METRIC

MIL-STD-3059 (MR)

22 November 2018

DEPARTMENT OF DEFENSE
TEST METHOD STANDARD

ACCEPTANCE CRITERIA FOR ADHESIVES FOR HIGH-LOADING RATE APPLICATIONS

AMSC N/A **AREA 8040**

FOREWORD

1. This specification is approved for use by the Department of the Army and DLA and is available for use by all Departments and Agencies of the Department of Defense.

2. The purpose of this standard provide acceptance criteria for adhesives to be used for bonding applications in ground vehicle platforms subjected to high-loading rate impact events. The adhesives will be screened for potential usage over a very broad performance spectrum to provide Army engineers, scientists, and researchers with the direction needed to meet operational priorities in a timely manner. Any deviation from the process details must be justified, fully documented, and submitted to the governing authority.

3. This standard will provide guidance for performance-based evaluation and grouping priority assignments/categorization of adhesives for high-loading-rate applications relevant to U.S. Army needs. All personnel working on adhesive development, fabrication, testing, characterizing, and evaluating adhesives for bonding applications will benefit from this test method standard. The objective is to reduce the certification time for new materials. Rationale and history for this Standard is documented in ARL-SR-0371 (Adhesives: Test Method, Group Assignment, and Categorization Guide for High-Loading-Rate Applications – History and Rationale).

4. Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Specifications and Standards Office, Attn: RDRL-WMM-C, Aberdeen Proving Ground, MD 21005-5069. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil/.

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1. SCOPE

1.1 Purpose. The purpose of this standard is to develop a test method that will assist in the evaluation and priority assignment of candidate adhesives for high-loading rate applications. It will provide minimal acceptance criteria for adhesives to be used on ground vehicle platforms for high-loading rate applications. The adhesives will be screened for potential usage over a very broad performance spectrum to provide Army engineers, scientists, and researchers with the direction needed to meet operational priorities in a timely manner. Any deviation from the process details must be justified, fully documented, and submitted to the governing authority.

1.2 Scope. This test method standard will provide the guidelines for assessing adhesives in the laboratory. All researchers performing adhesives development and evaluation work in the laboratory must follow the procedures outlined herein.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests.

(Copies of these documents are available online at https://quicksearch.dla.mil/.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ARMY REGULATIONS

Army Regulation (AR) 25-400-2	-	The Army Records Information System (ARIMS)

(Copies of these documents are available online at https://dmna.ny.gov/milpay/forms/AR_25_400_2.pdf.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM D1002	-	Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal).
ASTM D1151	-	Standard Practice for Effect of Moisture and Temperature on Adhesive Bonds
ASTM D5229/D5229M	-	Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
ASTM E865	-	Standard Specification for Structural Film Adhesives for Honeycomb Sandwich Panels

(Copies of these documents are available online at http://www.astm.org.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION Publications

ISO/IEC 2382:2015(en)	-	Information technology – Vocabulary
ISO 13008	-	Information and documentation – Digital records conversion and migration process.

(Copies of this document are available from http://www.iso.ch.)

SAE INTERNATIONAL STANDARDS / Aerospace Material Specifications

SAE AMS 3695	-	Adhesive Film, Epoxy Base, For High Durability Structural Adhesive

(Copies of these documents are available online at http://www.sae.org/.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Database. As stated within ISO/IEC 2382:2015(en), a database should be "a collection of data organized according to a conceptual structure describing the characteristics of these data and relationships among their corresponding entities, supporting one or more application areas."

3.2 Digital Archive. The term "digital archive" should be referred to as an electronic repository of digital data and metadata "to preserve the authenticity, reliability, integrity, and usability of such records" as stated in ISO 13008:2012(E).

3.3 Scope. The term "group," when referring to adhesives, should be defined as a collection of adhesives meeting designated property requirements; the term is based upon recognized testing

standards. Group requirements are intended to show correlation against response measured in nonstandard Army testing configurations. For example, the groups defined in this Standard define property regions from bonded single-lap-joint tensile tests with performance in bonded armor configurations tested against ballistic threats. Grouping assignments/ categorizations of adhesives are intended to be amendable as Army needs change or are further refined. The grouping assignment/categorization is independent of the adhesive's chemical, processing, application, and property data and is based exclusively on single-lap-joint tensile data and performance. Multiple grouping assignments/categorizations for a given adhesive are possible under this convention. Therefore, an adhesive could potentially be assigned simultaneous high- and low-priority groups in differing Standards, depending on the chemical, processing, application, or property data used in the specific correlation. For example, adhesive requirements for armor and munitions have different properties. Therefore, evaluation places different weights on distinct performance characteristics. Grouping requirements/categorizations are specified using conventionally accepted testing standards, which are elaborated upon further within this Standard. The intention is to facilitate communication of U.S. Army–specific property requirements for research and development to industry, as well as academia.

3.4 Material Pedigree. The term "material pedigree" should refer to the documentation used to ensure the traceability of an adhesive and its constitutive formulation ingredients to the original manufacturer.

3.5 Metadata. Per ISO/IEC 2382:2015(en), the term "metadata" pertains to "data elements, possibly including their data descriptions, and data about data ownership, access paths, access rights and data volatility."

3.6 Tier. The term "tier" should be considered a layer of testing protocols used to progressively characterize adhesive response. Each successive tier level requires an increasing commitment because of increasing experimental and analysis complexity.

4. GENERAL REQUIREMENTS

4.1 Records. Per Army Regulation (AR) 25-400-2, all records (including data and associated metadata) are assumed to "have value beyond the business process, such as for historical, lessons learned, or research purposes; these are generally long-term records." Records will be kept in physical laboratory notebooks and digitally archived for permanent retention, consistent with AR 25-400-2 code "TP" (i.e., Transfer Permanent).

4.2 Method Used to Characterize and Evaluate Adhesives. The method to characterize and evaluate an adhesive is a tiered system approach, whereby the adhesive is characterized and evaluated through standardized tests following a progression of increasing experimental difficulty. The first tier testing represents an initial screening level for the candidate adhesive, which must be passed to warrant further investment in the progressively more involved higher-tier screening levels. Advancement through the testing tiers is entrusted to the discretion of the researcher(s). The testing standards referenced in each tier are used as guidelines and should be followed when applicable. Deviations from the testing standards must be fully noted and accepted by the governing authority.

4.3 Adhesive Groups. Adhesives will be assigned and categorized according to the following groups based on single-lap-joint tensile performance at room temperature (RT) under dry

conditioning per sample preparation and testing procedures specified in ASTM D1002. Detailed sample preparation guidance can be found in ARL-SR-0356 (Adhesives: Test Method, Group Assignment, and Categorization Guide for High-Loading-Rate Applications – Preparation and Testing of Single Lap Joints). Samples are to be stored in a desiccator cabinet or sealed in moisture-resistant sample bags immediately following sample preparation, with continued moisture-free storage until testing. Displacement at failure is not specified in ASTM D1002 but is required for grouping assignment/categorizing in this Standard and shall be defined as the following.

4.3.1 Group I. Group I adhesives shall be categorized as having a maximum strength greater than or equal to 10.0 MPa (1450 psi) and a minimum complete failure displacement limit greater than 3.81 mm (0.15 in); (e.g., $d_{failure} > 3.81$ mm [0.15 in] and $S_{max} \geq 10.0$ MPa [1450 psi]).

4.3.2 Group II. Group II adhesives shall be categorized as also having a maximum strength greater than or equal to 10.0 MPa (1450 psi), yet their complete failure displacement limits fall between the range of greater than or equal to 1.60 mm (0.063 in) and less than or equal to 3.81 mm (0.15 in); (e.g., 1.60 mm [0.063 in] $\leq d_{failure} \leq$ 3.81 mm [0.15 in] and $S_{max} \geq 10.0$ MPa [1450 psi]).

4.3.3 Group III. Group III adhesives shall be categorized with a maximum strength greater than or equal to 10.0 MPa (1450 psi) but producing complete failures at a displacement less than 1.60 mm (0.063 in); (e.g., $d_{failure} < 1.60$ mm [0.063 in], $S_{max} \geq 10.0$ MPa [1450 psi]).

4.3.4 Group IV. Group IV adhesives shall be categorized as having a maximum strength less than 10.0 MPa (1450 psi) regardless of the amount of displacement at complete failure.

Adhesive grouping rejoins associated with their maximum strength versus displacement at complete failure is represented in FIGURE 1.

