NASM1312-21
STANDARD PRACTICE

FASTENER TEST METHODS

METHOD 21

SHEAR JOINT FATIGUE

CONSTANT AMPLITUDE

AEROSPACE INDUSTRIES ASSOCIATION

THE INITIAL RELEASE OF THIS DOCUMENT SUPERSEDES MIL-STD-1312-21

DESIGNATION FOR THIS TEST METHOD REMAINS MIL-STD-1312-21

①

LIST OF CURRENT SHEETS

NO.	1	2	3	4	5	6	7	8	9
REV.	1	NEW	NEW	NEW	NEW	NEW	NEW	NEW	NEW
NO.	10	11	12	13	14	15	16	17	18
REV.	NEW	NEW	NEW	NEW	NEW	NEW	1	NEW	NEW
NO.	19	20	21	22					
REV.	NEW	NEW	NEW	NEW					

FSC 53GP

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FOREWORD

This standard sets forth a standard test procedure for determining the shear joint fatigue of fasteners at room temperature.

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FIGURES

1. SCOPE

1.1 Applicability. This test method covers the procedure and apparatus required for testing the shear joint fatigue of fasteners at room temperature.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. Unless otherwise specified, the following specifications, standards and handbooks of the issue listed in the current Department of Defense Index of Specifications and Standards (DoDISS) and the supplement thereto (if applicable), form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

QQ-A-250/5	Aluminum Alloy Alclad 2024, Plate and Sheet
TT-P-1757	Primer Coating, Zinc Chromate, Low Moisture Sensitivity
MILITARY	
MIL-P-6808	Primer Coating, Zinc Chromate, Process for Application of
MIL-T-9046	Titanium and Titanium Alloy, Sheet, Strip and Plate

(Copies of specifications, standards, handbooks, drawings and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document(s) forms a part of this specification to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issue in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E4	Load Verification of Testing Machines
ASTM E8	Metallic Materials, Tension Testing of
ASTM E74	Verification of Calibration, Devices for Verifying Testing Machines

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

3. DEFINITIONS Not applicable.

4. GENERAL REQUIREMENTS

4.1 Test apparatus.

4.1.1 Fatigue test machine loading system. The dynamic loading system shall be accurate within ±2 percent of the programmed maximum load, for load greater than 10% of the range of the machine. The load maintaining system shall be capable of maintaining the required load. Machines operating without load maintainers shall be monitored at intervals by the operator. The intervals shall be determined according to the expected cycle life and equipment capability.

4.1.1.1 Calibration. The load accuracy of each machine shall be verified after each 1000 hours of operating time or every six months, whichever occurs first, and after any machine modification which could affect the load accuracy. All fatigue test machines shall be calibrated using static loads following the procedures of ASTM E4 using elastic calibration devices. Schematic arrangements of ring type and load cell calibration devices are shown in figure 1.

4.1.1.1.1 Elastic calibration. The elastic calibration device shall be checked for accuracy following the procedures of the latest issue of ASTM E74. The required loads may be produced with known dead weights, a force-calibration frame, and previously verified elastic calibration device or a testing machine with loading ranges that are accurate within 0.5 percent of reading and that match or overlap the force required for the verification of the calibration device. The three loading systems are listed in descending order of preference.

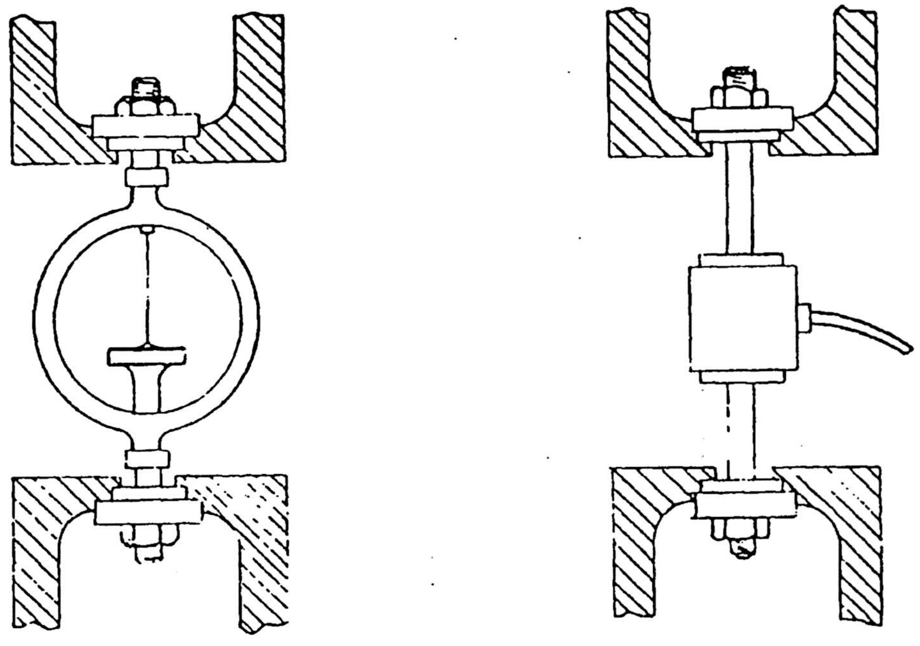


FIGURE 1. Elastic calibration devices.

