



Laser Welded Blanks Fabricated from Sheet Steel

1 Scope

1.1 Material Description. This standard defines the requirements for hot rolled or cold rolled laser welded blanks used by GM in the manufacture of stamped sheet steel parts. It applies only to the as-supplied condition of the tailored blanks. This specification also covers laser welded blanks for hot forming.

1.2 Symbols. Not applicable.

1.3 Applicability. Typical applications for these blanks include, but are not limited to, door inner panels, motor compartment rails, body side inners.

1.4 Remarks. Blanks supplied under this standard shall be made by laser butt welding two or more coated or uncoated sheet steel blanks used for subsequent cold forming or hot forming into a pre-determined configuration. For the requirements of the steel sheets the relevant specifications apply. In this specification, all steel materials are covered which can be laser welded with sufficient quality, strength, and formability required for a given application. The steel grades are divided in three specification classes:

1. Mild (GMW2), high strength (GMW3032), and advanced high strength steels (GMW3399) with minimum specified tensile strengths equal to or less than 780 MPa,
2. Advanced high strength steels (GMW3399) with minimum specified tensile strengths exceeding 780 MPa tensile strength, and
3. Press hardening steel (PHS) (GMW14400).

For coated blanks, all requirements shall be fulfilled according to the relevant coating specifications listed in GMW8, GMW11, or GMW14400.

2 References

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

2.1 External Standards/Specifications.

ISO 2768-1	ISO 16949	ISO 20482
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2.2 GM Standards/Specifications.

GMW2	GMW3032	GMW3335	GMW14400
GMW8	GMW3059	GMW3399	GMW16854
GMW11	GMW3224	GMW14019	

2.3 Additional References.

- EN 10359 (SEL100)
- GM-North America Plant Requirements for Coils and Blanks (NACB)
- Manufacturing Engineering (ME) Lastenheft

3 Requirements

3.1 Requirements on Delivery.

3.1.1 Chemical Requirements. Chemical composition of the component blanks shall meet the requirements of the base metal specification of the component blanks.

Additional demands and restrictions may be given by the central formability analysis organization.

3.1.1.1 Filler Wire Composition. If a filler wire is used, the composition must be agreed to between the purchaser and supplier.

3.1.2 Mechanical Requirements. The sheet steel of the component blanks shall meet the mechanical properties specified in GMW2, GMW3032, GMW3399, GMW14400 or other applicable specifications (see 1.4).

3.1.3 Physical Requirements.

3.1.3.1 Quality of Laser Weld Joint. Unless otherwise noted in the following, laser welds shall conform to the requirements in Table A1 and in Figures A1 through A8 (See EN 10359 (SEL100)). Weld porosity and geometry shall be controlled such that formability and function of the part are not affected.

3.1.3.1.1 Laser Weld Quality of Steels with Minimum Specified Tensile Strength ≤ 780 MPa. Laser welding steels in this category typically results in a weld seam and heat affected zone (HAZ) that is harder than the base material. The maximum hardness shall not exceed the lesser of 3x the harder base metal hardness or 500 HV.

3.1.3.1.2 Laser Weld Quality of Steels with Minimum Specified Tensile Strength > 780 MPa. Laser welding advanced high strength steels in this category typically results in heat affected zones that are softer than the substrates being welded. When welding a steel with tensile strength > 780 MPa, it is preferred that the higher strength steel be welded to a steel with tensile strength ≤ 780 MPa to reduce the detrimental condition in which the heat affected zone is of lower hardness/strength than both the base materials. As a result of the microhardness evaluation (see 3.1.4.2.2.1), the softening zone on both sides of the weld should not exceed 1 mm and must fulfill requirements from the cupping test (see 3.1.4.2.1) and the tensile test (see Section 3.1.4.2.3).

If two steels with minimum specified tensile strengths > 780 MPa are laser welded to one another, fracture is expected within the heat affected zone (softening zone) under certain loading conditions and should be avoided in product design.