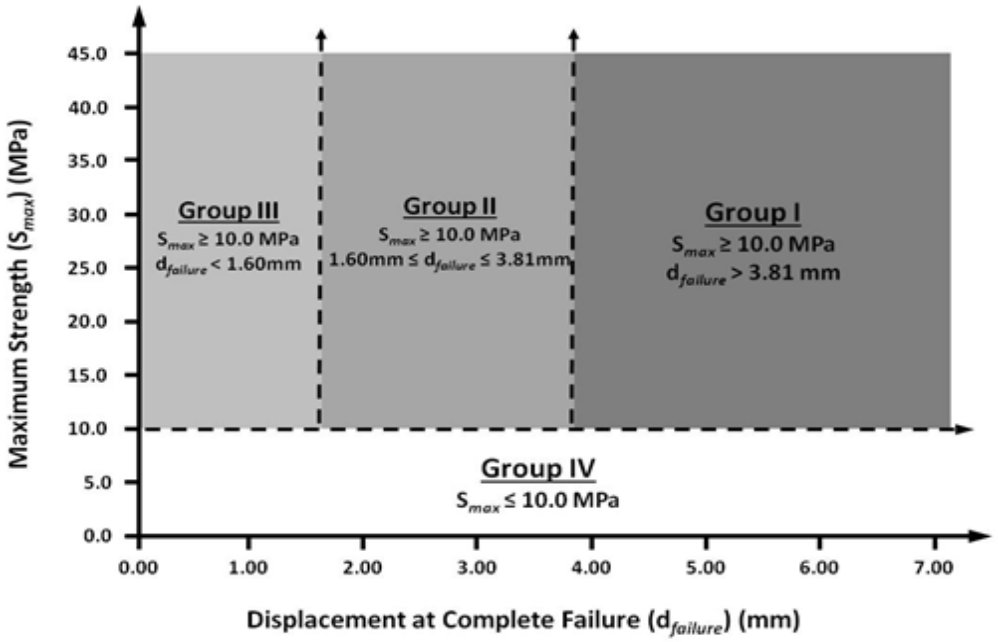


FIGURE 1. Adhesive groups based upon S_{max} and $d_{failure}$ for single-lap-joint performance at RT (dry conditioning).

5. DETAILED REQUIREMENTS

5.1 Tier I. Single-Lap-Joint Test at Room Temperature (Dry Conditioning). The single-lap-joint test specimen per ASTM D1002 is a convenient geometry for screening adhesive performance. An illustration of a typical test specimen is shown in FIGURE 2. The distribution of stress is non-uniform, and fundamental constitutive adhesive properties are difficult to derive. However, the overwhelming experimental simplicity, with respect to both fabrication and testing, heavily favors the single-lap-joint geometry as an initial screening configuration. Likewise, this joint geometry has also been studied extensively by academia, with numerous peer-reviewed literature results and modeling strategies available for comparison. The single-lap-joint is also a favored industry standard.

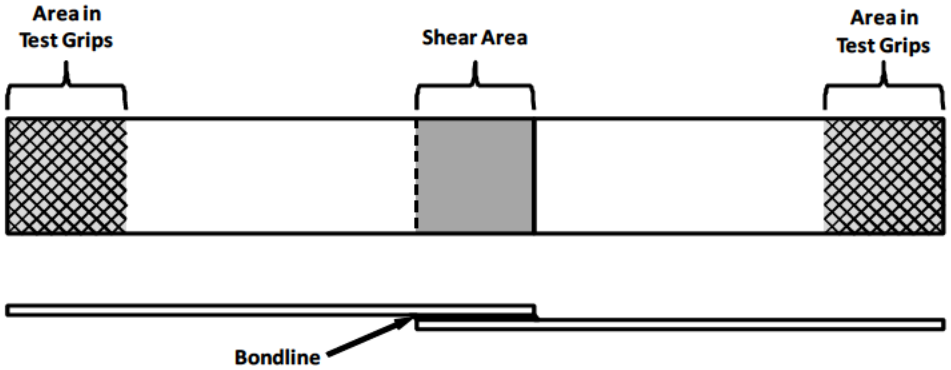


FIGURE 2. Illustration of the adhesively bonded single-lap-joint test specimen configuration (refer to ASTM D1002 for dimensions).

The specimen is placed within a mechanical testing machine and held into place at its ends by mechanical grips. Tensile load is applied until the joint fails. The maximum effective strength (S_{max}) of the adhesive joint is defined as the maximum load (P_{max}) per shear area. Displacement at failure ($d_{failure}$) is taken directly from the crosshead displacement of the testing machine. A typical load versus displacement curve showing P_{max} and $d_{failure}$ is illustrated graphically in FIGURE 3.

5.2 Tier II – Part 1. Single-Lap-Joint Testing After Hot/Wet Conditioning. This first part of the second tier test requires submersion of lap-joint specimens (i.e., non-ambient moisture conditioning) in a water immersion tank for fourteen (14) days at a constant temperature of 63 °C, +/–3 °C (145 °F, +/–5 °F). At the completion of the conditioning, specimens will be pat-dried and tested no later than thirty (30) minutes after being removed from the water immersion tank. As in the first tier, single-lap-joint tensile test data will be obtained via a mechanical testing machine at RT and at ambient air conditions as per ASTM D1002. Test duration and conditioning temperature is based upon considerations referenced in MIL-STD-810G, Laboratory Test Method 507.5, Humidity. Experimental technique considerations can be found in ASTM D5229/D5229M, ASTM D1151, and ASTM E865.

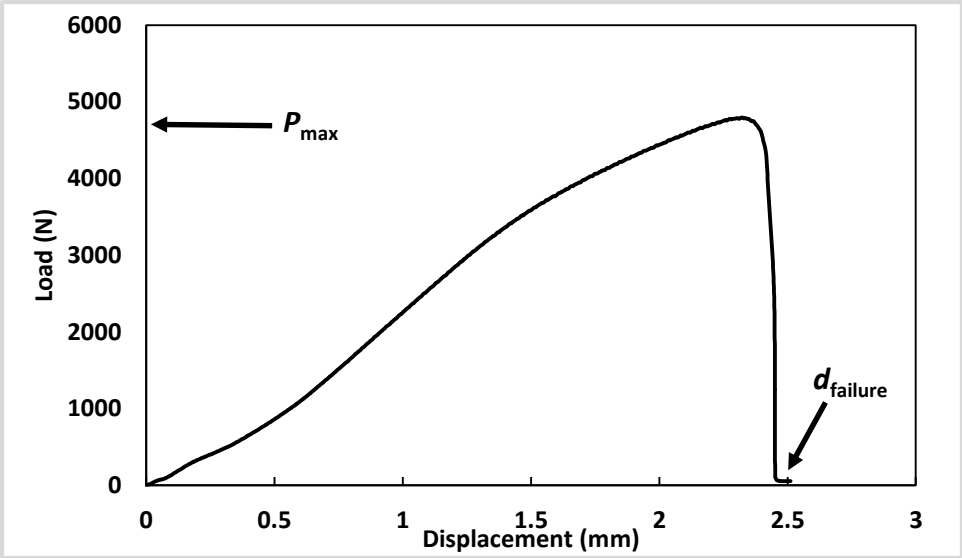


FIGURE 3. Graphical representation of P_{max} and $d_{failure}$ for a single-lap-joint tensile load versus displacement curve.

5.2.1 Requirements. Acceptance to the next tier of testing requires that second tier, part one conditioned adhesives retain a minimum of 75% of their initial dry maximum strength measured in first tier testing, section 8.2.2. It is important to note that group assignment/categorization is entirely based upon the initial S_{max} and $d_{failure}$ at RT at dry conditioning. Displacement at failure following hot/wet conditioning will be digitally archived but will not alter the First Tier group determination. Likewise, if S_{max} (RT, dry) for a given Group I, II, or III adhesive is at or just above 10.0 MPa (1450 psi) then measurement of the 75% strength retention following hot/wet conditioning will not reassign the adhesive to Group IV.

5.3 Tier II – Part 2. Single-Lap-Joint Testing at Elevated Temperature. Second tier, part two, tests shall progress by testing fabricated samples at an elevated temperature condition of 71 °C, +/–3 °C (160 °F, +/–5 °F) using an in situ heated test chamber on the mechanical testing frame. Prior to loading specimens, the test chamber shall be heated for at least forty five (45) minutes to ensure the chamber air and mechanical components of the mechanical testing machine, such as grips, are at temperature and are stable, as measured by a thermocouple probe/sensor. Once a sample is loaded within the heated chamber, but prior to tensile testing, it shall be held in situ for at least ten (10) minutes until it reaches temperature equilibrium and is stable as measured by a thermocouple probe/sensor. The temperature of the test is based upon considerations referenced in MIL-STD-810G, Laboratory Test Method 501.5, High Temperature. Experimental technique considerations can be found in ASTM D1151 and ASTM E865.

5.3.1 Requirements. Acceptance to the next tier of testing also requires that second tier, part two conditioned adhesives retain a minimum of 50% of their dry maximum strength as measured in section 5.1. As in section 4.3, group assignments/categorizations are based upon the initial S_{max} and $d_{failure}$ at RT and dry conditioning results. Displacement at failure at elevated temperature will be digitally archived but will not alter the First Tier group determination. Likewise, if S_{max} (RT, dry) for a given Group I, II, or III adhesive is at or just above 10.0 MPa (1450 psi), then measurement of the 50% strength retention at elevated temperature will not reassign the adhesive to Group IV.

