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FCA
FIAT CHRYSLER AUTOMOBILES

WELDING - ARC, GENERAL STANDARD

PS.50001/01<S>

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HARMONIZED DOCUMENT

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-	24-OCT-2014	Initial Release
A	28-APR-2016	- Corporate Name Change - Updated sections 3 and 4

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WELDING – ARC, GENERAL STANDARD

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1 GENERAL

This standard describes the Arc Welding requirements for all automotive components fabricated from steel, aluminum or other metals approved by Materials Joining, Chassis & Powertrain Materials Engineering, FCA US Engineering Office.

1.1 Purpose

This process is used to verify the quality of arc welds.

1.2 Coverage of this Standard (Applicability) and Limitations on Usage

This standard has been divided into general requirements, steel specific requirements and aluminum specific requirements. Any paragraph or section that does not specifically state either steel or aluminum shall be applicable for both materials. Paragraphs that specifically state steel or aluminum are only applicable for those materials and not interchangeable.

Other arc welding processes not listed in this standard may only be used when shown on the weld releases.

Weld releases noted as <S> or Safety must comply with the requirements of PS-5595<S> or PF-SAFETY<S> and supporting standards.

1.2.1 Coverage of Steel Specific Applications

This standard is applicable to all automotive components fabricated from FCA US approved zinc, iron-zinc coated or un-coated low carbon steels and high strength low alloy sheet steels.

The carbon equivalent determination must be carried out with the following formula:

$$C + Si/11 + Mn/8 + Cu/9 + Ni/17 + Cr/5 + Mo/6 + V/3$$

The values must be ≤ to those indicated in the following diagram, if not otherwise specified on the drawing.

It is desirable to keep the sulfur level below 0.035%, and it shall not be over 0.05%.

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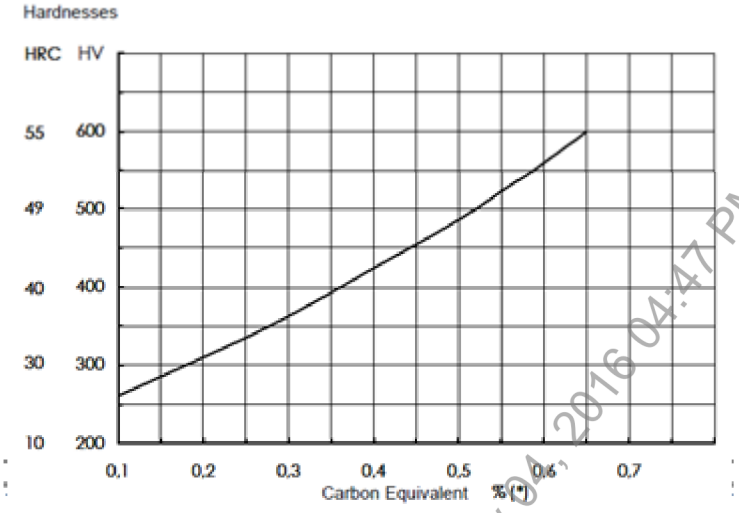

Figure 1 - Carbon Equivalency and Hardness Plot

Phosphorus shall not exceed 0.06%.

Boron levels shall not exceed 0.005%

1.2.2 Coverage of Aluminum Specific Applications

This standard is applicable to all automotive components fabricated from aluminum sheet, extrusions, and castings approved by the Body Materials Engineering Department, FCA US Engineering Office.

1.3 Requirements on Part Drawings

Engineering releases shall specify "Weld PS.50001/01<S>" in the title block. As required, the weld symbol and/or weld note shall specify the process by letter designation plus any additional requirements. "Weld Only" releases and weld releases may specify the process letter designation followed by "PS.50001/01<S>". Filler metals, if required, shall be listed by the appropriate material specification and grade designator.

Example: GMAW PS.50001/01<S> MS.90024/01 W101

Any welding requirements shown on the detail assembly, CATIA/NX drawings, weld only drawings, or weld releases take precedence over the requirements specified in this standard.

Special welding requirements specified in a purchase order shall be placed on the supplier's drawing or welding release.

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2 REFERENCES

2.1 Reference Documents

All reference documents are for clarification purposes only. FCA US Specifications override all conflicts or discrepancies between reference materials and FCA US specifications.

