GM WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW15421

Three-Point Bend Test for Hemming Performance Evaluation

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. The purpose of this test procedure is to determine the hemming performance of aluminum sheet material for body closure applications. In this test, a sheet sample is bent in a 3-point bend test device to 180 degrees.

1.2 Applicability. This test procedure and evaluation method applies for all hemming processes, including table top hemming, press hemming, and roller hemming.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM A681	ASTM E4	ISO 4957	ISO 7500

2.2 GM Standards/Specifications.

GMW15192	GMW15420

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Tool Geometry. The tool consists of a 3-point bending device, with two (2) roller supports and a punch, as seen in Appendix A, Figure A1.

3.2.1.1 Roller Supports. The length of the supports must be greater than the width of the test piece. The diameter of the roller supports must be a minimum of 10 mm. The typical roller support diameter is 30 mm. The roller supports shall be of sufficient hardness and made from ASTM A681, S1 tool steel, ISO 4957-60WCrV8 1.2550, or equivalent material. The roller support surfaces must be polished to a surface finish of 0.2 µm.

3.2.1.2 Distance Between Roller Supports. The distance between the roller supports is a critical test parameter. The distance between the roller supports (**d**) shall be:

- **d** = 2 r + 2 t, -0 mm/+0.2 mm

Where:

- **r** is the punch radius and (**t**) is the initial as-received material thickness as shown in Appendix A, Figure A1.
- The distance (**d**) between the supports should be adjusted as described in 4.3.6.

3.2.1.3 Punch. The length of the punch must be greater than the width of the test piece. A range of punch radii shall be available to ensure conformance to GMW15192. The punch must be parallel to the roller supports. The

© Copyright 2018 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15421 2018

punch shall be of sufficient hardness and made from ASTM A681, S1 tool steel, ISO 4957-60WCrV8 1.2550 or equivalent material. The punch surfaces must be polished to a surface finish of 0.2 µm.

Note: The punch sides must be parallel as shown in Appendix A, Figure A1. The punch width should be 2 r.

3.2.1.4 Guide pins may be used to ensure the direct axis of the sample is perpendicular to the direct axis of the punch, to within ± 1 degree.

3.2.2 Testing Machine. The test fixture shall be placed in a test machine, capable of measuring applied force and displacement. The test machine must conform to ASTM E4 and ISO 7500, and shall be a minimum of Class 1 according to ISO 7500.

3.3 Test Vehicle/Test Piece. The data required to be submitted for each shipment will be determined by the regional manufacturing location. For qualification, test locations and number of samples may be found in GMW15420. The longitudinal zero (0) degrees direction is defined as having the long dimension parallel to the rolling direction, with the punch bending line perpendicular to the rolling direction, as shown in Appendix A, Figure A2. The transverse 90 degrees direction is defined as having the long dimension perpendicular to the rolling direction, with the punch bending line parallel to the rolling direction, as shown in Appendix A, Figure A3.

3.4 Test Time. Varies by supplier resources.

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Test technician familiar with test facilities and equipment.

4 Procedure

4.1 Preparation.

4.1.1 Sample Geometry. The samples shall have a minimum width of 30 mm ± 0.5 mm and a length of 50 mm, +5 mm/-1 mm, as seen in Appendix A, Figure A2 and Figure A3.

4.1.2 Sample Preparation. Samples shall be cut using a mechanical shear or a milling machine. Any areas of the material affected by shearing or similar operations shall be removed. The edges of the test pieces shall be rounded so that no burrs or scratches are present which might affect the test results.

4.1.3 Prestraining. Samples shall be prestrained 10%in uniaxial tension. An example of a prestrain sample is shown in Appendix A, Figure A4. A strain gage should be used to measure the amount of prestrain. After prestraining, three 50 mm long samples shall be removed from the middle of the longer sample as shown in Appendix A, Figure A4. Grip sections and excess scrap shall be removed and discarded prior to bend testing. If desired, the prestrain samples may be wider than the final sample dimension, and then trimmed down to the 30 mm width after prestraining. The designated plastic prestrain is stated in Hemming Requirements of GMW15192. The prestrain direction should be along the length of the sample as shown in Appendix A, Figure A2 and Figure A3.

4.1.4 Lubrication. If lubricant has already been applied to the test sample, additional lubrication is not necessary. If the test sample has not been lubricated, the surfaces of the punch and roller supports may be coated with oil.

4.2 Conditions.

4.2.1 Environmental Conditions. Test shall be performed at room temperature +23 °C ± 5 °C.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Adjust the distance between the roller supports to 2r + 2t, -0 mm/+0.2 mm.

4.3.2 Center the sample in the fixture with the punch parallel to the short dimension. Care should be taken to ensure the sample is parallel to the punch.