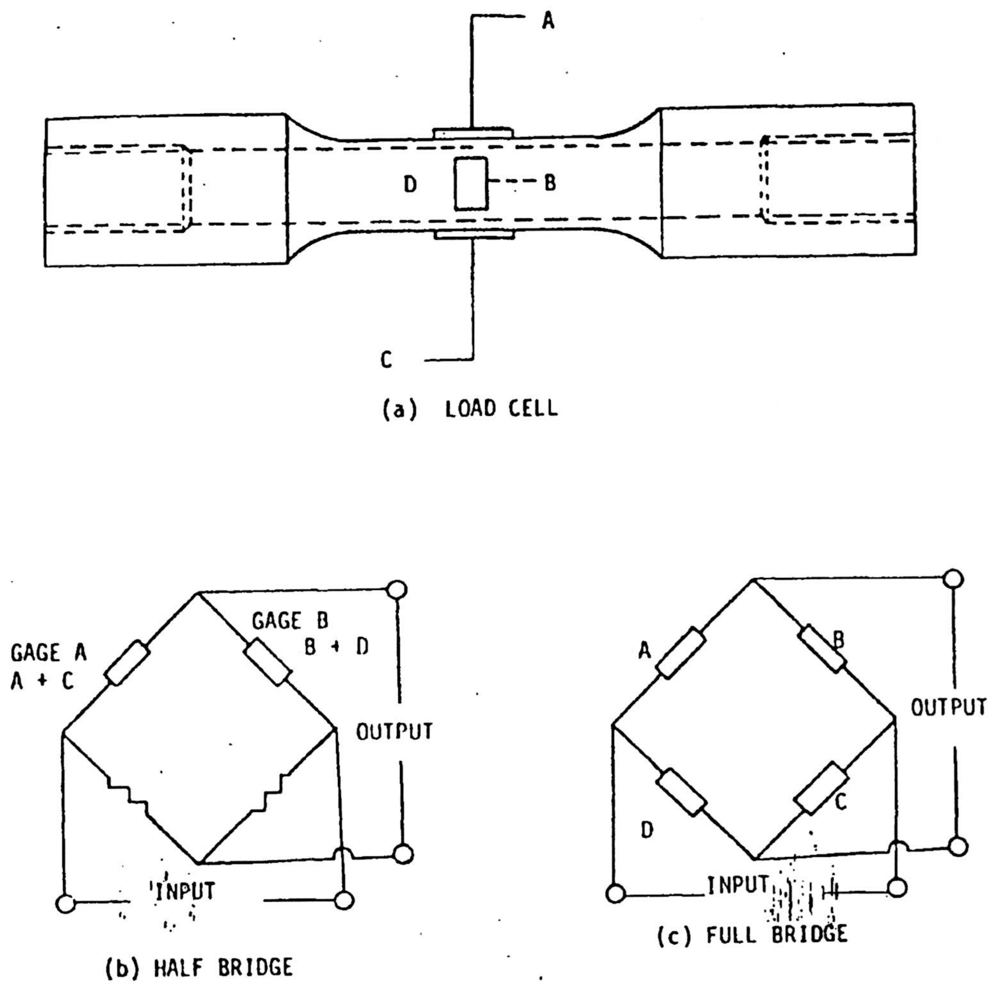


FIGURE 2. Typical load cell circuits.

NOTE: Load Cell Instrumentation

Most load cells used as elastic calibration devices make use of bonded resistance strain gages as the sensing elements. These gages are usually connected to form all or part of a Wheatstone bridge circuit. Some of the possible configurations are shown on figure 2. The full bridge, figure 2c is the preferred method and should be used wherever possible. If the circuits as shown in figure 2b must be used, care must be taken to protect lead wires and resistors from thermal and mechanical effects that might cause resistance changes. The active elements (strain gages) must be mounted on the load cell column in a manner to minimize the effects of bending figure 2a. The identical load cell system, including the indicator, power supply and all accessory equipment that was used during the load cell verification must be used during calibration of the fatigue test machine.

4.1.2 Static alignment. Static alignment of each fatigue test machine shall be verified at any time necessary to insure meeting the alignment requirements of this standard. Alignment check may be accomplished by mechanical or stain gaged alignment cell systems. The method employed shall be capable of proving that the stress caused by misalignment of eccentric loading shall not exceed 6 percent of the average stress. One method of determining is as follows:

4.1.2.1 Equipment.

4.1.2.1. Strain gage load cell (figure 3a).

4.1.2.1.2 A digital strain indicator (or equivalent) (figure 3b).

4.1.2.1.3 Alignment cells. Static alignment cells shall be designed to operate between 15 and 60 KSI at the test load. The test load shall be 10% of the maximum machine capacity. Typical alignment cells, the material from which they were made, and test loads that cover maximum machine capabilities from 4400 pounds to 250,000 pounds are shown in figure 4. Tubular cells or actual test bolts of appropriate load range may be used.

4.1.2.3 Procedure. Four strain gages shall be bonded 90° apart around the circumference on a common plane perpendicular to the axis of the cell. Each active strain gage shall be wired into a separate channel of the switch and balance unit so it can be individually balanced and switched into the strain indicator.