Table 1 - References

Document Number	Document Title
ASTM E3-11	Standard Guide for Preparation of Metallographic Specimens
AWS A3.0M	Standard Welding Terms and Definitions
AWS D8.8	Specification for Automotive Weld Quality – Arc Welding of Steel
AWS D8.14	Specification for Automotive Weld Quality – Arc Welding of Aluminum
MS.90024/01	Welding Electrode – Carbon Steel General Purpose
MS.90024/02	Welding Electrode – Carbon Steel Special
MS.90024/03	Welding Electrode – Low Alloy Steel
MS.90024/04	Welding Electrode – Stainless Steel
MS.90024/05	Welding Electrode – Galvanized Steel Special
MS.90024/06	Welding Electrode - Aluminum
MS.90024/07	Brazing Electrode – Copper Based
MS.90025/05	Braze Filler Materials – Aluminum
PS.50002/07<S>	Brazing - MIG
PS.50006/01	Reprocessing – BIW Arc Welds
PF-8500	REQUIREMENTS FOR VERIFICATION, VALIDATION AND CONTINUING CONFORMANCE TESTING
PF-SAFETY<S>	PRODUCT SAFETY - USE OF SAFETY SHIELDS <S>
PS-5595<S>	PF-SAFETY<S>/EMISSIONS<E> WELD AREA CLASSIFICATION AND QUALITY REQUIREMENTS
CS-9801	QUALITY REQUIREMENTS
CS-9800	GENERAL INFORMATION
CS-9003	SUPPLIER REQUIREMENTS FOR VEHICLE AND SERVICE PARTS: MATERIAL CONTENT REPORTING, MARKING, AND RECYCLABILITY

3 DEFINITIONS/ABBREVIATIONS/ACRONYMS/SYMBOLS

3.1 General Definitions

Reference *AWS A3.0M: Standard Welding Terms and Definitions* for terminology and definitions in FCA US specifications, unless otherwise noted in this specification.

Arc Welding: A group of metal joining processes where fusion is produced with an electric arc. Additional filler metal is always used except for the Gas Tungsten Arc Welding (GTAW) and Plasma Arc Welding (PAW) processes noted below. These processes may be manual, semi-automatically or automatically controlled.

Discrepant Weld: A weld that differs from the requirements of this standard. Even though the weld differs, it may still have useful engineering properties.

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Weld Crater Fill: A weld process adjustment designed to terminate the weld in a gradual manner by decreasing the weld current over a predetermined period of time as the weld is completed. This feature will minimize the formation of a weld crater, and is effective in eliminating crater cracking.

Weld Notch: Described as meltback of base materials, such that fusion of the leg cannot be achieved from a normal length of weld, possibly resulting in a hole of the base material along the toe of the weld.

Weld Skip: A normal length of weld that is interrupted but is not an intermittent weld.

3.2 Process Definitions and Descriptions

Flux-Cored Arc Welding (FCAW): A process similar to GMAW. The continuous wire electrode is a metal tube filled with flux. The flux provides the protective atmosphere and leaves the weld covered with a thin slag coating. Electrodes designed for use with an externally supplied shielding gas are also available. This process enables the efficient welding of zinc, iron-zinc coated steels with a specifically compounded ferrous filler metal electrode (MS.90024/05).

Gas Metal Arc Welding (GMAW): Welding with equipment which automatically feeds a continuous wire electrode to a holder or torch. A protective atmosphere is provided by a gas typically supplied through the torch nozzle. Argon and carbon dioxide are the typical shielding gases. This process is sometimes referred to as Metal Inert Gas (MIG) or Metal Active Gas (MAG) welding.

Gas Tungsten Arc Welding (GTAW): Welding where fusion is produced by heating with an arc between a non-consumable tungsten electrode and the work. Filler metal may be added if required. An inert shielding gas is directed through the electrode holder. The Process is sometimes referred to as TIG welding. This process shall not be specified for welding coated steels because the zinc vapors contaminate the tungsten electrode.

Metal Core Arc Welding (MCAW): A process similar to GMAW. A composite tubular filler metal electrode that consists of a metal sheath and a core of various powered materials, primarily iron, which produces no more than slag islands on the face of the weld bead. The core of the metal-cored wire contributes almost entirely to the deposited weld metal.

Plasma Arc Welding (PAW): An arc welding process similar to the GTAW process. Coalescence is produced by heating with a constricted arc between an electrode and the work-piece or between the electrode and the constricting nozzle. Filler metal may or may not be added. This process shall not be specified for welding coated steels as the coating may contaminate the tungsten electrode.

Pulsed Gas Metal Arc Welding (GMAW-P): A variation of GMAW using a special power source providing a "pulsed peak" current superimposed upon a background current. An advantageous process for welding zinc, iron-zinc coated and thin bare sheet steel, and for welding aluminum alloys with aluminum alloy filler metal. There is a derivative of GMAW-P that runs in the short circuit mode of transfer. The process relies upon feedback from information obtained at the arc which results in changes in the character of the arc making the process advantageous for solid steel wires on thin gauge assemblies.

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4 PROCESS AND PROCESS CONTROL REQUIREMENTS

4.1 Part Surface and Environment

4.1.1 Condition of Steel Material

The surface of the steel part at the time of welding shall be free from scale, rust, paint, sealer and adhesive and any other contaminants that would adversely affect the quality of the weld.

Release compounds that harden with age shall be removed prior to welding. The arc welding process shall not be used in areas where primer, adhesives and sealers are present or closer than 25 mm.