4.3.3 Slowly bring the punch into contact with the test sample.

4.3.4 Apply the bending force at a rate of 1 mm/s. Continue to apply the bending force until the test sample has passed through the roller supports, and has been bent to 180 degrees.

4.3.5 Record the bending force as a function of crosshead displacement.

4.3.6 Use the force displacement curve and visual observation of the sample to ensure that the test is complete and that the roller gap amount is correct.

© Copyright 2018 General Motors Company All Rights Reserved

Documents
Document Sharing Hub
Full document details: GMW GMW15421 2018

Force displacement curves are seen in Appendix A, Figure A5 for different roller gap amounts, with a 0.5 mm punch radius and 1.00 mm sheet thickness. The target gap for a 1.00 mm sheet thickness and a 0.5 mm punch is 3.00 mm to 3.20 mm, according to 3.2.1.2. Start with the ideal roller gap, 2r + 2t. If a second bump is observed in the force displacement curve as seen in Appendix A, Figure A5 with a 2.70 mm gap, the sample is being extruded through an opening that is too small. This condition does not represent the hemming process. Increase **d** until the second bump disappears and a smooth force-displacement curve is obtained, as seen in Appendix A, Figure A5 for a 3.04 mm gap.

4.3.7 Ensure that the test is complete by visual observation of the sample in the fixture. The sample should completely wrap around the punch. Appendix A, Figure A5 shows pictures of the sample in the fixture for different gap amounts with a 0.5 mm punch radius and 1.00 mm sheet thickness. While the curve for the 3.30 mm gap is the correct shape, the picture shows that the sample has not completely wrapped around the punch so the gap is too big and the test is incomplete.

4.3.8 Evaluate the resulting sample according to 5.1.1 If cracks, crack initiation lines, or any other surface defect are observed, the test should be repeated with a larger radius punch.

4.3.9 Continue to increase radius punch size until resulting samples have an acceptable surface, such as, no cracks, crack initiation lines, or surface defects.

5 Data

5.1 Calculations. Calculate the hemming factor (**f**) using the smallest radius tested that produces an acceptable rating as defined in 4.3.9.

- The hemming factor **f**, is defined as **f = r/t**, where **r** is the punch radius and **t** is the initial as-received material thickness. Sample quality must conform to GMW15192.

5.1.1 Evaluation and Rating. The test sample shall be observed without magnification, and with magnification of 10x looking for cracks or any other defect on the outside of the bent part. Cracks and crack initiation lines are not permitted. The pictures in Appendix A, Figure A6 show the boundary conditions for acceptable surfaces. The pictures in Appendix A, Figure A7 and Figure A8 show the boundary conditions for unacceptable surfaces, showing both crack initiation lines and cracks. The samples are rated as follows:

- **Acceptable:** No cracks or crack initiation lines. Mild to moderate orange peel is acceptable.
- **Unacceptable:** Any cracks, continuous or discontinuous, are unacceptable. In addition, crack initiation lines (i.e., lines of localized thinning or crazing) parallel to the bend line are unacceptable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. The following data should be documented and provided in a test report:

- Material grade tested
- Coil identification, coil certification sheet
- Solution heat treat date
- Date of testing
- Location of sample in coil, head or tail
- Test direction, longitudinal or transverse
- Amount of prestrain, punch radius
- Sheet thickness
- Hemming factor as defined in GMW15192
- Roller gap and rating

Refer to Appendix B, Table B1 for Example Test Report.

5.3.1 Details should also be provided for the specific test fixture, including a picture of the fixture, specific fixture geometry, punch radii, roller diameter, etc. An example of a bend test device is included in Appendix C, Figure C1. Complete test fixture drawings are available upon request.

© Copyright 2018 General Motors Company All Rights Reserved

Documents
Document Sharing Hub
Full document details: GMW GMW15421 2018

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

S1: Shock resisting tool steel

7.2 Acronyms, Abbreviations, and Symbols.

ASTM	ASTM International
d	Distance Between Roller Supports
EDT	Electric Discharge Texture
f	Hemming Factor
GSSLT	Global Subsystem Leadership Team
ID	Identification
L	Sheet Sample Length
MF	Mill Finish
r	Punch Radius
t	Sheet Thickness
SHT	Solution Heat Treat

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW15421

9 Release and Revisions

This standard was originated in August 2006. It was first approved by the Global Sheet Metal Specialist Team in July 2008. It was first published in July 2008.

Issue	Publication Date	Description (Organization)
1	JUL 2008	Initial publication.
2	OCT 2013	Updated to current template. (Ferrous, including Sheet Metal Global Subsystem Leadership Team)
3	OCT 2018	5 year refresh. Figure A4 revised to show 3 samples as opposed to 4 (Materials – Ferrous Metals Global Subsystem Leadership Team (GSSLT))

© Copyright 2018 General Motors Company All Rights Reserved

Documents
Document Sharing Hub

Full document details: GMW GMW15421 2018