3.1.3.1.3 Laser Weld Quality of Press Hardening Steel. Decarburization of the weld seam and of the heat affected zone must be reduced to a minimum. After press hardening, the hardness of the weld seam must conform to the hardness range of GMW14400 for the base material.

When welding two PHS blanks (of the same grade, typically GMW14400M-ST-S-HS1300T/950Y-MS), the allowable weld defects and required weld cross section are dependent upon the thickness ratio and the potential use of filler wire. Under certain circumstances approved by Materials Engineering, other weld combinations may be considered (GMW14400M-ST-S-HS1300T/950Y-MS substrates welded to alternative substrates – i.e., soft zone technology) and must adhere to the requirements in Table A1 without restriction.

3.1.3.1.4 Filler Wire. Usage of filler wire is allowed under certain conditions to improve weld quality and performance for cold stamping applications. The hardness of the weld seam with filler wire shall exceed the hardness of the lower hardness substrate and be ± 50 HV relative to the harder substrate being welded. In the case of multi-gauge, like-substrates being welded, the weld seam must be within ± 50 HV of the substrate hardness.

For PHS (GMW14400) applications, the filler wire must be approved by Materials Engineering and shall result in a weld seam hardness within ± 50 HV following hot stamping, relative to the substrates being welded. For tailored PHS blanks containing differing substrate chemistries/grades, the resultant weld seam hardness with filler wire shall be between the hardness values of both substrates following hot stamping.

3.1.3.2 Blank Edge Preparation. The welder of the sub-blanks is responsible for determining and controlling the quality of the edges to be welded. Maximum allowable burr on any non-welded edge shall be $\leq 10\%$ metal thickness.

For PHS applications, the blank edges must be properly prepared prior to laser welding to ensure the laser weld performance requirements are met. For Al-Si coated PHS, this may include ablation techniques to adequately remove the coating to avoid detrimental effects of the coating contaminating the weld, resulting in low weld strength.

3.1.3.3 Material Thickness. The thickness and tolerance for the component blanks shall be specified by the detailed engineering math data. For the tolerances of the single sheet thickness, refer to GMW3224.

3.1.3.4 Lubrication. The welded blank shall be free from corrosion products. The raw material sheet stock shall have oil as specified in GMW14019 to provide rust protection in the coil and component blanks. However, an applied oil weight greater than 1.5 g/m^2 is not allowed due to process concerns.

3.1.3.5 Surface Quality of Laser Welded Blanks. The surface quality and the roughness of the laser blanks shall comply with the relevant material specifications.

3.1.3.6 Paint Adhesion on Laser Weld Seam. The requirements for paint adhesion as described in GMW2, GMW8, GMW11, GMW3032 GMW3399 and GMW14400 shall be fulfilled on both the base material and the weld seam.

3.1.3.7 Weld Seam Location. The location of the weld seam shall not deviate by more than ± 1.0 mm, as measured from a given reference point. An example is given in Figure A9. Deviations of this criterion can be issued by the local business unit.

3.1.3.8 Blank Dimensional Tolerances. Tolerances for linear and angular dimensions without individual tolerance indications shall be determined according ISO 2768-1, class C. The method of measurement shall be on a master sample, with reference points agreed upon by GM Supplier Quality (SQ). During production the influential dimensions have to be measured.

Note: Regulations may be different in the GM units and will be issued by the local business unit.

3.1.3.9 Lead Edge Offset. Regulations are handled differently in the GM units and will be issued by the local business unit.

3.1.3.10 Length/Width Tolerance. Unless otherwise specified, the maximum offset of the sheets (see Figure A10) is ± 1.5 mm. Deviations may be issued by the local business unit.

3.1.3.11 Start/Finish of Weld. Unless otherwise specified, the weld shall start and finish within 2 mm (GME) or 3 mm (GMNA) of the edge of the sheets (see Figure A11). The detailed definition will be issued by the local business unit.

3.1.3.12 Flatness of Individual Blanks After Welding: Flatness of individual blanks after welding shall be agreed upon by purchaser and supplier.