4.1.2 Condition of Aluminum Material

The surface of the aluminum part at the time of welding shall be free of all contaminants, such as sealer and adhesive, mill oils, or coatings that would adversely affect the quality of the weld. Any aluminum material being welded on must be at or above 0°C (32°F) prior to being welded on unless another preheat temperature is required or specified.

Prior to arc welding, the joint area shall be free of water vapor, hydrocarbon films and excessive mill oxides. Hydrocarbon films shall be removed by an alkaline solution, vapor degreasing or solvent wiping. Use of either a caustic solution or abrading with a stainless steel wire brush to remove mill oxides are required procedures to minimize weld metal porosity and assure adequate joint fusion.

The arc welding process shall not be used in areas where primer, adhesives, sealers and other flammable materials are present or closer than 25 mm.

4.1.3 Electrode Filler Metal

4.1.3.1 Aluminum Specific Filler Metal Selection (MS.90024/06 and MS.90025/05)

Selection of the electrode filler metal to be used will be a function of the aluminum alloy/alloys being welded and design function considerations. The electrode filler metal shall be approved by the Body Materials Engineering Department, Materials Engineering, and FCA US Engineering Office and shall be specified on the weld releases.

4.1.3.2 Steel Specific Filler Metal Selection

Electrodes used for production purposes must be on the source approval lists that appear in the corresponding filler material specs starting with MS. 90024. If the desired filler material is not listed, Materials Engineering must be notified before proceeding with the desired filler materials use or consideration.

When less than 413 MPa (60,000) yield strength steels are welded to themselves or to higher strength steels, MS.90024/01 W101, W102 or W103 solid filler metals shall be used and specified as one grade on the weld releases.

When 413 to 552 MPa (60,000 to 80,000 psi) yield strength steels are welded to themselves or to higher strength steels, MS.90024/03 solid filler metal shall be used and specified on the weld releases.

On zinc coated steels, if the internal and external porosity requirements of this standard cannot be met or sustained, MS.90024/05 W501 or W502 shall be specified on the release.

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4.1.4 Part Fit-Up

All releases using the arc welding process shall show mating parts to be in "line-to-line" contact.

The maximum acceptable gap as designed including the tolerance stack and the actual gap occurring during manufacturing shall not exceed the lesser value of the thinner metal thickness or 1.2 mm.

4.1.5 Material Thickness Restriction Recommendations

Process recommended limits due to steel thickness are shown in Table 2.

Table 2 - Steel Arc Welding Metal Coating and Steel Thickness Recommendations (Metal Gauge Specification Refers To The Thinner Of The Two Pieces Joined.)

	MIG-BRAZE (PS.50002/07<S> MS.90025/07) Thickness Required mm (in.)	GMAW (MS.90024/01 W101,W102,W103) (MS.90024/03 W301) Thickness Required mm (in.)	FCAW (Flux-Core) (MS.90024/05 W501, W502) Thickness Required mm (in.)	MCAW (Metal-Core) (MS.90024/02 W203) Thickness Required mm (in.)
STEEL THICKNESS	0.7 min. 1.2 max.	1.0 min.	1.0 min. Permissible/Not Required **(NOTE 1)**	1.0 min. Permissible/Not Required **(NOTE 1)**
SEALERS, ADHESIVES & OTHER FLAMMABLE MATERIALS	NO ARC WELDING CLOSER THAN 25 mm TO SURFACES OR EDGES COATED WITH SEALER OR ADHESIVE. NO ARC WELDING WITHIN 25 mm OF OTHER FLAMMABLE MATERIALS.			

NOTE 1: MS.90024/05 shall be used if compliance to internal and external porosity per 4.2.2.3 cannot be met or sustained.

4.2 Inspection Requirements

The following procedures shall always be performed on parts during set-up and during production at a regular frequency as determined by the appropriate FCA US Quality Group and the Manufacturing facility per PF-8500 compliance requirements.

4.2.1 Visual Inspection (Non-Destructive)

Many discrepant welds can be detected visually. Welds can be discrepant because of either a lack of length, number or quality in the weld. The following description of discrepant welds and the following limitations on these welds are to be applied individually. Exceeding any of the maximum limitations permissible or failure to meet any of the minimum requirements of this standard is cause to reject a weld. Reference figures 3, 4, 5 and 6.

4.2.1.1 Quantity of Weld <S>

The number of welds shall be as specified and located as noted on the weld release.

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4.2.1.2 Weld Segments

No more than two weld segments can be performed to achieve an acceptable weld length. The total weld length must meet the minimum required fused leg, throat and surface requirements at the start and stop locations.

4.2.1.3 Length of Welds

Length welds are permitted a 3 mm discrepant start and a 5 mm discrepant stop (including crater). The start and stop discrepancies must not reduce the effective weld length below that specified on the print. The remaining weld length shall be at least 90% free of discrepant lengths. Discrepant lengths in the remaining weld length shall not reduce the overall acceptable weld length below that specified. Welds without a length requirement specified shall be welded along the entire joint formed by the mating parts with the same allowance for discrepant start and stop and 90% discrepancy free requirement. The minimum acceptable weld length should not be specified as less than 13 mm.

