PERFORMANCE, STEEL, SHEET, BORON TREATED, ALUMINIZED, HIGH STRENGTH, 1300 MPa MINIMUM ULTIMATE TENSILE STRENGTH — **WSS-M99P39-A1**

PERFORMANCE, STEEL, SHEET, BORON TREATED, ALUMINIZED, HIGH STRENGTH, 1400 MPa MINIMUM ULTIMATE TENSILE STRENGTH — **WSS-M99P39-A2** **NOT FOR NEW DESIGN**

PERFORMANCE, STEEL, SHEET, BORON TREATED, ALUMINIZED, HIGH STRENGTH, 1550 MPa MINIMUM ULTIMATE TENSILE STRENGTH — **WSS-M99P39-A3** **NOT FOR NEW DESIGN**

PERFORMANCE, STEEL, SHEET, BORON TREATED, ALUMINIZED, HIGH STRENGTH, ULTIMATE TENSILE STRENGTH DEFINED ON PRINT — **WSS-M99P39-A4**

1. SCOPE

These specifications define performance requirements for a fully killed, fine grained, hot dip aluminized, high strength, boron treated steel used to form direct press hardened parts. The standard production method combines furnace heating of blanks that are formed hot and die quenched. Use in conjunction with material specification WSS-M1A357-A1.

2. APPLICATION

These specifications were released originally for AlSi coated direct press-hardened body structure parts.

Mechanical properties of the fully processed part are a function of the specific press hardening process selected for part manufacture. The complete part fabrication process shall be outlined in detail in the Process Flow Diagram/PFMEA and maintained in accordance with the documented Control Plan.

Mechanical properties are expected to differ from point to point on a press hardened part. Sampling location(s) and orientation(s) of tensile test samples and metallographic sections for coating thickness / Vickers hardness measurement for validation of requirements of this specification shall be as specified on the individual Engineering Drawing (see also paragraph 3.3.).

Mechanical properties of the fully processed part, if not covered by this specification, shall be listed in detail on the individual part Engineering Drawing using variant A4 as the material callout (see paragraph 4.9).

Press hardened parts can be designed with soft zones (including hardness transition areas) where a local area of the part is specified to a lower strength level than the surrounding material. The location(s) and expected attributes of the soft zone are to be called out on the part drawing and the manufacturing process shall be described in detail in the part Supplier's Control Plan.

There are 2 different thicknesses of the hot dip aluminized coating covered by this specification and in WSS-M1A357-A1. The AlSi coating will provide protection of the surface during the heating cycle to avoid the formation of scale and (limited) corrosion protection of the finished part. No de-scaling is permitted for parts produced to this specification.

The AS150 coating is the standard product for general applications; it offers a certain degree of corrosion protection in the form of a barrier coating. The AS80 coating has a thinner coating and is

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2016 08 24	Revised/N Status	A2/A3 N Status, See section 5 for revision summary	D. Ruhno A.Toennessen
2007 03 07	Activated		D. Jordan

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optionally used in “above belt line” and/or dry environments if functional requirements are met. Neither coating wt. provides significant galvanic protection in normal automotive environments.

2.1 LIMITATIONS

- Due to the hardenability response of this material, individual welding schedules must be developed for each application (see also para. 3.9).
- Stress relief annealing or hydrogen bake-out processes (per WSS-M99A3-A) may be necessary for certain process paths, e.g. if the parts have demonstrated a risk for delayed cracking. If a stress relief anneal is required, all details of the heat treatment have to be listed in detail in the Supplier's Control Plan, see para 4.7.
- Prior to use, the fully processed part must be evaluated under the intended application conditions. Compliance with this specification does not imply that the engineered part will function for any potential application on a vehicle.
- Any subsequent heat treatment will change the mechanical properties and has to be considered in the part design, test and development processes.

3. REQUIREMENTS

3.1 APPROVED SOURCES

This specification is performance based and does not have approved sources. Some aspects of this specification may be used to support WSS-M1A357-A1 source approvals.