4.1.2.4 Alignment example.

4.1.2.4.1 To check the alignment on a 24,000 pound fatigue machine, take 10% x 24,000 = 2,400 pounds. From figure 4 select cell No. 7 rated for use between 2,400 and 9,600 pounds.

4.1.2.4.2 Assemble the alignment cell into the test machine using equipment that meets the specified fixture requirements.

4.1.2.4.3 Load the alignment cell to 2400 pounds and record the strain in order from gages 1, 2, 3 and 4. Unload the machine and rotate the alignment cell 180; load the cell again to 2400 pounds and record the readings from gages 1, 2, 3 and 4.

4.1.2.4.4 Sample calculation of strain gage results from the 2400 pound test loadings:

Strain Readings from:

	Gage 1	Gage 2	Gage 3	Gage 4
2400 lbs load	573	570	604	603 Mean Strain = 587
Minus Mean:	587	587	587	587
Difference:	14	17	17	16

Avg Difference of Gages 1 Plus 3 from Mean: $\frac{14 + 17}{2} = 15.5$

Avg Difference of Gages 2 Plus 4 from Mean: $\frac{17+ 16}{2} = 16.5$

Max value from mean: 15.5 + 16.5 = 28.63

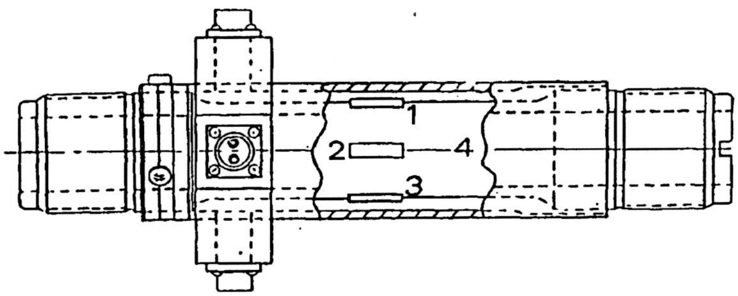
% Bending - $\frac{\text{Max value from mean}}{\text{MEAN}} \times 100 = \frac{2.263}{587} = 3.85\%$

Rotate Alignment Cell 180°

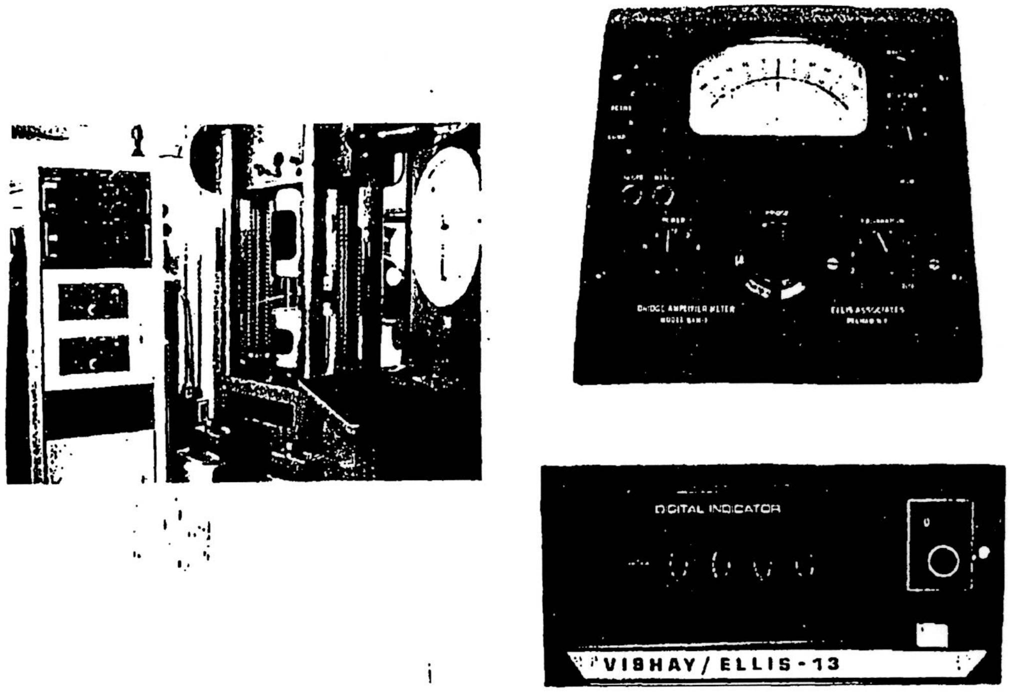
Strain Readings from:

	Gage 1	Gage 2	Gage 3	Gage 4
2400 lbs load	610	609	580	578 Mean Strain = 594.3

Circulate as above for % bending = 3.62%



(a) LOAD CELL



(b) DIGITAL STRAIN INDICATOR

FIGURE 3. Typical equipment used for checking alignment.

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$$\text{Avg Bending} = \frac{3.86 + 3.62}{2} = 3.74\%$$

4.1.3 Fixtures. Unless otherwise specified, the method of holding the sheet specimen in the testing machine may be either pin loading or clamping devices or a combination of both.

4.2 Test specimen.

4.2.1 General. The specimen shown in figure 5 shall be used for high-load transfer testing; the figure 6 specimen shall be used for low-load transfer testing; and the figure 7 specimen shall be used for no-load transfer testing.