Adhesives that pass Tier I, II, and III requirements may be considered conditionally qualified. Test data, associated experimental metadata, and materials pedigree information for the adhesives will be submitted by the vendor for consideration review and digital archive to usarmy.APG.arl.mbx.adhesive-research@mail.mil

5.4 Tier III. Crack Extension Test. Mode I tensile strain energy release rate while undergoing stress corrosion cracking (G_{ISCC}) will be performed, as described in SAE-AMS-3695. Double cantilever beam (DCB) samples shall be prepared by bonding two 300 mm x 350 mm 2024-T3 aluminum plates with a separator film (25 mm – 38 mm) along one edge, per SAE-AMS-3695, as shown in FIGURE 4. Plate thicknesses shall be 12.7 mm. Samples shall be cut into widths of 25.4 mm. Tapped bolts will be used to initiate an opening displacement (y) of 2.54 mm. FIGURE 5 shows the DCB test specimen configuration. Samples will be exposed to elevated temperature and moisture conditions of 60 °C, +/–1.1 °C (140 °F, +/–2 °F) and 100% relative humidity (RH) for 5 weeks, as specified by SAE-AMS-3695/1.

5.4.1 Requirements. G_{ISCC} is determined at a constant loading tip displacement (y) by measuring the crack length (a) upon completion of 5 weeks of elevated temperature humidity exposure. The minimum acceptable value of G_{ISCC} after 5 weeks of exposure is 0.61 KJ/m^2 (3.5 in lb/in^2), as specified in SAE-AMS-3695. G_{ISCC} can be found using the following equation.

$$G_{ISCC} = \frac{y^2 E h^3 [3(a + 0.6h)^2 + h^2]}{16[(a + 0.6h)^3 + ah^2]^2}$$

where:
y = opening displacement, 2.54 mm (0.100 in)
E = Young's modulus, 73.08 GPa[1] (10600 ksi) for 2024-T3 aluminum
h = height of one beam, 12.7 mm (0.50 in)
b = width of one beam (not shown), 25.4 mm (1.0 in)
a = crack length measured from the loading point

The expression for G_{ISCC} (KJ/m^2) can be simplified by substituting constant values for y, E, and h.

$$G_{ISCC} = \frac{0.00096578\left[3\left({}^{a}/_{1000} + 0.00762\right)^2 + 0.00016129\right]}{16\left[\left({}^{a}/_{1000} + 0.00762\right)^3 + \left({}^{a}/_{1000}\right)0.00016129\right]^2}$$

Crack length (a) is measured in millimeters.

[1] *ASM Handbook, Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990.*

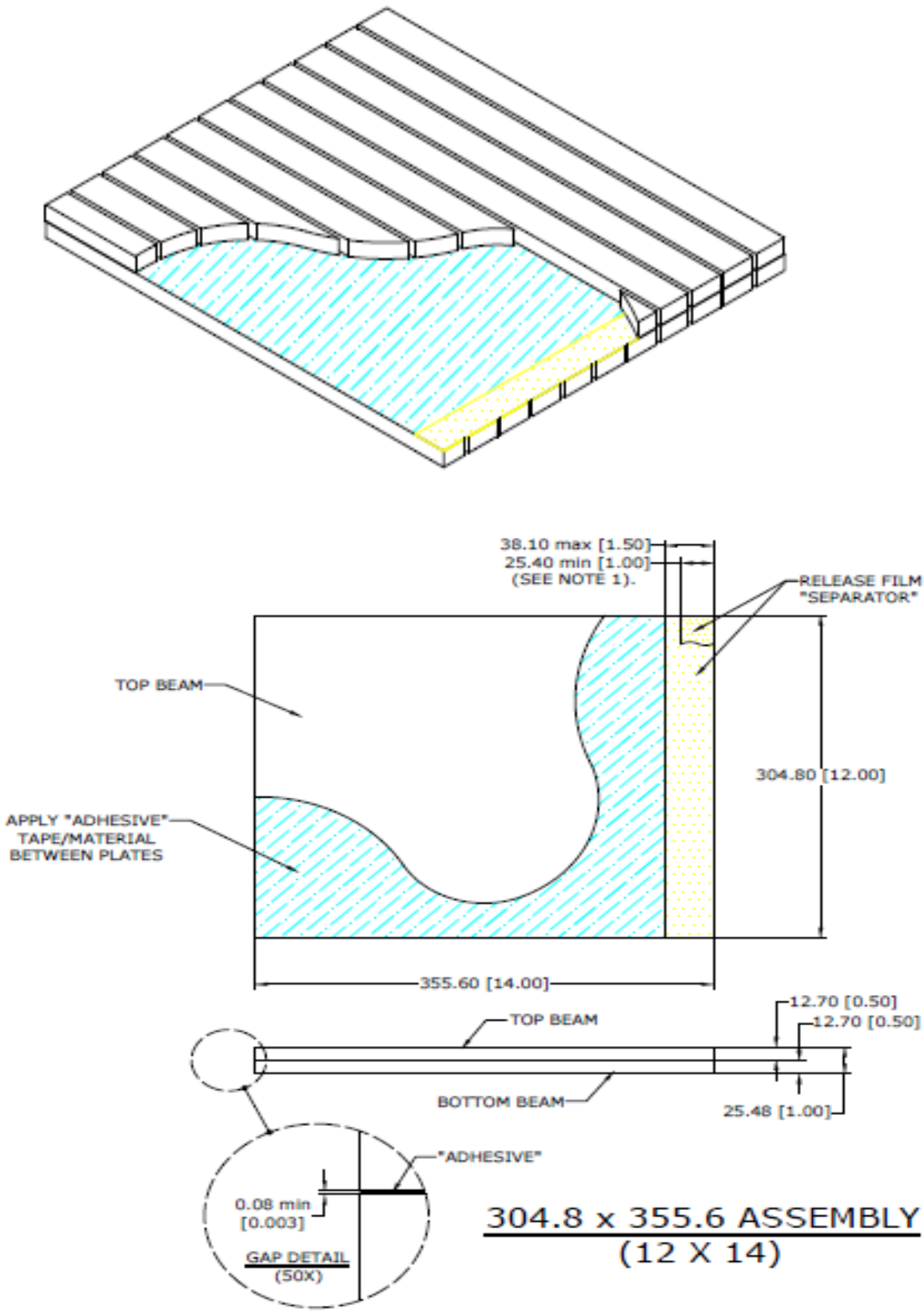


FIGURE 4. Bonded plate configuration for as specified by SAE-AMS-3695.

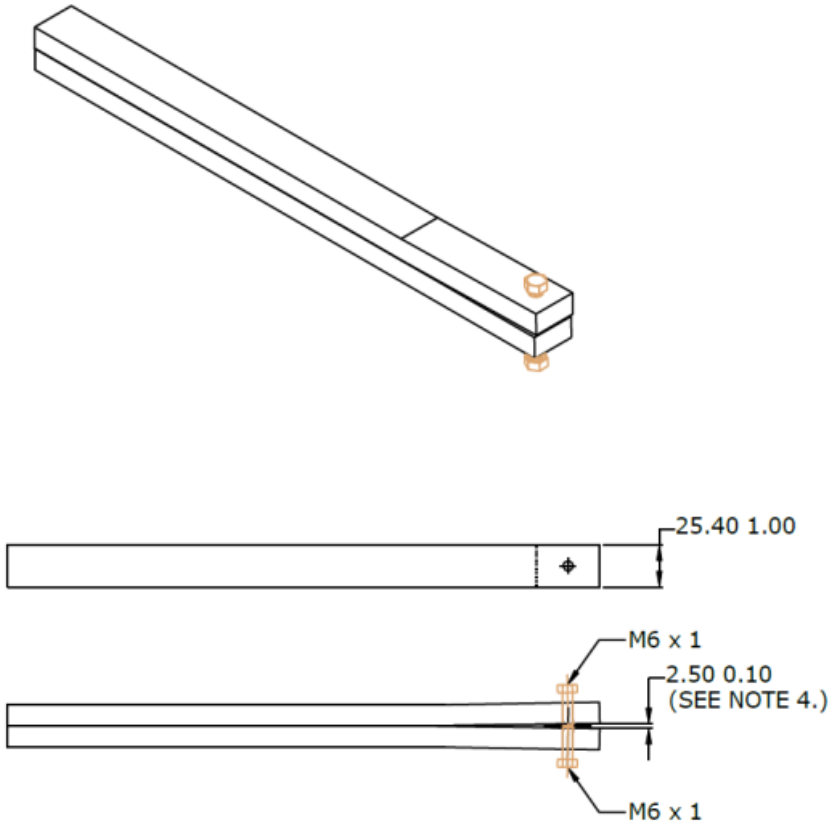


FIGURE 5. DCB sample configuration for environmental stress corrosion as specified by SAE-AMS-3695.