See paragraphs 4.1. - 4.3 and the accompanying test matrix guideline (see appendix) for qualification requirements, ongoing supplier responsibilities and restricted substance management.

Parts supplied according to this specification shall undergo a PPAP qualification process including successful production trials that fully meet end product requirements.

Any changes to the heat treatment and/or manufacturing process to which the part was successfully validated, have to be notified by a SREA request and the part properties must be tested and re-qualified to the proper Production Part Approval Process (PPAP). See the test matrix in Appendix A for guidance.

3.2 MANUFACTURING/PROCESS REQUIREMENTS

Final material properties in the part shall be achieved primarily through the heat treatment of the blank that is heated above the austenitization temperature (fully or partially as defined by the process) and then formed and rapidly cooled (quenched).

Quenching shall be accomplished by any method (e.g. standard coolant-jacketed die, direct water contact) that achieves final part properties and all other affected requirements of these specifications. The specific quenching method and materials shall be described in detail in the part Supplier's Control Plan.

Flexible rolling (a.k.a. tailor rolling, variable rolling) blanks, tailor welded blanks, patch welding, or other methods to locally change thickness are allowed, provided all requirements of this specification are met in all thickness regions or plateaus.

3.2.1 General Material Requirements and Restrictions

All test samples used to verify compliance to the material requirements in paragraph 3 have to be taken from material that has been subjected to the specific, complete and intended process representative press hardening thermal profile and environmental exposure (e.g., austenitization, quenching, welding, oiling).

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Any agreed upon "quality level" of the sheet steel material used for a specific component:

- Shall not conflict with any specified requirements listed in paragraphs 3 of the Engineering Material Specification (WSS-M1A357-A1) and of this Engineering Performance Specification
- Shall be described in detail on the manufacturing activity specifications Sheet 3 (Americas), Gbl 2066 (Ford of Europe), or Supplier's Control Plan (independent stampers/fabricators)
- Shall be a mandatory extension of these Engineering Material Specifications

3.2.2 General Process Requirements and Restrictions:

- The coating must be protected during uncoiling / blanking to avoid local damage or local removal which may cause oxidation during hot stamping or reduce the corrosion protection of the finished part, see paragraph 3.8.

- The thermal processing of the blank (heating rate, max. blank temperature, total furnace time, transfer time) is a main contributor to the final properties of the coating layer and the part surface. These have an impact to the productions processes like spot welding or painting or corrosion protection. Coating thickness, hardness, micro-structure and surface roughness are physical parameters which need to be controlled to ensure limited process variation and optimum product quality. Typical thermal processing parameters ranges are listed in para 4.1, they are for indication only. The final optimum process parameter selection will depend on blank thickness, part geometry etc. and will be documented in the part specific control plan.

- The maximum temperature of the blank in the furnace shall not exceed 930 °C.

- The furnace process window has to be adjusted properly to achieve the mechanical properties and ensure that the coating layer and surface quality properties comply with the material and functional requirements listed in paragraphs 3.8 to 3.13.

- All parts supplied to this specification must be free of hydrogen embrittlement, see paragraph 4.4. Hydrogen generating processes including furnace atmospheres with residual water content or cleaning and/or coating processes with the risk to release hydrogen have to be avoided. See paragraph 4.7. for a recommended dew point control of the furnace atmosphere.

- The microstructure of the steel in the press hardened part shall be effectively martensite with a small amount of bainite.

- The edge quality of the final trim process is critical for the finished part performance. Laser cutting/trimming is recommended, other hard cutting processes must be validated, see paragraph 4.7.

- Blank / tube austenitization by induction heating is not allowed.

- De-scaling parts by acid pickling or blasting is not allowed.

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3.3 MECHANICAL PROPERTIES AFTER DIRECT PRESS HARDENING

Location and orientation of samples for tensile testing as shown on Engineering Drawing, 50 mm gauge length tested to ISO 6892-1 /ASTM E 8M.