4.2.2 Method for loading. The configuration of the joint specimen outside the lap area is optional. Certain parent sheet materials may be relatively low strength or thin enough to permit satisfactory gripping in standard friction type holding fixtures. However, for higher strength parent sheet material and for cases where grip slipping may be encountered, the use of pin loading holes is recommended. When pin loading holes are used, they shall be located so that the load will pass through the centerline of the fastener hole pattern with 0.005 inch.

4.2.3 Preparation.

4.2.3.1 Unless otherwise specified, specimens shall be fabricated from bare 2024-T3 (or 2024-T351) aluminum per QQ-A-250/5 or annealed 6 AL-4V titanium per MIL-T-9046. Tooling holes shall be confined to the grip area.

4.2.3.2 Unless otherwise specified, the faying sheet surfaces shall be prepared by degreasing for the full load transfer joint (figure 5) and the no-load transfer joint (figure 7). The low-load transfer joint shall be prepared in accordance with 4.2.3.2.1 and 4.2.3.2.2.

4.2.3.2.1 Sheet surface preparation, low-load, aluminum. The faying surfaces of the sheets shall be coated with zinc chromate primer, TT-P-1757 applied in accordance with MIL-P-6808.

4.2.3.2.2 Sheet surface preparation, low-load, titanium. The faying surface of the sheets shall be coated with "Molykote 106" bonded lubricant or equal.

4.2.4 Strip material mechanical properties. Three samples of each sheet or plate material employed in the actual joint strength evaluation shall be tested for tensile properties. Test procedures and method for determination of strip tensile properties shall be in accordance with ASTM E8. The values for ultimate, yield and elongation shall be determined. The grain direction shall be the same as the lap joint specimen.

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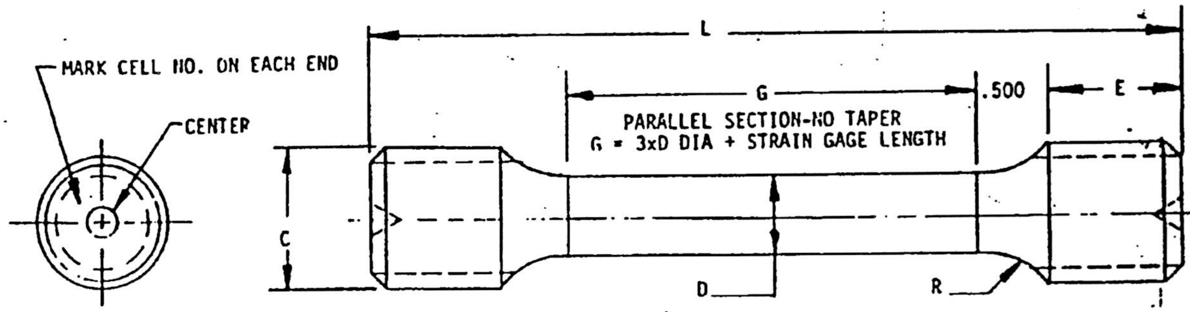

Cell	D ±.001	G ±.005	C Class 3A	L Ref	E Retain	R +.000 -.100	Area sq. in.	Min load-lbs (based on 15 KSI)	Min load-lbs (based on 60 KSI)	Machine type reference only
1	1.366	5.000	1.5000-12	10	2.000	0.500	1.466	22,000	88,000	Amsler
2	1.129	3.900	1.5000-12	10	2.500		1.000	15,000	60,000	Schenck
3	1.050	3.650	1.5000-12	10	2.675		0.866	13,000	52,000	Mts
4	0.714	2.650	1.000-14	7	1.675		0.400	6,000	24,000	Ivy
5	0.652	2.500	1.000-14	7	1.750		0.333	5,000	20,000	Mts
6	0.552	2.156	1.000-14	7	1.900		0.240	3.600	14,400	Vibrophore
7	0.452	1.860	1.000-14	7	2.000		0.160	2.400	9,600	Vibrophore
8	0.357	1.570	0.7500-16	5.5	1.465		0.100	1,500	6,000	Krouse
9	0.204	1.220	0.7500-16	5.5	1.640	0.500	0.0326	490	1,960	Vib & Krouse

NOTES:
1. Blend thread into radius R.
2. All cylindrical surfaces to be ground on common center.
3. Thread to be ground per Note 2.

FIGURE 4. Typical alignment cells.