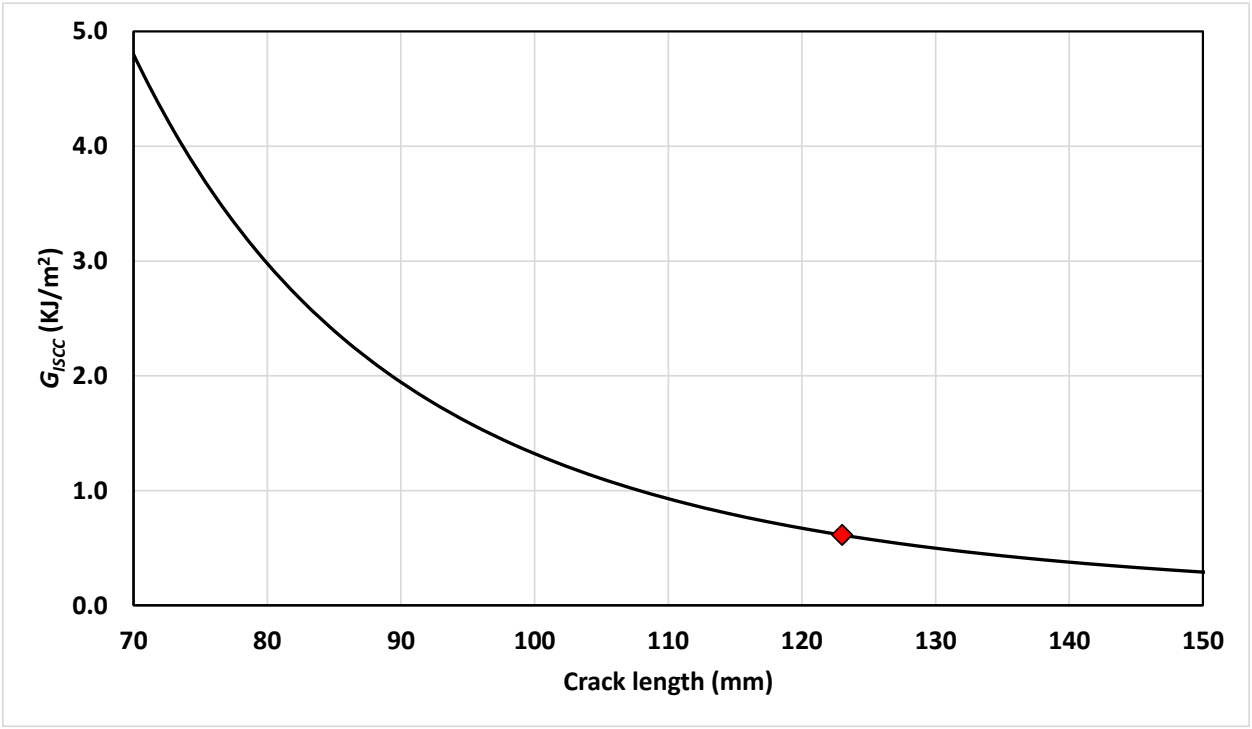


FIGURE 6. Plot of G_{ISCC} versus crack length showing G_{ISCC} = 0.61 KJ/m^2 at crack length (a) = 123 mm.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This military standard is intended to provide guidance for performance-based evaluation and grouping priority assignments/categorization of adhesives for high-loading-rate applications relevant to U.S. Army needs. All personnel working on adhesive development, fabrication, testing, characterizing, and evaluating adhesives for bonding applications will benefit from this test method standard.

6.2 Acquisition requirements. Acquisition documents should specify the title, number, and date of this standard.

6.3 Drawings. For viewing ease and use with computer-aided design software, supplemental test panel and tooling fixture drawings (as PDFs and DXFs) are attached as Appendixes.

A. SINGLE-LAP-JOINT TEST PANEL DIMENSIONS
   Drawing #1: Title: ASTM D1002 Optional Panel

B. SINGLE-LAP-JOINT TEST PANEL TOOLING FIXTURE DIMENSIONS
   Drawing #2: Title: Single-Lap-Joint Tooling Fixture
   Drawing #3: Title: Single-Lap-Joint Tooling Fixture – Top Plate
   Drawing #4: Title: Single-Lap-Joint Tooling Fixture – Bottom Plate
   Drawing #5: Title: Single-Lap-Joint Tooling Fixture – Dowel Pin
   Drawing #6: Title: Single-Lap-Joint Tooling Fixture – Shim Plate

C. CRACK EXTENSION TEST PANEL AND DCB DIMENSIONS
   Drawing #7: Title: Crack Extension Testing – SAE-AMS-3695 Assembly
   Drawing #8: Title: Crack Extension Testing – SAE-AMS-3695 DCB Detail

D. SINGLE-LAP-JOINT FABRICATION CHECK LIST

E. SINGLE-LAP-JOINT MECHANICAL TESTING CHECK LIST

F. SINGLE-LAP-JOINT BONDLINE THICKNESS MEASUREMENTS

G. CRACK EXTENSION TEST SAMPLE FABRICATION CHECK LIST

H. CRACK EXTENSION TEST ENVIRONMENTAL CONDITIONING CHECK LIST

I. CRACK EXTENSION TEST BONDLINE THICKNESS MEASUREMENTS

J. CRACK EXTENSION TEST CRACK LENGTH MEASUREMENTS

6.4 English units. When English divisions are required, units for meter, kilogram, meter per second, and mega Pascal may be converted to the English equivalent by multiplying them by the following conversion factors:

TABLE I. Metric SI to English unit conversion factors.

Metric SI unit	**Multiply by**	**Equals**	**English**
inch	0.0254	=	meter (m)
foot	0.3048	=	meter (m)
pound	0.4534	=	kilogram (kg)
feet/sec	0.3048	=	meter per second (m/s)
pounds/sq. inch	0.006895	=	mega Pascal (MPa)

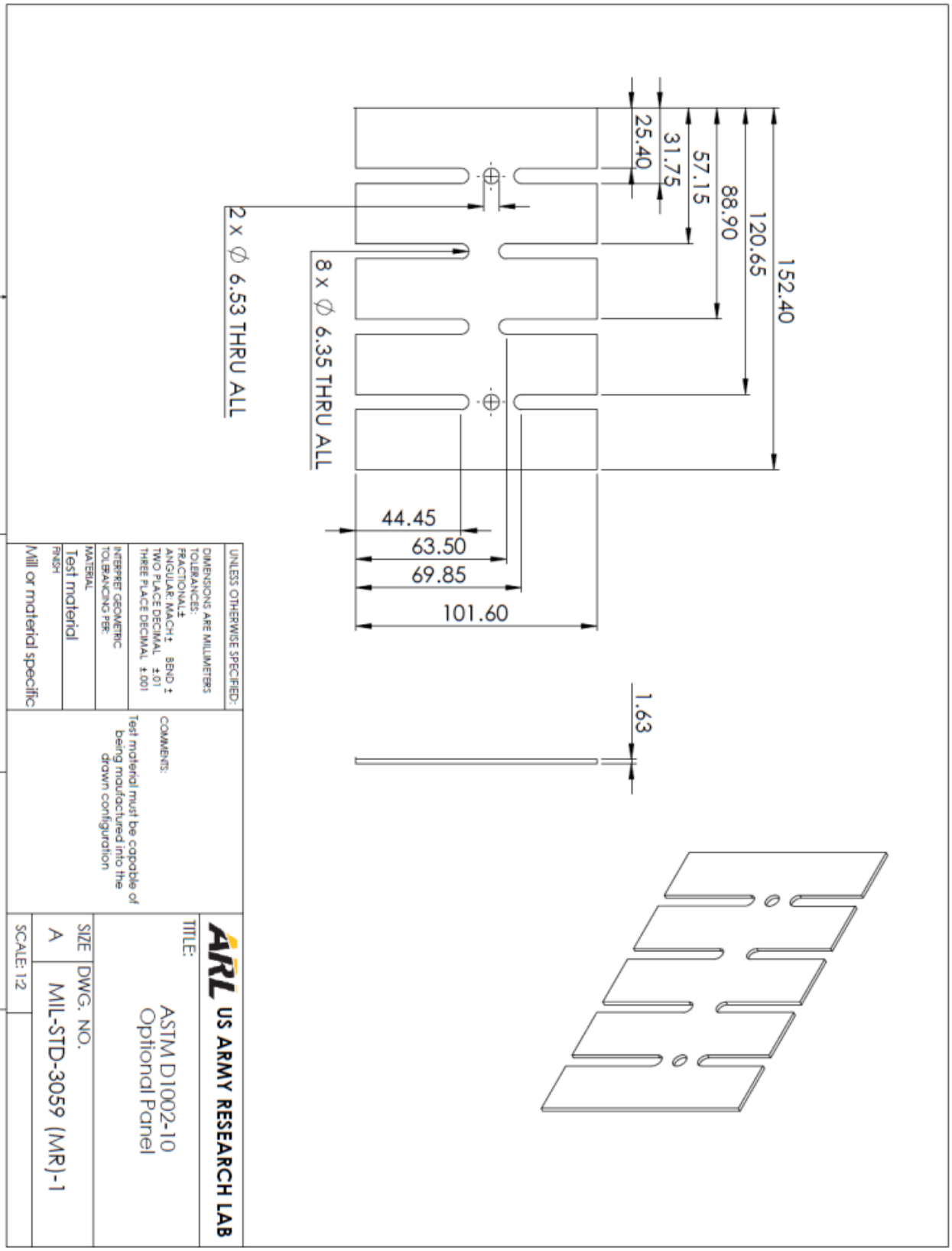
6.5 Subject term (key word) listing.