4.2.1.4 Maximum Continuous Discrepant Length

In welds over 200 mm the maximum continuous discrepant length shall not exceed 20 mm.

4.2.1.5 Weld Starts

Starts of arc welds shall not be considered as part of the acceptable weld length unless they meet the required fused leg & throat dimension as specified in this standard or weld releases. Reference Figure 3.

4.2.1.6 Weld Stops

The stops (crater) of arc welds shall not be considered as part of the acceptable weld length unless they meet the required fused leg and throat dimensions as specified in this standard or weld releases. Craters, if not filled, must not reduce the thickness of the materials being joined. Reference Figure 3.

4.2.1.7 Weld Notch

Weld notch described as meltback of base material shall not be considered part of the acceptable weld. Any deviation of the weld notch shall be specified on the weld releases. Reference Figure 6.

4.2.1.8 Weld Burn Through

Weld “Burn-Through”, a hole completely through the weld and substrate or adjacent to the weld in the base material is not allowed.

4.2.1.9 Surface Porosity

Individual pinholes separated by at least their own diameter and other scatter surface porosity is allowable. The total length of porosity (sum of diameters) cannot exceed 6.4 mm in any 25 mm of weld.

The maximum pinhole diameter should not exceed 80% of the thickness of the thinner member or 1.6 mm (1/16 in) whichever measurement is the lesser. Reference Figure 5.

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4.2.1.10 Groove Weld (Butt Joint)

Groove welds (Butt joint) cannot be visually inspected unless there is visual access to both sides of the joint, and the weld is specified as requiring 100% penetration. Reference Figure 7.

4.2.1.11 Cracks, Quality of Weld <S>

Cracks are not permitted in any weld.

4.2.1.12 Undercutting

A weld is discrepant if the parent metal is undercut by more than 10% of its thickness for more than 20% of the length of weld.

4.2.1.13 Weld Skips

Weld skips are not permitted in any welds.

4.2.2 Metallographic Inspection (Destructive Evaluation)

4.2.2.1 Fused Leg and Throat

For Fillet and Lap Welds, the minimum fused leg dimension shall not be less than .9t (where "t" is the thinnest gauge member being welded) unless otherwise specified on the engineering releases. The throat dimension for fillet welds, T, shall be a minimum of .6t unless otherwise specified on the engineering releases.

For Flare-Bevel & Flare-V Groove Welds the minimum fused leg and throat requirements are 0.9t and 0.6t respectively, where "t" is the thickness of the thinnest gauge member being joined. The method to measure these dimensions are shown in Figures 8 & 9. It should be noted that the throat dimension (T) is measured at the thinnest cross sectional area.

If there is a question of fused leg or throat size, cracking or internal porosity, the weld in question shall be sectioned and examined in accordance with this standard.

In cases where the engineering release deviates from the default fused leg dimension requirement of this standard, the throat dimension will not be automatically scaled. Any deviation from the default throat or leg dimension must be specified on the weld release in addition to being reviewed by FCA US Materials Engineering-Welding.

4.2.2.2 Fused Leg and Throat Inspection <S>

The Fused Leg Inspection shall consist of sectioned arc welds to verify the visual inspection and to check for fusion, of both fused legs, and other internal substandard weld conditions.

The fusion requirement for a fillet weld is specified by Fused Leg 1 & Fused Leg 2 representing fused legs of a triangular shaped weld deposit as shown in See Figure10.

The fusion requirements for a groove weld (butt joint), "L", are specified by one dimension representing the fusion dimension (Leg size), throat dimension and penetration into the joint as shown in Figure 7. The butt weld release (Figure 7) shows a 100% penetration weld, which is the minimum penetration required

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unless otherwise specified on the release. For square butt joints of two different thicknesses “L” is the thickness of the thinnest member.

Depth of leg measurement shall be the lesser of either 0.1 mm or 10% of the thinner material thickness.
Fused leg measurement begins where depth of penetration meets or exceeds the depth of leg measurement and ends when the depth of penetration fails to meet the minimum depth of leg measurement. See Figure 10.

The throat (T) requirement for a fillet weld is the minimum dimension (length) from the weld root to the weld face, as shown in Reference figures 8 - 11.

4.2.2.3 Internal Porosity

Internal porosity shall not exceed 15% of the area of the weld section being examined. The sum of pores must not reduce the required throat dimension below 60% of the thickness of the thinner member.

On zinc coated steels, if the internal porosity requirements cannot be met or sustained, MS.90024/05 W501 or W502 shall be specified on the release.

The maximum pinhole diameter should not exceed 30% of the thickness of the thinner member or 1.6 mm (1/16 in) whichever measurement is the lesser.

4.2.2.4 Cracks <S>

No cracks or fissures are permissible.

4.2.2.5 Incomplete Root Fusion

Incomplete fusion must be ≤ 10% of the thinnest sheet joined and ≤ 20% of the weld segment length. See Figure 9.