3.1.4 Testing of Weld Seam.

3.1.4.1 Non-Destructive Testing. Each tailored blank shall be tested online (100% by online system) with appropriate and assured test procedures approved by SQ. Additional visual inspection is possible. It is recognized that up to 5 mm maximum at the beginning and end of the weld cannot be monitored by state of the art online test procedures.

3.1.4.2 Destructive Testing. Unless otherwise specified, destructive testing shall be performed at least once per production run prior to shipment.

3.1.4.2.1 Cupping Test. Destructive testing of weld joints with the Erichsen cupping test is considered the best practice procedure. The cup test shall be performed according to ISO 20482. Other documented methods, such as GMW16854 or Olsen cup tests may be used with a required ball punch diameter of 20 mm to 30 mm. The evaluation of weld quality is done according to the example images in Table A2.

3.1.4.2.2 Cross Section. Samples shall be taken at a minimum of 5 mm from weld ends. Samples should concentrate on high strain areas of the formed part, as communicated by GM to the blank supplier. Measurement shall be performed according to the method outlined in Appendix A, section A2.

3.1.4.2.2.1 Microhardness. A microhardness traverse shall be obtained on a representative cross-section to ensure the quality requirements of the weld are fulfilled. Results shall be reported on the Vickers hardness scale (HV). To fully characterize the weld, a mid-thickness traverse shall be obtained, extending from one substrate, through the respective HAZ zones and weld seam and into the second substrate. Testing shall be performed at Production Part Approval Process (PPAP) and with a frequency defined in the production control plan.

3.1.4.2.3 Tensile Tests. Tensile tests with the laser weld transverse to the load axis according to GMW3335 shall be performed at PPAP and at a frequency defined in the production control plan. Fracture shall occur outside of the weld seam and HAZ.

For PHS applications, this requirement must be met following the hot stamping process and shall be demonstrated during PPAP by a simulated hot stamping treatment. The control plan shall state the subsequent testing frequency.

3.1.4.2.3.1 Hydrogen Embrittlement. During PPAP of welded blanks containing at least one substrate > 980 MPa minimum ultimate tensile strength (UTS) for cold stamping applications, the supplier must ensure that the diffusible hydrogen content in the weld seam or in the blank caused by the welding process does not negatively affect the part during a subsequent forming operation. If necessary, an appropriate hydrogen effusion step may be required after welding.

3.1.5 Additional Requirements.

3.1.5.1 Blank Packaging Specification (GM Direct Stamping). Blank packaging is specific to a part and the front of line requirements at the GM stamping plant. Therefore, each part number will have a blank packaging specification that is unique to that part and GM stamping plant. The GM stamping plant that will receive the blanks is responsible to create a blank packaging specification for each part. The blank stack should meet the requirements shown in Figures A12 thru A14 unless otherwise specified. If there is any discrepancy between this document and the blank packaging specification sheet, the blank packaging specification sheet shall be used.

If dimpling is used, the blank packaging specification sheet shall show the type and location of the dimples. Recommended dimple dimensions are provided in Figure A15 and Figure A16. Note that small dimples may be present for de-stacking purposes. These small de-stacking dimples should not be present along the edge to be welded.

Blank packaging shall follow the requirements in the North America Plant Requirements for Coils and Blanks (NACB) specification for GM-North America unless otherwise specified in this document. If there is any discrepancy between the NACB specification and this document, this document shall be used.

Blank packaging shall follow the requirements in the Lastenheft document for GM-Europe, unless otherwise specified in this document. If there is any discrepancy between the Manufacturing Engineering (ME) Lastenheft and this document, this document shall be used.

3.1.5.2 Dimensions and Tolerances of the Blank Stack. The blanks shall be stacked so that each stack is identical in shape with the edges flush. The dimensions and tolerances for the stacks are also outlined in the NACB specification for North America, and the ME Lastenheft document for GME. If there is any discrepancy between the NACB (North America) or between the ME Lastenheft (Europe) and this document, this document shall be used.

3.1.5.3 Stack Shift, Blank Stagger and Stack Lean Tolerances. Permissible tolerances for these requirements are 5 mm (Figure A12 and Figure A13).