Adhesive
Database
Material pedigree
Metadata
Single lap joint
Testing

APPENDIX A

SINGLE-LAP-JOINT TEST PANEL DIMENSIONS

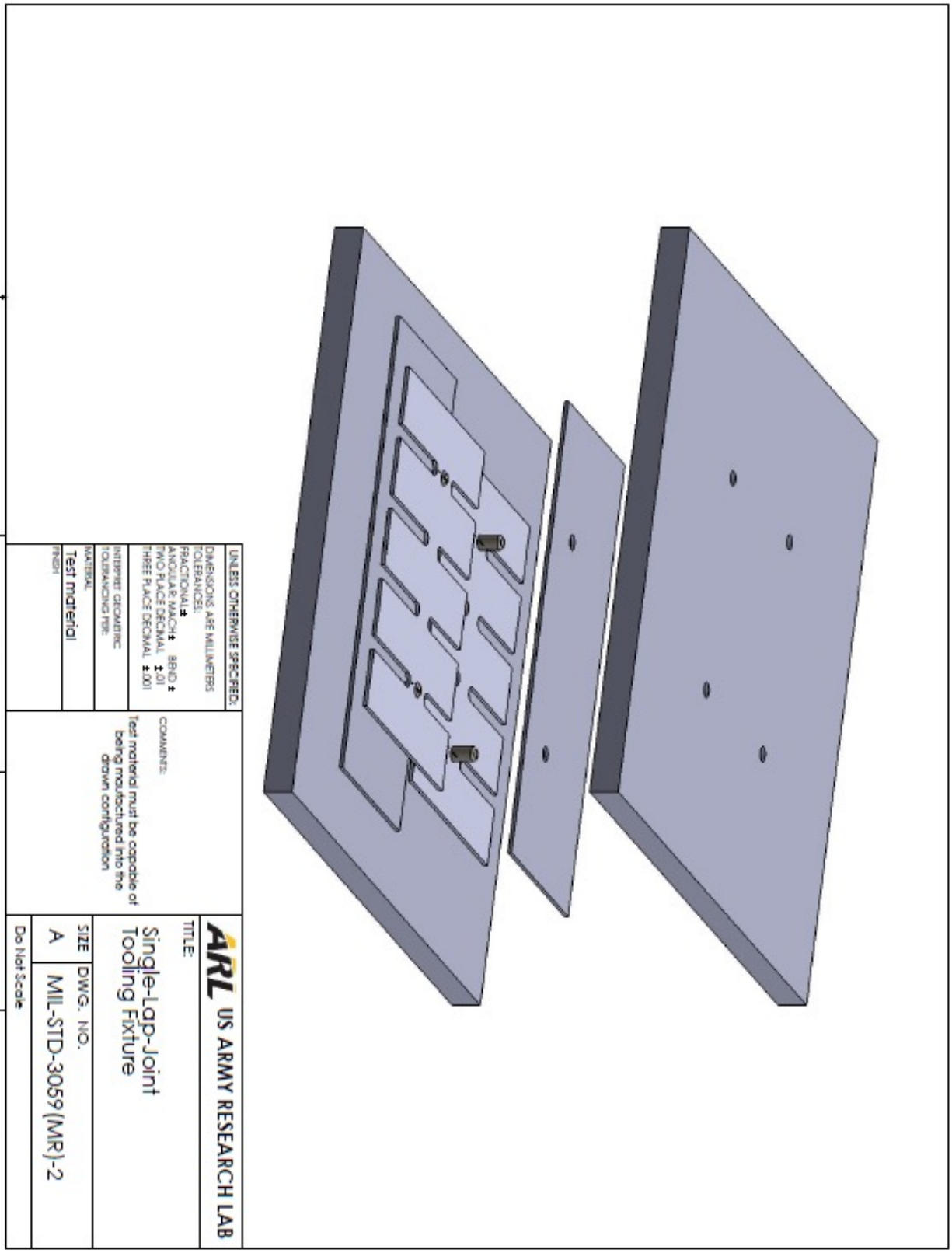
A.1 ASTM D1002 Optional Panel.



APPENDIX B

SINGLE-LAP-JOINT TEST PANEL TOOLING FIXTURE DIMENSIONS

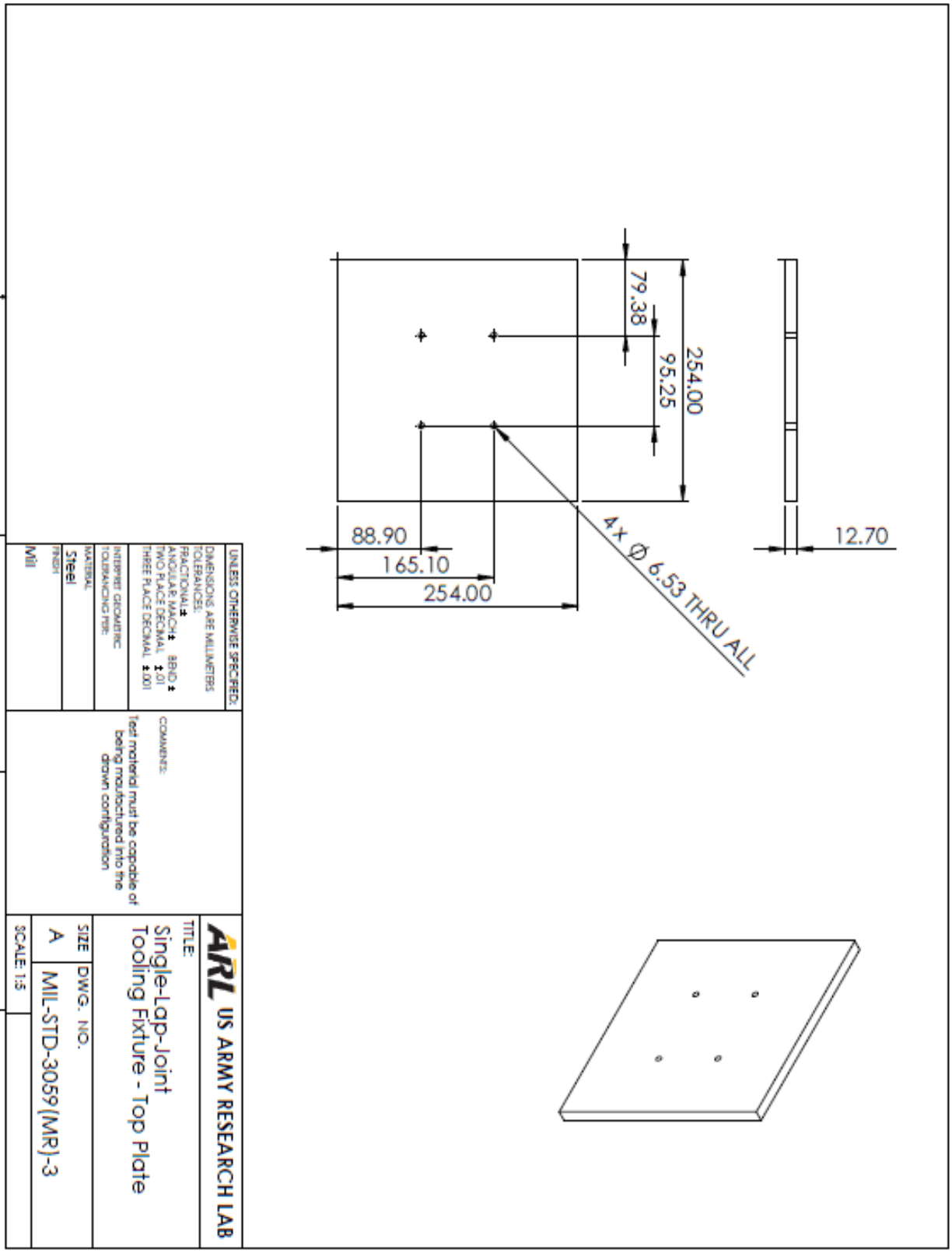
B.1 Single-Lap-Joint Tooling Fixture.