4.2.2.6 Penetration

The required minimum penetration shall be 15% of the thickness of the thinner member being joined. It is desirable to achieve 60% penetration as a process control limit.

There is no minimum required penetration on the edge face of the overlapping member of a lap joint when the edge has been melted back and evidence of full fusion has occurred. See Figure 11.

Melt through (excessive penetration) is allowable. If no melt through is allowed, it shall be stated on the print.
The maximum penetration or melt through shall not exceed 100% the thickness of the thinner member.

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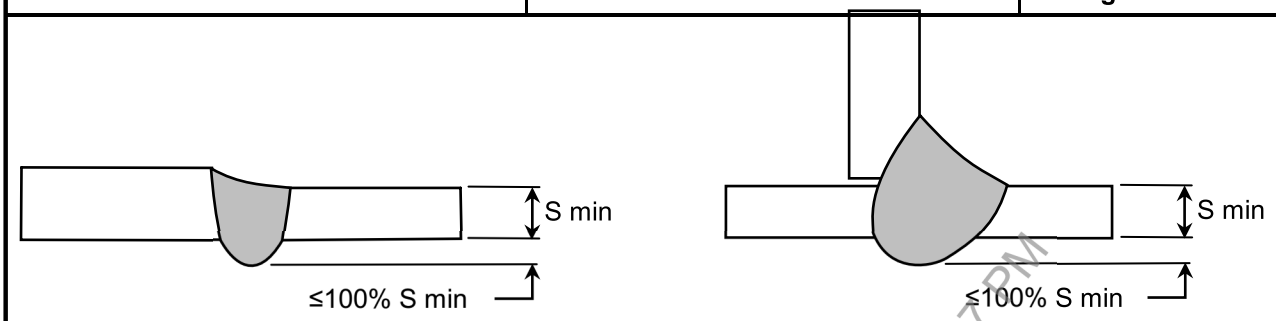

Figure 2 - Excessive Penetration or Melt Through

4.3 Re-process

4.3.1 Rework of Aluminum Discrepant Welds

Rework of discrepant welds is generally not permitted except in cases where the rework is to correct for short or missing welds. Any reprocessing shall be documented and agreed upon by the FCA US team consisting of the Releasing Engineer, Supplier Quality Engineer and either Supplier Quality Welding Engineer or Materials Engineering – Welding Engineering. This document shall contain what is and is not a repairable discontinuity both by definition, extent of discontinuity and number of attempts allowable if applicable. The reprocessing procedure shall contain the preparation process, repair procedure including all process parameters and also any post finishing requirements. Any reprocessed component must meet the requirements of this standard upon completion of the reprocessing procedure.

Short and/or missing welds shall be repaired using the original specified process and electrode material. The strength and weld quality of the repaired welds shall not be less than the original requirements of the engineering release.

4.3.2 Rework of Steel Discrepant Welds

4.3.2.1 Body In White Welds

Reference PS.50006/01 “Reprocessing - BIW Arc Welds” for further descriptions.

4.3.2.2 Non-Body in White Welds

Rework of discrepant welds is generally not permitted except in cases where the rework is to correct for short or missing welds. Any reprocessing shall be documented and agreed upon by the FCA US team consisting of the Releasing Engineer, Supplier Quality Engineer and either Supplier Quality Welding Engineer or Materials Engineering – Welding Engineering. This document shall contain what is and is not a repairable discontinuity both by definition, extent of discontinuity and number of attempts allowable if applicable. The reprocessing procedure shall contain the preparation process, repair procedure including all process parameters and also any post finishing requirements. Any reprocessed component must meet the requirements of this standard upon completion of the reprocessing procedure.

Short and/or missing welds shall be repaired using the original specified process and electrode material. The strength and weld quality of the repaired welds shall not be less than the original requirements of the engineering release.

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5 SPECIAL REQUIREMENTS

Not Applicable.

6 QUALITY

Refer to CS-9801 for general quality requirements.

7 TEST EQUIPMENT

Not Applicable.

8 SAFETY PRECAUTIONS

The welding materials and the welding process may contain and release toxic elements. The user shall comply with all applicable Corporate and/or Government fume ventilation requirements when soldering.

Certain important information relative to this standard has been included in separate standards. To assure the processes submitted meet all of FCA US requirements, it is mandatory that the requirements in the following standards be met.

CS-9800 - Application of this standard, the subscription service, and approved sources
CS-9003 - Regulated substances and recyclability

9 APPROVED SOURCE LIST

Not Applicable.

