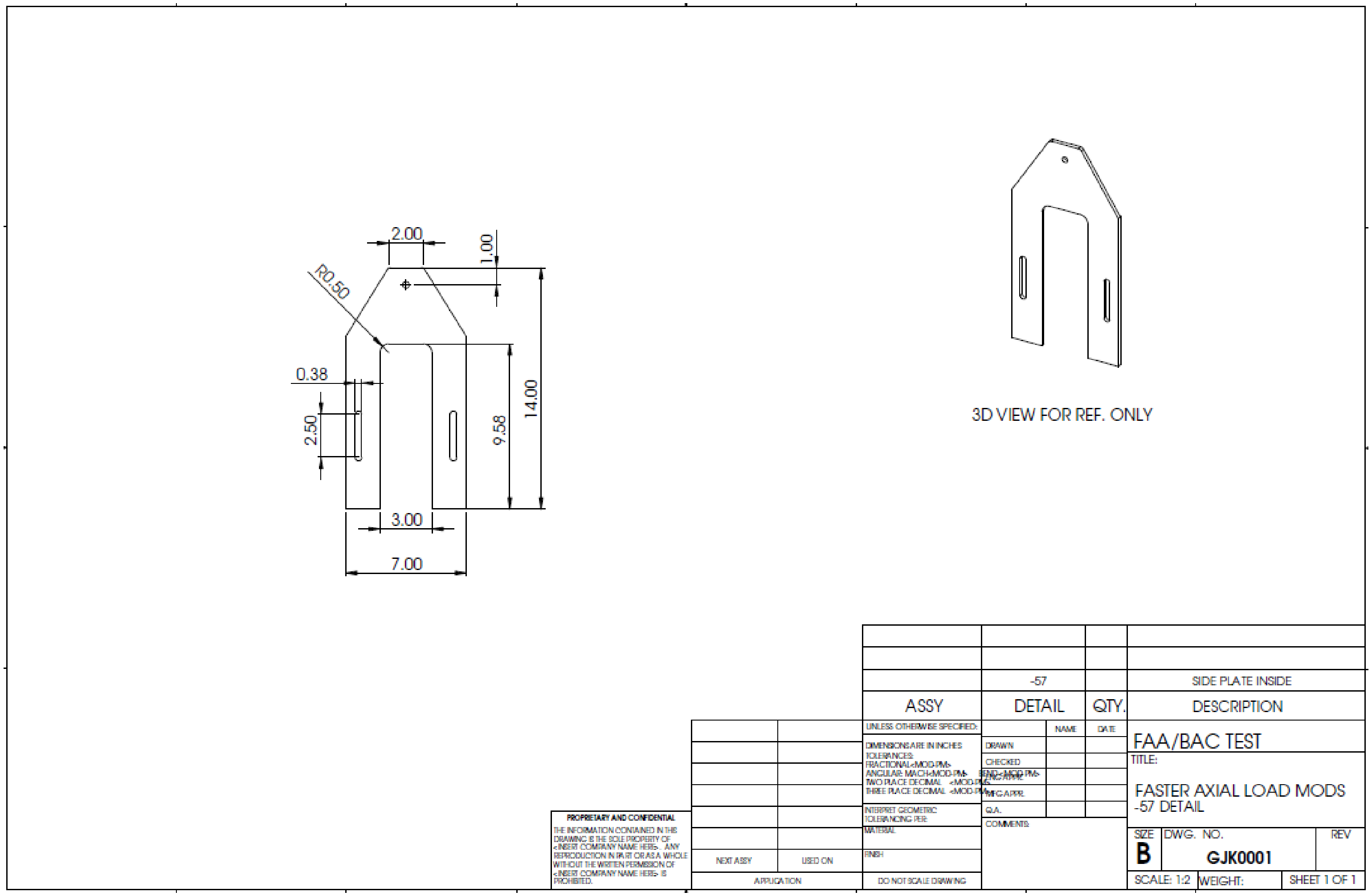
Scale N/A | CAD File | Sheet 1 of 1



Inside plate
Outside plate
3D VIEW FOR REF. ONLY
Outside Plate
10.00
5.675
1.00
1.50
2.00
R0.50
3.00
8.00
-55
0.25
2.00
0.25
27.50
OUTSIDE PLATE
SIDE PLATE INSIDE
-53 CENTER
-55
GUIDE RAIL ASSY
4
ASSY
DETAIL
QTY.
DESCRIPTION
FAA/BAC TEST
TITLE:
FASTER AXIAL LOAD MODS
-53 ASSEMBLY_Center
SIZE
B
DWG. NO.
GJK0001
REV
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
Q.A.
COMMENTS:
MATERIAL
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL


3D VIEW FOR REF. ONLY
10.00
5.68
1.00
2.00
3.00
7.00
R0.50
SIDE PLATE INSIDE
-55
ASSY
DETAIL
QTY.
DESCRIPTION
FAA/BAC TEST
TITLE:
FASTER AXIAL LOAD MODS
-55 DETAIL
SIZE
B
DWG. NO.
GJK0001
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
Q.A.
COMMENTS:
NAME
DATE
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL


INSIDE PLATE
OUTSIDE PLATE
3D VIEW FOR REF. ONLY
14.00
9.58
1.00
2.00
R0.50
0.38
2.50
3.00
3.00
8.00
OUTSIDE PLATE
-57
0.25
0.25
27.50
OUTSIDE PLATE
SIDE PLATE INSIDE
GUIDE RAIL ASSY
DESCRIPTION
-57
4
-53_SIDE
ASSY
DETAIL
QTY.
FAA/BAC TEST
TITLE:
FASTER AXIAL LOAD MODS
-53 ASSEMBLY_SIDE
SIZE
B
DWG. NO.
GJK0001
REV
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1


2.00
1.00
R0.50
0.38
2.50
9.58
14.00
3.00
7.00
3D VIEW FOR REF. ONLY
-57
SIDE PLATE INSIDE
ASSY
DETAIL
QTY.
DESCRIPTION
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
FAA/BAC TEST
DRAWN
CHECKED
TITLE:
FASTER AXIAL LOAD MODS
-57 DETAIL
Q.A.
COMMENTS:
MATERIAL
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
SIZE
B
DWG. NO.
GJK0001
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1