APPENDIX B

SINGLE-LAP-JOINT TEST PANEL TOOLING FIXTURE DIMENSIONS

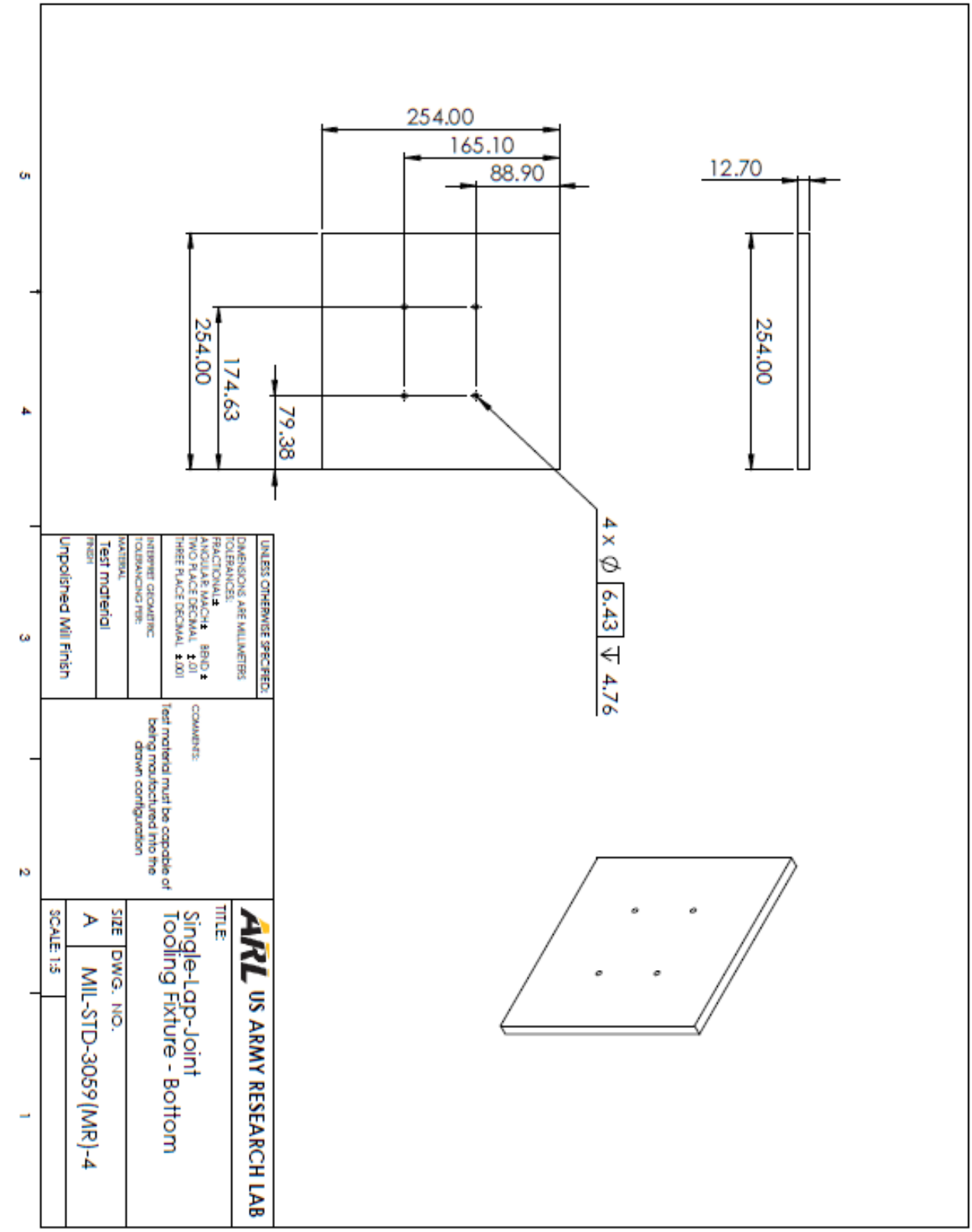
B.2 Single-Lap-Joint Tooling Fixture – Top Plate.



APPENDIX B

SINGLE-LAP-JOINT TEST PANEL TOOLING FIXTURE DIMENSIONS

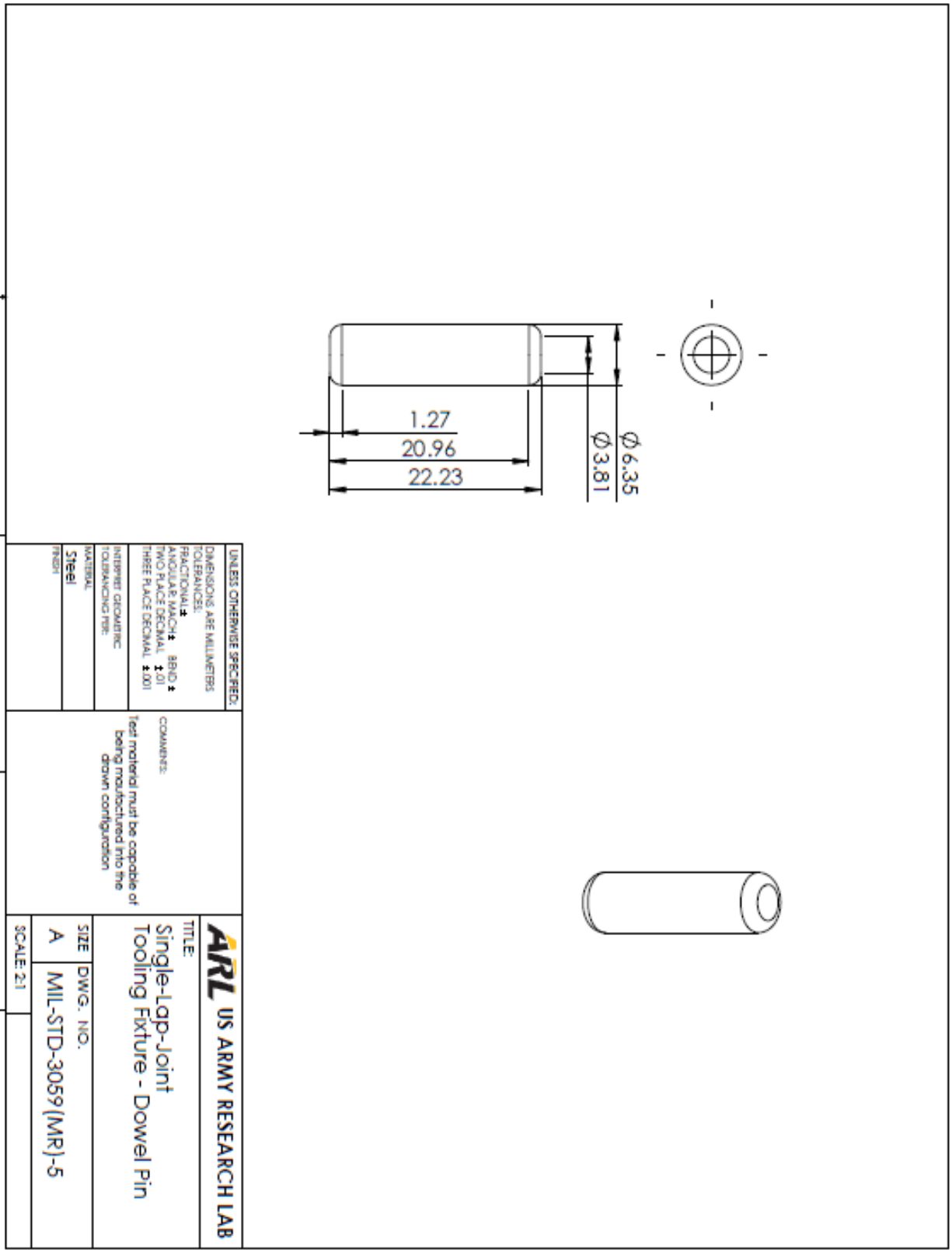
B.3 Single-Lap-Joint Tooling Fixture – Bottom Plate.



APPENDIX B

SINGLE-LAP-JOINT TEST PANEL TOOLING FIXTURE DIMENSIONS

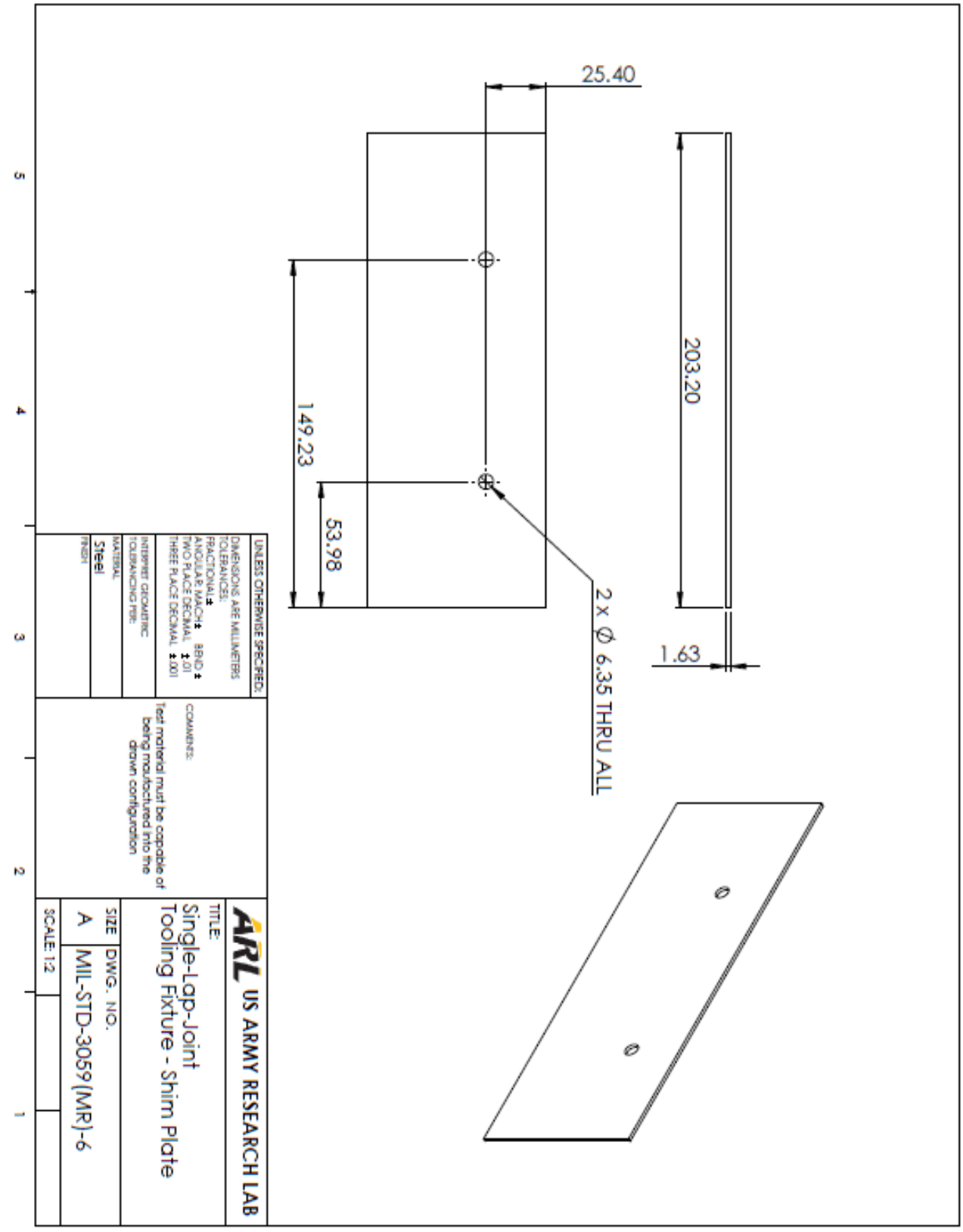
B.4 Single-Lap-Joint Tooling Fixture – Dowel Pin.