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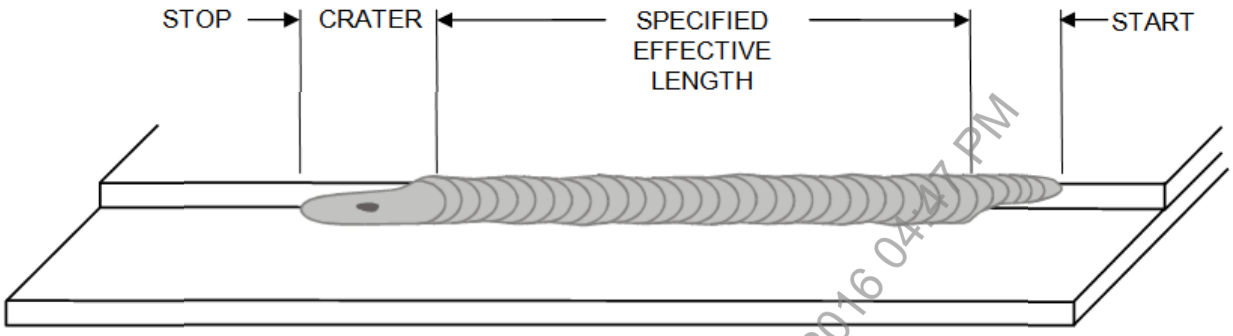

Figure 3 - Fillet Weld

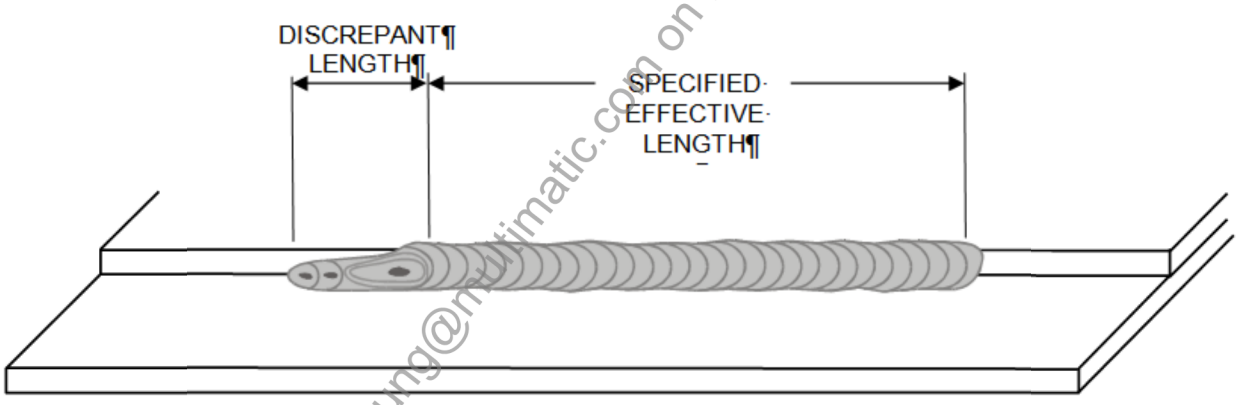

Figure 4 - Example Of An Acceptable Weld Length

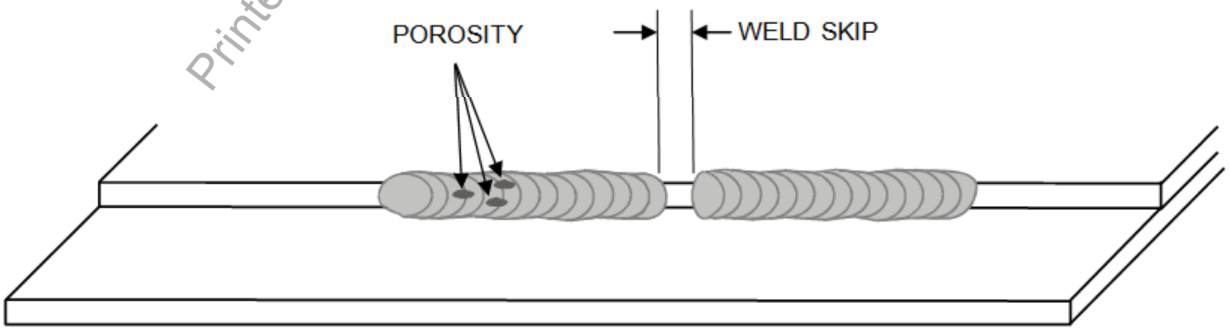

Figure 5 - Weld Porosity & Skip

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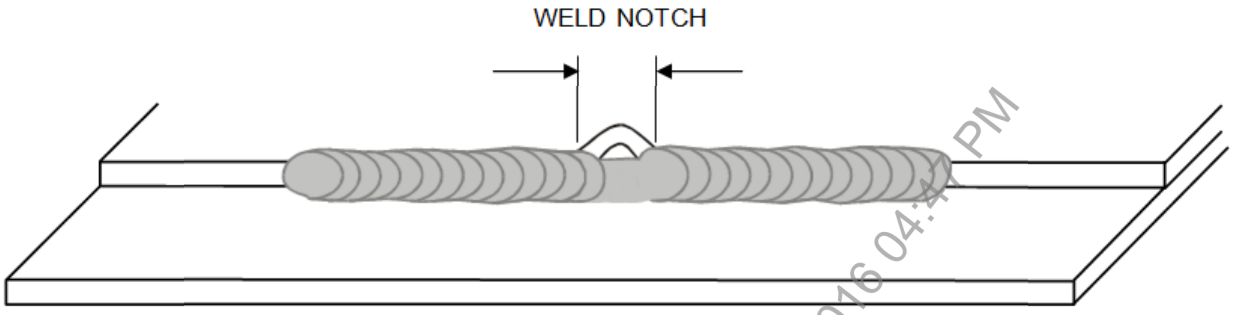