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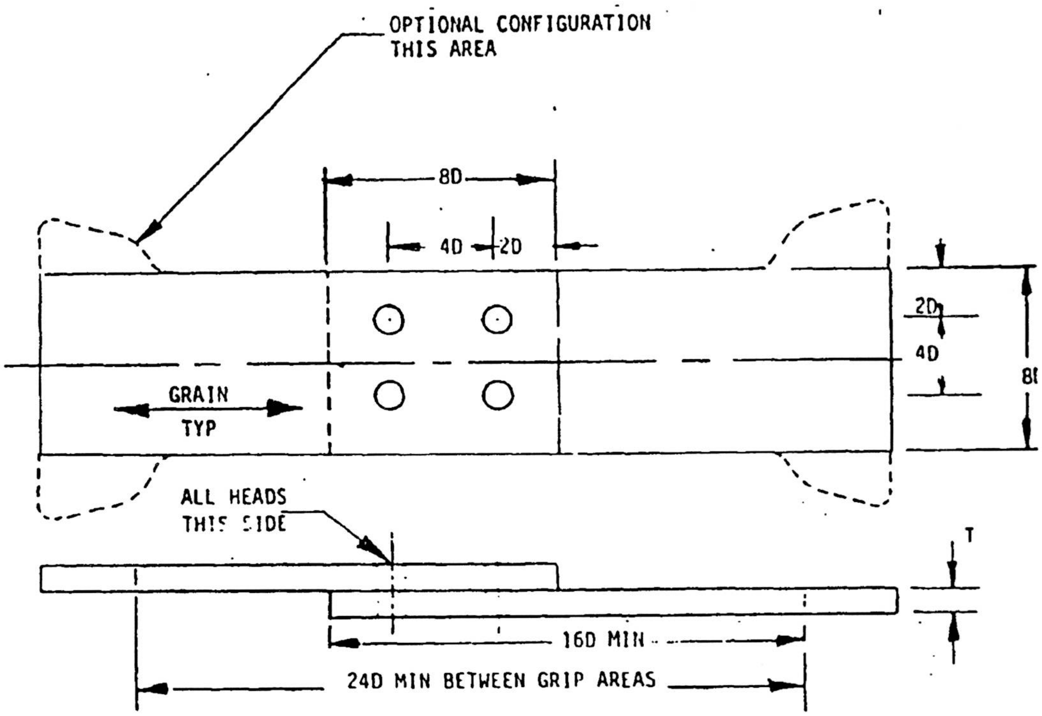
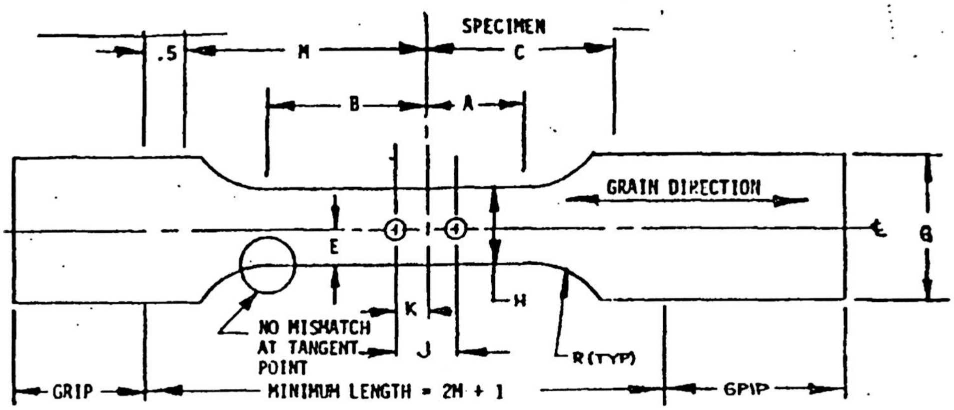


Nom Dia	D
1/8	0.125
5/32	0.156
3/16	0.188
1/4	0.250
5/16	0.312
3/8	0.375
1/2	0.500

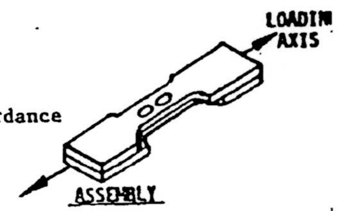
NOTES:

1. All edges machine 63/ or better.
2. No scratches, gouges or scribe marks in 24D area.
3. Chamfer or radius holes .005 max.
4. Tolerance on 2D and 4D dimension shall be ±0.005.
5. D = Dimension shown is to establish configuration dimensions only.
6. Unless specified otherwise, the sheet thickness T = 0.750.
7. This joint configuration may not be suitable for testing fasteners 5/16 inch nominal diameter (or larger) installed in sheet/plate materials (UTS 790 KSI) utilizing the sheet thickness specified (T = 0.750).

FIGURE 5. Lap joint specimen - single shear 100% load transfer



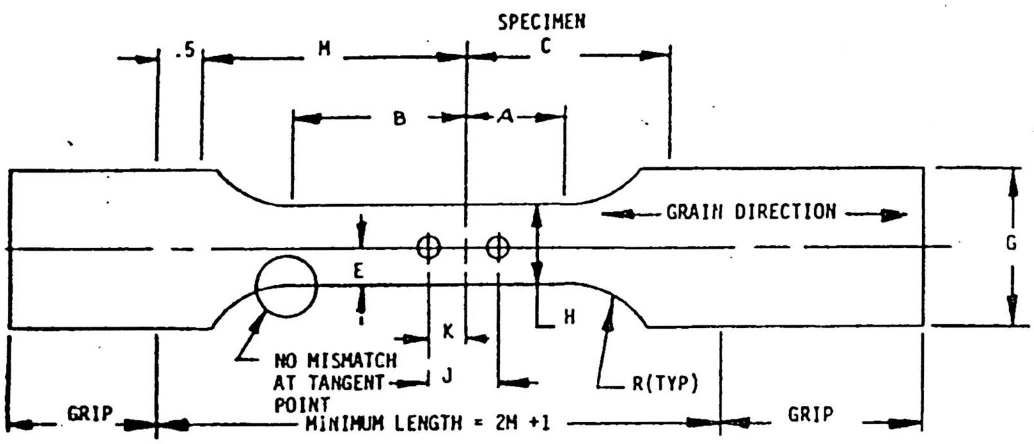
Nom Dia	D
1/8	0.125
5/32	0.156
3/16	0.188
1/4	0.250
5/16	0.312
3/8	0.375
7/16	0.437
1/2	0.500