APPENDIX B

SINGLE-LAP-JOINT TEST PANEL TOOLING FIXTURE DIMENSIONS

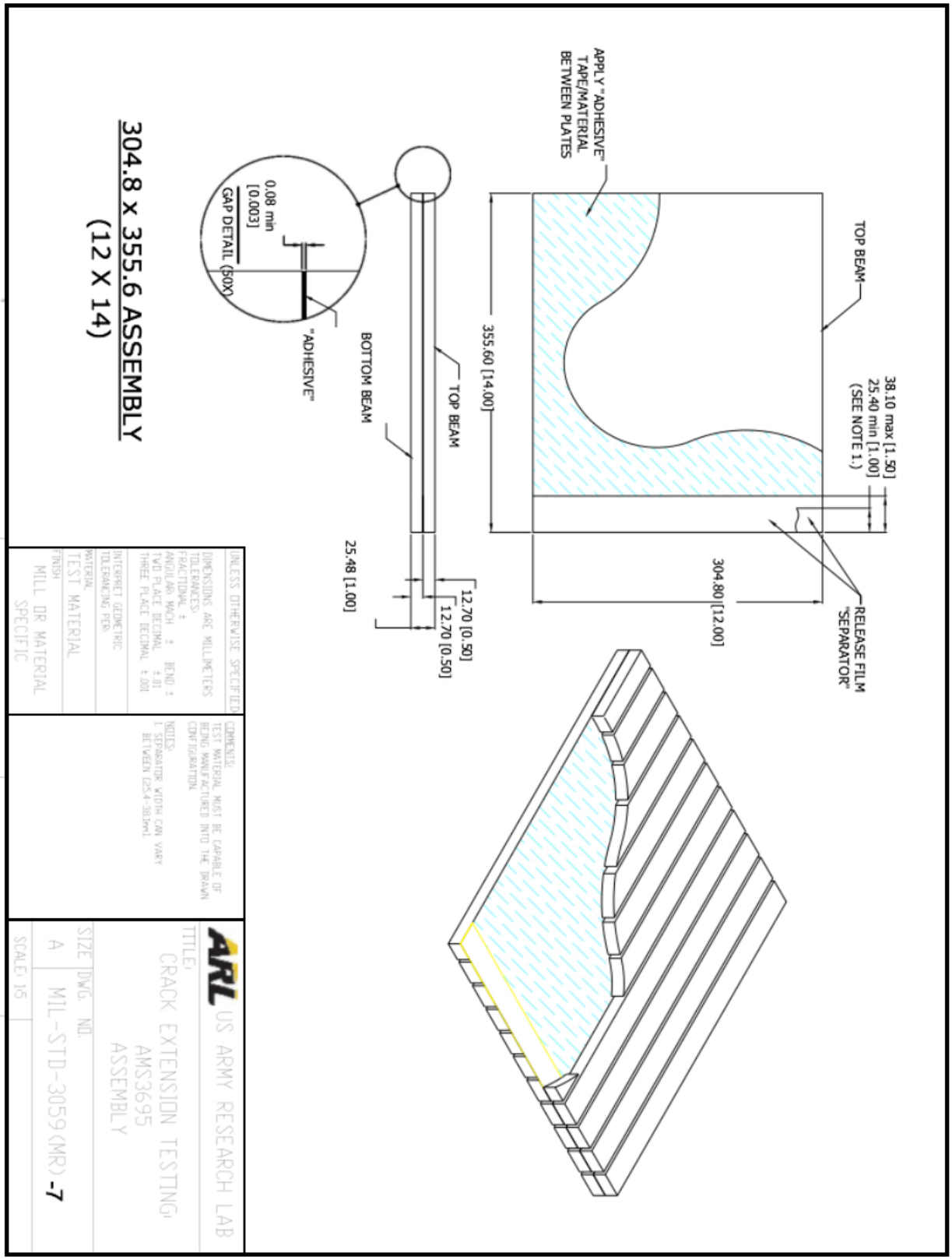
B.5 Single-Lap-Joint Tooling Fixture – Shim Plate.



APPENDIX C

CRACK EXTENSION TEST PANEL AND DCB DIMENSIONS

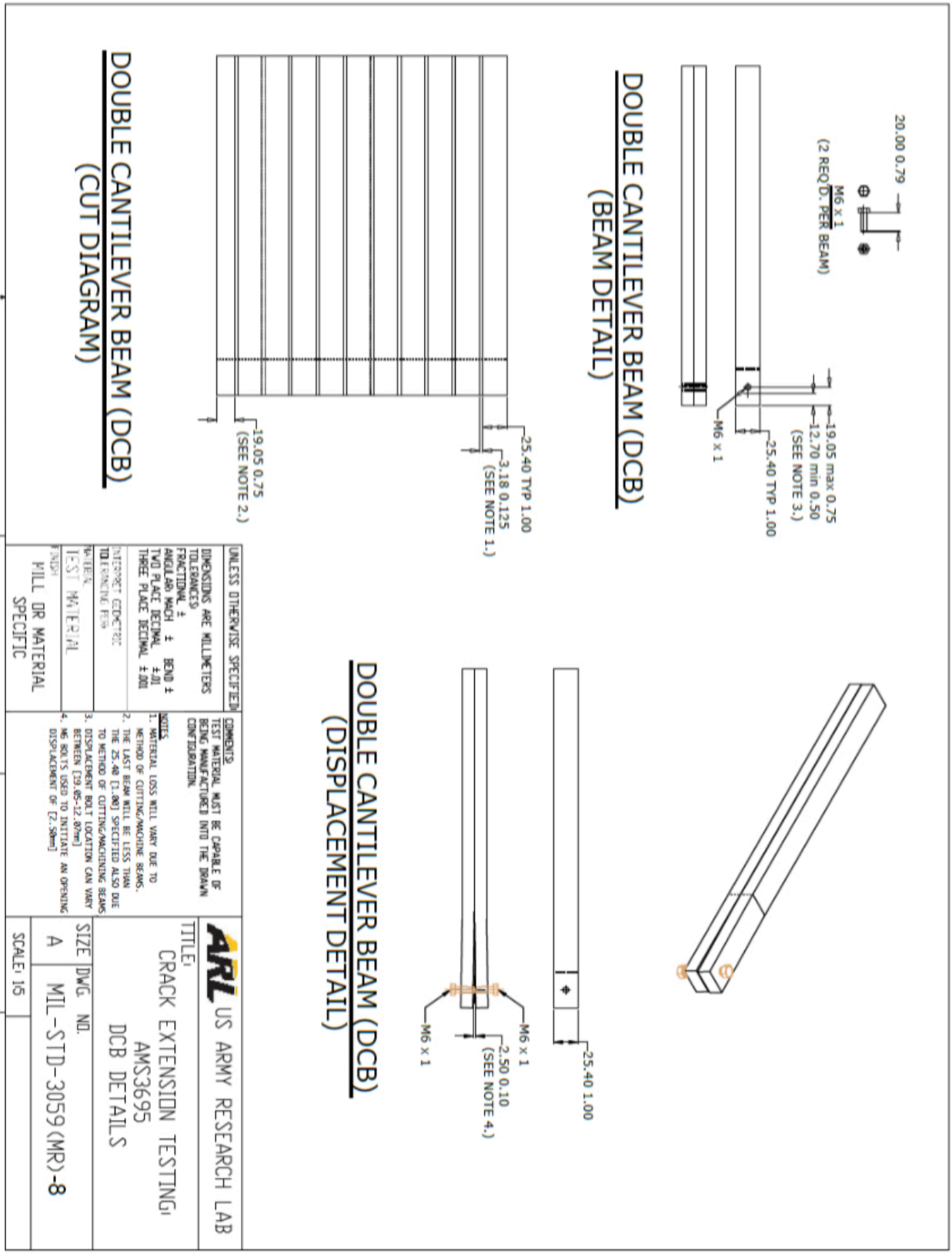
C.1 Crack Extension Testing – SAE-AMS-3695 Assembly.