Figure 6 - Weld Notch

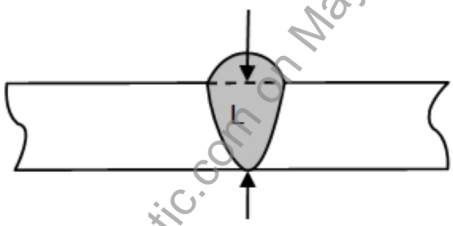

Figure 7 - Fusion Dimension And Penetration Groove Weld (Butt Joint)

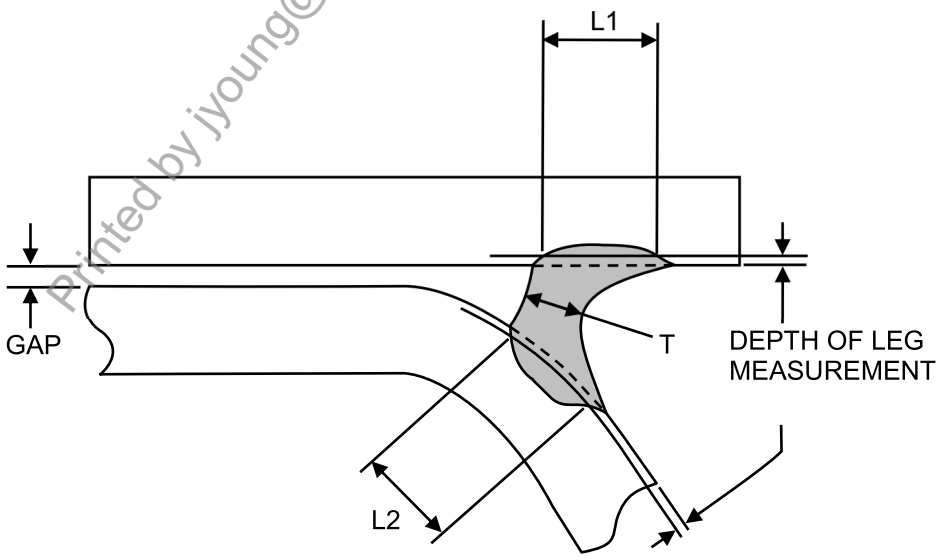

Figure 8 - Groove Weld Flare

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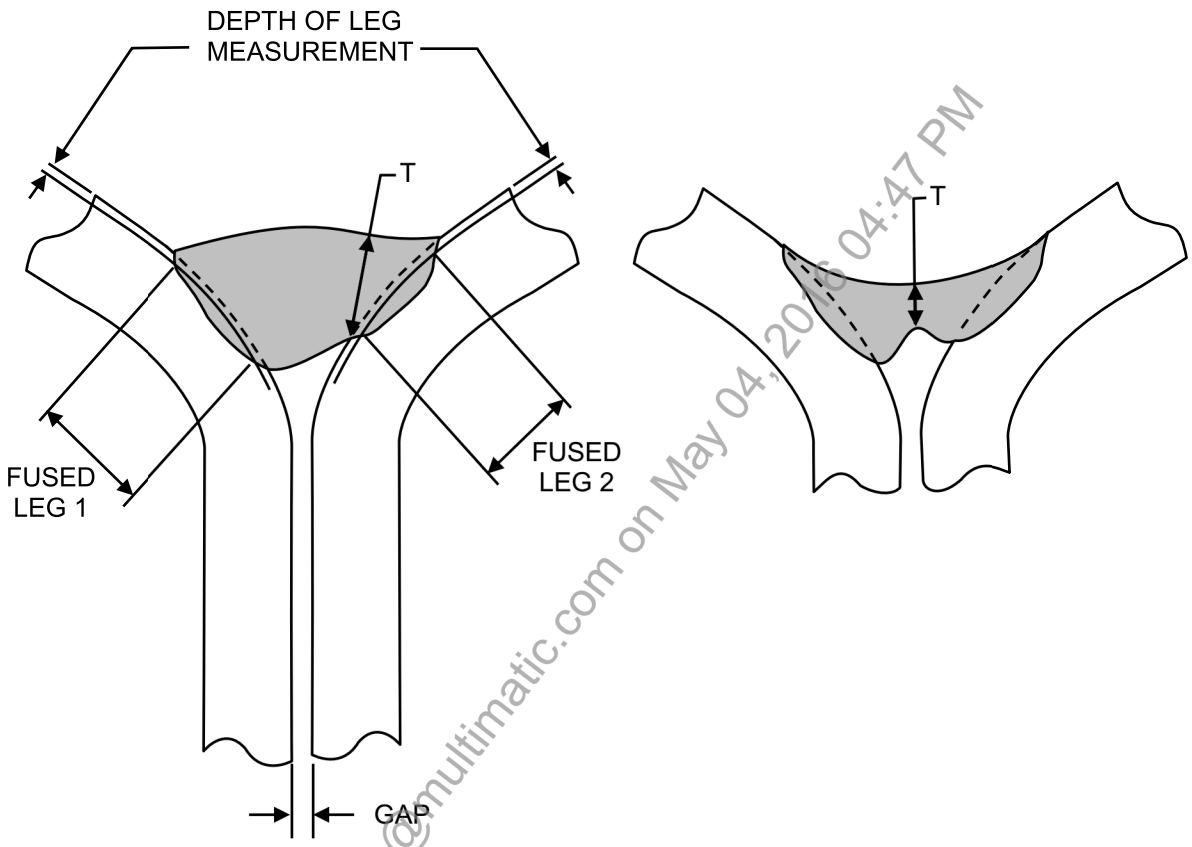