NOTES:
1. All edges machine 63/ or better.
2. No scratches, gouges or scribe marks in M & C areas.
3. Chamfer or radius holes 0.005 max.
4. Faying surfaces must be coated with zinc chromate or bonded lubricant in accordance with 4.2.3.2.1 or 4.2.3.2.2.
5. Plan view is one-half of specimen, two parts required, assemble as shown.
6. Dimensions in inches.
7. Unless specified otherwise, sheet thickness T = 0.750.

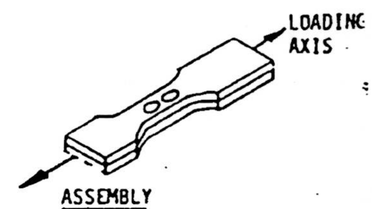
Nominal fastener size	G	H ±0.005	M (Ref)	C (Ref)	B	A	R	J ±0.005	K ±0.005	E ±0.005
1/8	2.50	0.750	3.190	2.370	1.570	0.750	2.0	0.500	0.250	0.375
5/32	2.50	0.938	3.900	2.705	2.033	0.938	2.5	0.625	0.313	0.469
3/16	2.50	1.126	4.237	3.037	2.325	1.125	3.0	0.750	0.375	0.563
1/4	3.50	1.500	5.345	4.146	2.700	1.500	4.0	1.000	0.500	0.750
5/16	3.50	1.875	5.990	4.700	3.075	1.875	5.0	1.250	0.625	0.938
3/8	3.00	2.250	6.110	4.916	3.460	2.250	6.0	1.500	0.750	1.125
1/2	5.00	3.000	6.442	5.317	5.125	3.000	6.0	2.000	1.000	1.500

FIGURE 6. Specimen detail, low load transfer test specimen joint.



Nom Dia	D
1/8	0.125
5/32	0.156
3/16	0.188
1/4	0.250
5/16	0.312
3/8	0.375
7/16	0.437
1/2	0.500

NOTES:
1. All edges machine 63/ or better.
2. No scratches, gouges or scribe marks in M & C areas.
3. Chamfer or radius holes 0.005 max.
Degrease prior to assembly.
Plan view is one-half of specimen, two parts required, assemble as shown.
6. Dimensions in inches.
7. Unless specified otherwise, sheet thickness T = 0.750.



Nominal fastener size	G	H ±0.005	M (Ref)	C (Ref)	B	A	R	J ±0.005	K ±0.005	E ±0.005
1/8	2.50	0.750	3.190	2.370	1.570	0.750	2.0	0.500	0.250	0.375
5/32	2.50	0.938	3.900	2.705	2.033	0.938	2.5	0.625	0.313	0.469
3/16	2.50	1.126	4.237	3.037	2.325	1.125	3.0	0.750	0.375	0.563
1/4	3.50	1.500	5.345	4.146	2.700	1.500	4.0	1.000	0.500	0.750
5/16	3.50	1.875	5.990	4.700	3.075	1.875	5.0	1.250	0.625	0.938
3/8	3.00	2.250	6.110	4.916	3.460	2.250	6.0	1.500	0.750	1.125
1/2	5.00	3.000	6.442	5.317	5.125	3.000	6.0	2.000	1.000	1.500

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FIGURE 7. Specimen detail, no load transfer test specimen joint.

4.2.5 Fastener holes. Fastener holes shall be line drilled perpendicular to the sheet surface within 1/2 degree. Holes shall be deburred on both sides of each sheet not to exceed 0.005 radius or chamfer. Surface finish of the hole shall be RHR 63 or better.

4.2.5.1 Hole diameter. Fastener hole diameter shall be in accordance with applicable specifications or manufacturers' recommended procedure.

4.2.5.2 Countersunk fastener holes. Holes for countersunk fastener shall be prepared with an integral drill countersink tool to maintain concentricity of the countersunk with the hole. The depth of countersunk shall be maintained such that the installed fastener is flush with +0.002 -0.005 inch.

4.2.5.3 Protruding fastener holes. The holes for protruding fasteners shall be relieved on the head side the minimum amount necessary to clear the fastener head-to-shank fillet radius.

4.2.5.4 Fastener orientation. The manufactured heads of all the fasteners shall be on the same side of the joint.

4.2.6 Assembly.

4.2.6.1 Fastener installation. If the fastener installation requires a torquing procedure, the applied torque shall be the minimum specified value for the particular fastener. If the fastener installation requires controlled material deformation, the deformation shall be the minimum specified value for the particular fastener. If these techniques are used, they shall be reported.

4.2.6.1.1 Unless otherwise specified, lubrication and corrosion protection media, except as part of the product specification, shall not be used.

4.2.6.2 Sheet gap. Particular care should be taken to assure no gap exists between the sheets at the fastener subsequent to assembly. The gap away from the fastener shall be considered excessive if a .002" thick gage can be slid between the sheets.