3.1.5.4 Flatness of a Stack. The parallelism and flatness tolerance for the stack must fall between two planes parallel to the plane of the pallet. A stack height deflection of ± 25 mm is permitted ($h = \pm 25$ mm), as seen in Figure A14, unless otherwise specified by the receiving GM Stamping Plant on the blank packaging specification sheet.

If necessary, dimples may be added to the stack to maintain the flatness of the stack. Recommended dimensions for the dimples are described in Figure A15 and Figure A16. Round dimples may be also used with agreement between purchaser and supplier. Dimples should either be staggered, or put on every other blank in a stack. The parallelism shall not be obtained by additional devices. Dimple type and location shall be agreed upon by purchaser and supplier. All required dimples should be included in the formability analysis prior to P2 data release to address any potential issues. Final dimple locations and dimensions shall be finalized in primary tryout.

3.1.5.5 Process Control. The supplier shall develop quality process control procedures compliant with ISO 16949 demonstrating that the product will conform to all specification requirements listed in this document. This shall include a statistically-based sampling plan based upon product quality performance. The data required to be submitted for this specification for each shipment will be determined by the manufacturing location. The process shall be assured by traceability from stack label back to the batch number of steel sheet or coil.

3.1.5.6 Other Specifications. If there is any discrepancy between the GMNA Stamping Plant Requirements for Sheet Metal Coils and Blanks (NACB) specification and this document, this document shall be used. If there is any discrepancy between the Lastenheft and this document, this document shall be used.

3.2 All materials supplied to this standard must comply with GMW3059, Restricted and Reportable Substances, including the requirement to submit a full material composition disclosure to GM via the International Material Data System (IMDS) or via a completed GMW3059 report form.

4 Manufacturing Process

Not applicable.

5 Rules and Regulations

5.1 Legal Regulations. All materials must satisfy applicable laws, rules, regulations and recommendations valid in the country of usage.

5.2 Language. In the event of conflict between the English and domestic language, the English language shall take precedence.

5.3 Inspection and Rejection. Samples of components or materials released to a GM material specification shall be tested for conformity with the requirements of this material specification and approved by the responsible Engineering department prior to commencement of delivery of bulk supplies.

A new approval must be received for any changes, e.g., properties, manufacturing process, location of manufacture, etc. If not otherwise agreed, all testing and documentation normally required for initial release must be completed.

It is the responsibility of the supplier to inform the customer in a timely manner, without solicitation, and to include documentation of all modifications of materials and/or processes and to apply for a new release.

5.4 Material Safety Data Sheets/Safety Data Sheets (MSDS/SDS). For new product submissions, or when a change in chemical composition of an existing product has occurred, a complete copy of the Material Safety Data Sheet/Safety Data Sheet must be submitted in compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) requirements or other country-specific MSDS/SDS requirements.

6 Approved Sources

Materials supplied to this specification must be approved by General Motors.

The appropriate GM Materials Engineering department(s) must confirm material as meeting the requirements of this specification. Any test data sheets of material submitted to General Motors for such confirmation (e.g., during Production Part Approval Process (PPAP)) under this material specification must list all properties and must apply corresponding test methods of this material specification.

The supplier of the component blanks must be approved to the respective base metal specifications (i.e., GMW2, GMW3032, GMW3399, GMW14400, etc.)

7 Notes

7.1 Glossary. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

f	Porosity Projection Fraction
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GSSLT	Global Subsystem Leadership Team
h	Deviation in mm
HAZ	Heat Affected Zone
HV	Vickers Hardness
IMDS	International Material Data System
ME	Manufacturing Engineering
MPS	Material Parts Specification
MSDS	Material Safety Data Sheet
PPAP	Production Part Approval Process
SDS	Safety Data Sheet
SEL	Stahl-Eisen-Lieferbedingungen
SQ	Supplier Quality
t₁	Thickness of Thicker Sheet
t₂	Thickness of Thinner Sheet
UTS	Ultimate Tensile Strength