APPENDIX C

CRACK EXTENSION TEST PANEL AND DCB DIMENSIONS

C.2 Crack Extension Testing – SAE-AMS-3695 DCB Detail.



APPENDIX D

SINGLE-LAP-JOINT FABRICATION CHECK LIST

Sample ID's:_____, _____, _____,_____,_____

Date: _____ Temperature:_____ Humidity_____

Testing facility and operator: _____

Adhesive, type, and form: _____

_____

Lot ID, manufacturer's code, expiration date: _____

_____

Method of cleaning and preparing bonding surface:_____

_____

_____

_____

_____

Adhesive preparation, application, and bonding conditions:

_____

_____

_____

_____

_____

Tooling fixture and bonding pressure notes: _____

_____

_____

Adhesive mixing to applied pressure time: _____

Cure cycle: _____

_____

_____

Oven used (model and serial number):_____

Conditioning procedure: _____

_____

_____

Comments:_____

_____

_____

_____

_____

_____

APPENDIX E

SINGLE-LAP-JOINT MECHANICAL TESTING CHECK LIST

Sample ID's:_____, _____, _____,_____,_____

Test date: _____ Test temperature:_____ Test humidity_____

Testing facility and operator: _____

Test frame model and serial number: _____

Test frame calibration date: _____

Load cell model and serial number: _____

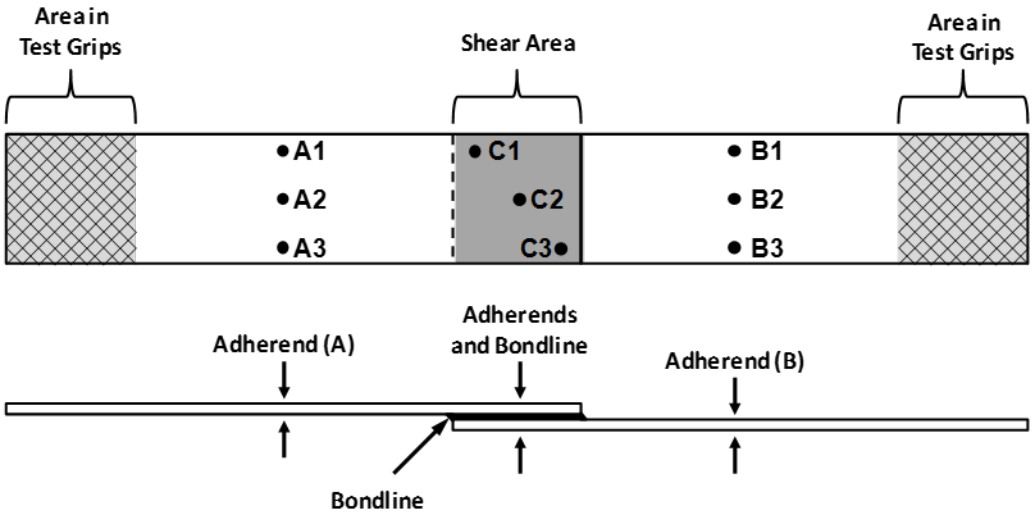
Load cell calibration date: _____

Crosshead speed: 1.3 mm/min (0.05 in/min), list other_____

Nature of failure and other comments:

APPENDIX F

SINGLE-LAP-JOINT BONDLINE THICKNESS MEASUREMENTS



Aluminum grade: _____ Mfg. nominal thickness:_____(mm – in)

Micrometer model, serial number, calibration date _____

_____

Measurement units (circle) – mm or in

Sample ID	**Adherend (A1)**	**Adherend (A2)**	**Adherend (A3)**	**Average (A)**
	Adherend (B1)	**Adherend (B2)**	**Adherend (B3)**	**Average (B)**
	Adherends and Bondline (C1)	**Adherends and Bondline (C2)**	**Adherends and Bondline (C3)**	**Average (C)**
				C – (A + B)
Comments		**Average bondline thickness**		

APPENDIX G

CRACK EXTENSION TEST SAMPLE FABRICATION CHECK LIST

Sample ID's:_____,_____,_____,_____,_____,
_____, _____,_____,_____,_____,_____

Date: _____ **Temperature:**_____ **Humidity**_____

Testing facility and operator: _____

Adhesive, type, and form: _____
_____

Lot ID, manufacturer's code, expiration date: _____

_____

Method of cleaning and preparing bonding surface:_____
_____
_____
_____
_____

Adhesive preparation, application, and bonding conditions:
_____
_____
_____
_____
_____

Plate alignment and bonding pressure notes: _____
_____
_____

Adhesive mixing to applied pressure time: _____

Cure cycle: _____
_____
_____

Oven used (model and serial number):_____

Conditioning procedure: _____
_____
_____

Comments:_____
_____
_____
_____
_____

APPENDIX H

CRACK EXTENSION TEST ENVIRONMENTAL CONDITIONING CHECK LIST

Sample ID's:_____,_____,_____,_____,_____,
_____, _____,_____,_____,_____,_____

Test start date: _____ **Test temperature:** _____ **Test humidity**_____

Test end date: _____ **Test temperature:** _____ **Test humidity**_____

Testing facility and operator: _____

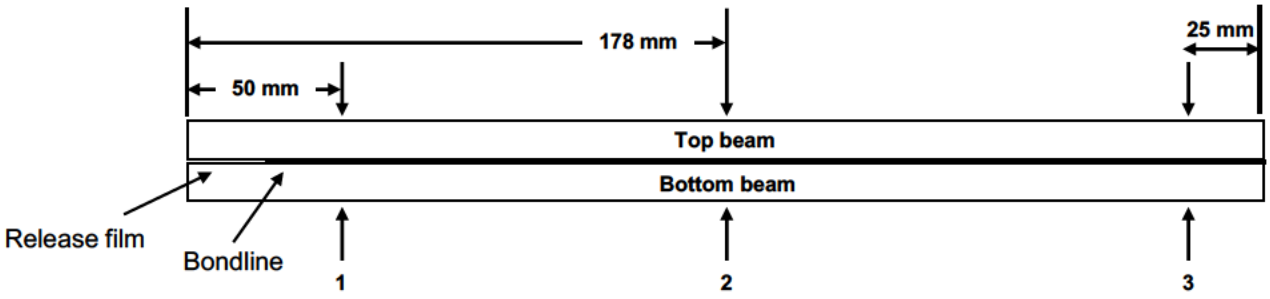
Environmental test chamber model and serial number: _____
_____

Environmental test chamber calibration date: _____

Nature of failure and other comments: _____

APPENDIX I

CRACK EXTENSION TEST BONDLINE THICKNESS MEASUREMENTS



Aluminum grade:_____ Mfg. nominal thickness:_____(mm – in)

Micrometer model, serial number, calibration date _____

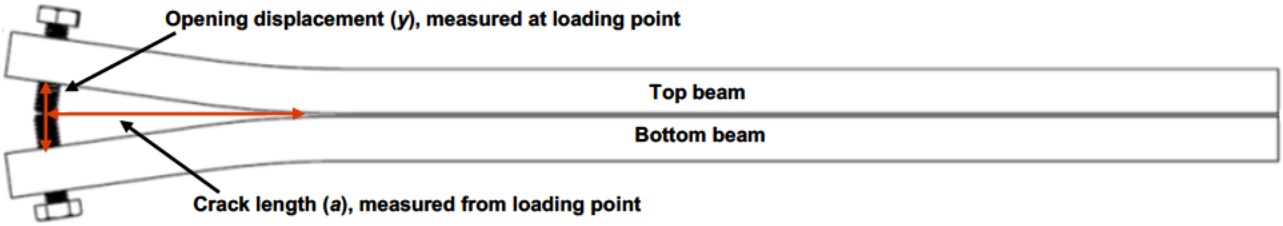
_____

Measurement units (circle) – mm or in

Sample ID	**Top beam height (A1)**	**Top beam height (A2)**	**Top beam height (A3)**	**Average (A)**
Comments	**Bottom beam height (B1)**	**Bottom beam height (B2)**	**Bottom beam height (B3)**	**Average (B)**
	Beam and Bondline (C1)	**Beams and Bondline (C2)**	**Beams and Bondline (C3)**	**Average (C)**
				C – (A + B)
		Average bondline thickness		

APPENDIX J

CRACK EXTENSION TEST CRACK LENGTH MEASUREMENTS



Micrometer model, serial number, calibration date _____

_____

Measurement units (circle) – mm or in

Sample ID	$a_{initial}$ **(side 1)**	a_{final} **(side 1)**
Opening displacement (*y*)	$a_{initial}$ **(side 2)**	a_{final} **(side 2)**
Conditioning time (hours)	$a_{initial}$ **(average)**	a_{final} **(average)**
Mode-of failure (circle) – adhesive cohesive mixed-mode _____% adh. _____% coh.		
Comments:		

CONCLUDING MATERIAL

Custodian:
Army - MR

Preparing activity:
Army - MR
Project 8040-2017-001

Review activities:
Army - AV, MI, PT
DLA- DH, IS, GS4

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil/.