4.2.6.3 Fastener head seating. There shall be no gap greater than 0.005 inches for more than 50% of the circumference of the head.

5. DETAIL REQUIREMENTS

5.1 Test procedures.

5.1.1 Installation. The specimen shall be installed in the holding fixture and clamped or pinned in position. The load shall be transmitted along a line passing through the centerline of the faying surface within 0.005 inch.

5.1.2 Test conditions.

5.1.2.1 Joint static strength. To establish the joint static ultimate strength a specimen similar to that used for the fatigue test shall be prepared and tested. The ultimate strength shall be the value indicated at the first peak of the load-deflection curve.

5.1.2.2 Load level. A minimum of five load levels shall be used to establish a S-N curve. One value shall be chosen which does not fail at less than 3,000,000 cycles; three others shall be at 67, 50 and 30 percent of the joint static strength and the fifth as necessary to define the curve. A minimum of three specimens shall be tested at each load level.

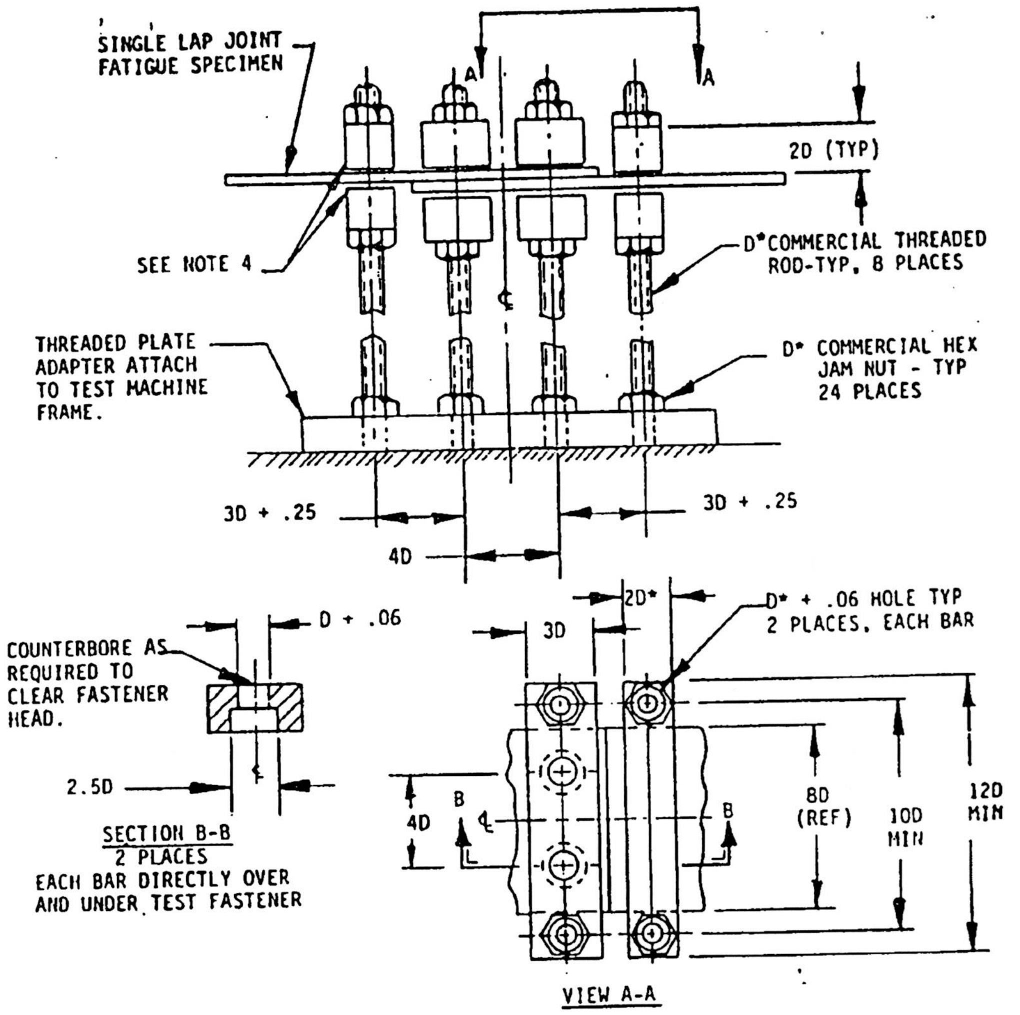
5.1.2.3 Fatigue test type. Unless otherwise specified the load applied shall be sinusoidal constant amplitude.

5.1.2.4 Load ratio. The load ratio for the 100% load transfer joint (figure 5) shall be +0.1 for the low and no load transfer joint, -0.05 (figures 6 and 7).

5.1.2.5 Test speed. The maximum test speed shall be selected which will not cause the specimen temperature to exceed 150°F.