	A1	A2	A3	A4
Ultimate Tensile Strength (MPa)	1300 min.	1400 min.	1550 min.	Call-out
Yield Strength (MPa)	950 min.	1000 min.	1100 min.	Call-out
Total Elongation	5 % min.*	5 typ.	5 typ.	Call-out

Exception for A1: Elongation 4% min for gauge < 1.2 mm

Mechanical properties shall be measured on tension test specimens sampled from location(s) and orientation(s) on the part as identified on the individual Engineering Drawing. The alloyed aluminized coating shall not be removed prior to mechanical property testing and the coating thickness shall be included in the total cross-sectional area value used for stress calculations.

To verify that the minimum strength level is attained in areas of the part from which standard tension test specimens cannot be sampled, a protocol that correlates measured micro hardness values in those areas with known ultimate tensile strength values shall be included in the part Supplier's Control Plan, see paragraph 4.2. In all cases the minimum expected hardness is > HV 400, values significantly below that would indicate a non-martensitic microstructure.

Note: The hardness requirements for intentionally softened zones need to be agreed upon between Ford Product Development and the part supplier, documented on the part drawing and addressed in the suppliers control plan.

3.4 FORMABILITY

Aluminum-Silicon coated blanks shall not be cold stamped prior to heat treatment. Pre-forming of the material by roll forming or flexible rolling may be allowed provided the coating is not damaged during the process. See WSS-M1A357-A1, paragraph 3.7 for details.

3.6 STEEL MICROSTRUCTURE

The microstructure of the steel in the press hardened part shall be effectively martensite with a small amount of bainite likely and allowed.

Note: Process parameters like temperature of deformation, local strain and strain rate and the quench rate are factors which will affect the local phase transformation path and the resulting fraction of martensite / bainite phases as well as the microhardness. They have to be developed and balanced within the process cycle during the part / die design development process. The resulting process parameter window will be documented in the control plan (see paragraph 4.4).

Requirements for locally softened zones must be documented on the part drawing including the dimensions and location of the area affected and the expected materials attributes which may include but are not limited to a specific hardness range and/or microstructure.

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3.7 DIMENSIONS AND DIMENSIONAL TOLERANCE

The material thickness specified on the Engineering Drawing shall be nominal and shall include both the substrate thickness and the coating thickness.

The press hardening process may result in a thickness reduction in the part as compared to the incoming blank. The amount of allowable thickness reduction in selected areas of the press hardened part shall be identified on the Engineering Drawing.

3.8 COATING PROPERTIES AFTER PRESS HARDENING (BEFORE PAINT PROCESSING)

Note: The coating must be protected during uncoiling / blanking to avoid local damage or partial removal which may cause oxidation during hot stamping and/or affect the part performance. See paragraph 3.8.3.

3.8.1 Coating Thickness after Thermal Processing

Note: Only substrate initially coated to AS 150 requirements shall be used for the production of Flexible Rolled Blanks. See WSS-M1A357-A1 section 3.7 for details.

Coating thickness shall be measured at locations which have been identified on the drawing or in agreed upon production control plans.

The coating thickness requirements are expected to be valid on both sides of the part at any location with the exception of cut edges.

The coating thickness requirements for press-hardened parts are listed in Table 1.

The coating thickness of flexibly rolled blanks will be reduced at each plateau by the same amount as the substrate in that location (i.e. gauge of substrate reduced by 30% = thickness of coating reduced 30%). Therefore, the Total Coating Thickness requirements in Table 1 are also reduced by the degree of cold work for each plateau. The Interdiffusion Layer thickness for flexible rolled blanks shall not exceed 12 µm.

Photomicrographs of Al-Si coating cross sections after different heat treatments are shown in paragraph 3.8.2., Figure 1. The total coating thickness and the thickness of the interdiffusion layer are marked on the photos to demonstrate the measurement method.

Table 1: Coating Designation and Thickness Requirements

Coating Designation	Condition	Total Coating Thickness (µm)	Interdiffusion Layer (IDL) Thickness (µm)
AS 150	Press-hardened	30 - 50	≤ 16
AS 80	Press-hardened	15 - 30	≤ 12

Note: See WSS-M1A357-A1 for coating weight requirements of the raw material.

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