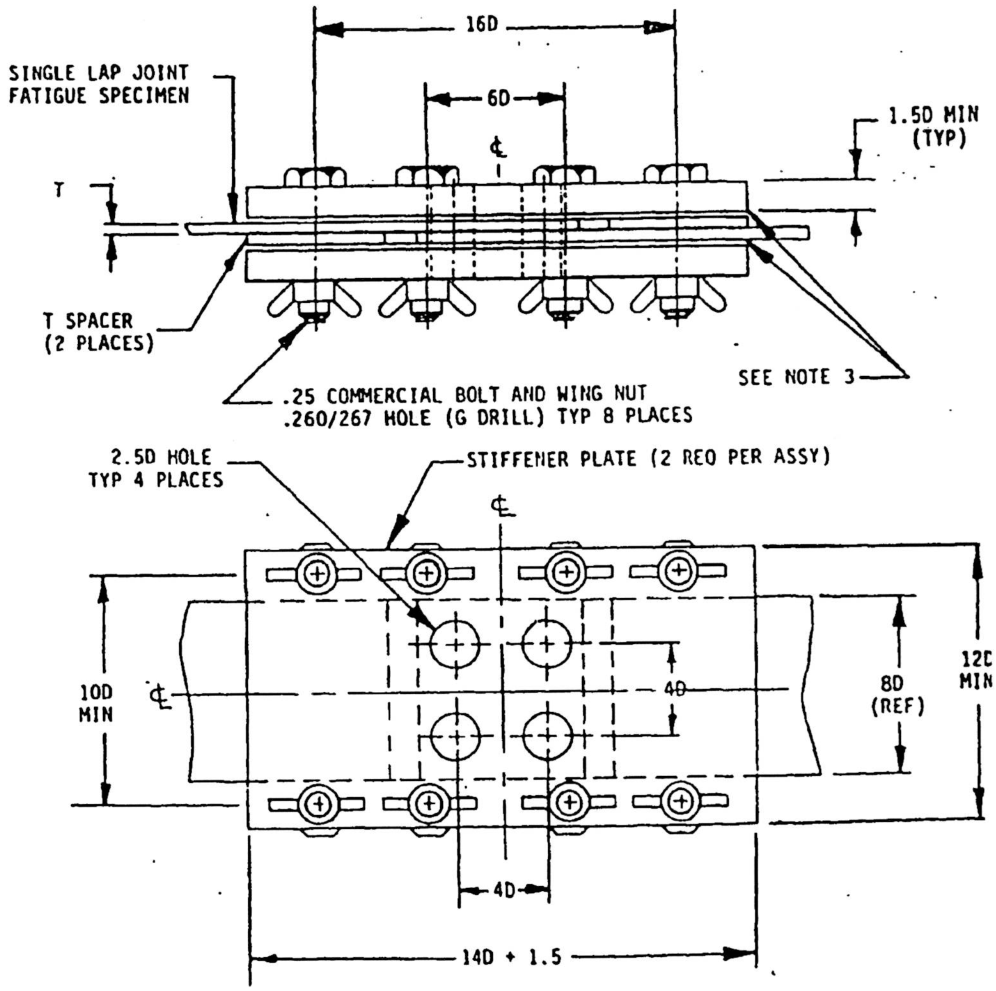
5.1.2.6 Specimen restraints. To preserve the initial alignment a restraint of the type shown in figure 8 or figure 9 shall be used with the high load transfer specimen shown in figure 5. Care shall be taken in the use of either device to assure that the restraint does not transfer a portion of the load. In testing fasteners (dia 5/16) installed in high strength materials, UTS 90 KSI, difficulty will be experienced in maintaining initial specimen alignment in test machine regardless of type restraint used.

5.1.2.7 Failure. The specimen will be considered to have failed when the test machine will no longer maintain the load due to failure of the specimen.



NOTES:
1. D = Nominal fastener dia under test.
2. D* = Minimum for these dimensions = 0.188.
3. Rod and bar material - mild steel.
4. Teflon, nylon, micarta, etc., must be interfaced between bars and test specimen surface.

FIGURE 8. Specimen restraint fixture (flexure pivot/90° offset).



NOTES:
1. D = Nominal fastener dia under test.
2. Stiffener plate and bolt material - mild steel.
3. Teflon, nylon, micarta, etc., material must be interfaced between stiffener plates and test specimen surfaces.
4. Tighten wing nuts only finger tight.

FIGURE 9. Specimen restraint fixture (sandwich type).

6. NOTES

6.1 Test report. The test report shall include the following data:

a. Description of the fastener and part number (and component if more than one piece).

b. Actual measured diameter of each fastener.

c. Fastener material by alloy and condition.

d. Fastener lot identification.

e. Sheet material by alloy and condition.

f. Sheet thickness (actual).

g. Hole size - individual measurements of each hole.

h. Sheet-hole corner radius for protruding head fasteners.

i. Actual interference level and method used in determination.

j. Specimen configuration.

k. Description of actual test installation such as special techniques, installation torque, special tools and conformance to any applicable specification.

l. Primer thickness.

m. Static data sheet and joint determination by paragraph 4.2.4 and paragraph 5.1.2.1.

n. Gross area stress level and load ratio.

o. Type of test restraints.

p. Actual value of cycles to failure.

q. Description and location of failure mode.

r. Machine test speed.

s. Machine manufacturer and type.

t. Machine calibration date.

u Gap.

v. Mill certification of sheet composition.

6.2 Preparation of data. The data shall be plotted on semi-log paper with the load as the ordinate on the linear scale and cycles to failure as the abscissa on the logarithmic scale. Actual cycles to failure shall be shown versus the applied maximun load stress.