Figure 9 - Groove Weld – V

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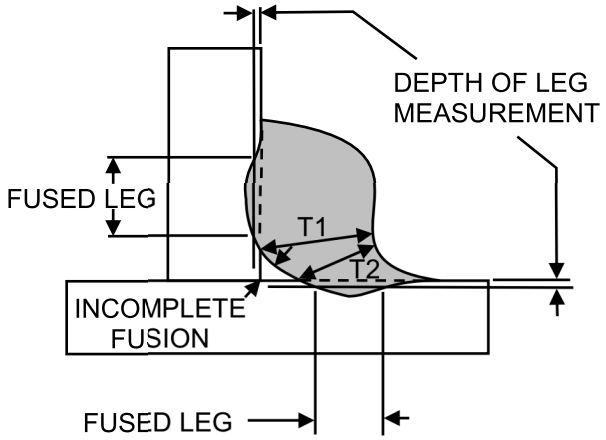
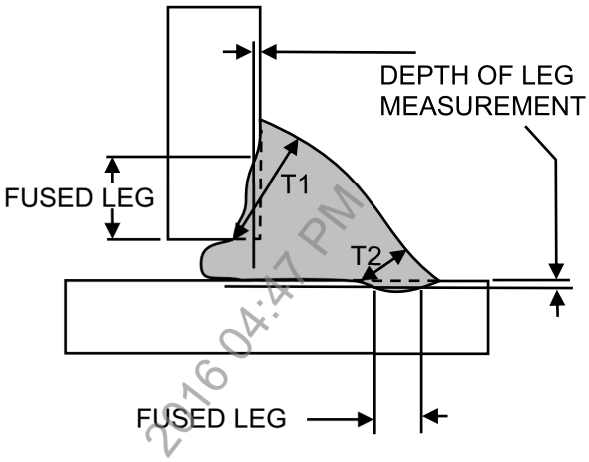
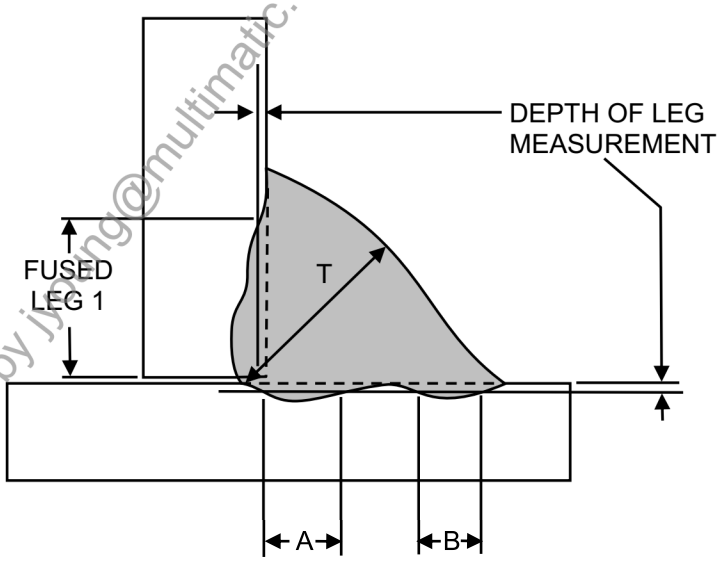


FILLET WELD WITH INCOMPLETE FUSION
AT ROOT OF JOINT
T2 < T1, T2 is the reported throat.



T-JOINT WITH ROOT OPENING
(Gap between parts)
T2 < T1, T2 is the reported throat.



FUSED LEG 2 = A + B

Interrupted Penetration Below Depth Of Leg Measurement
No More Than 2 Accumulative Segments Allowed

Figure 10 - Examples Of Weld Measurement

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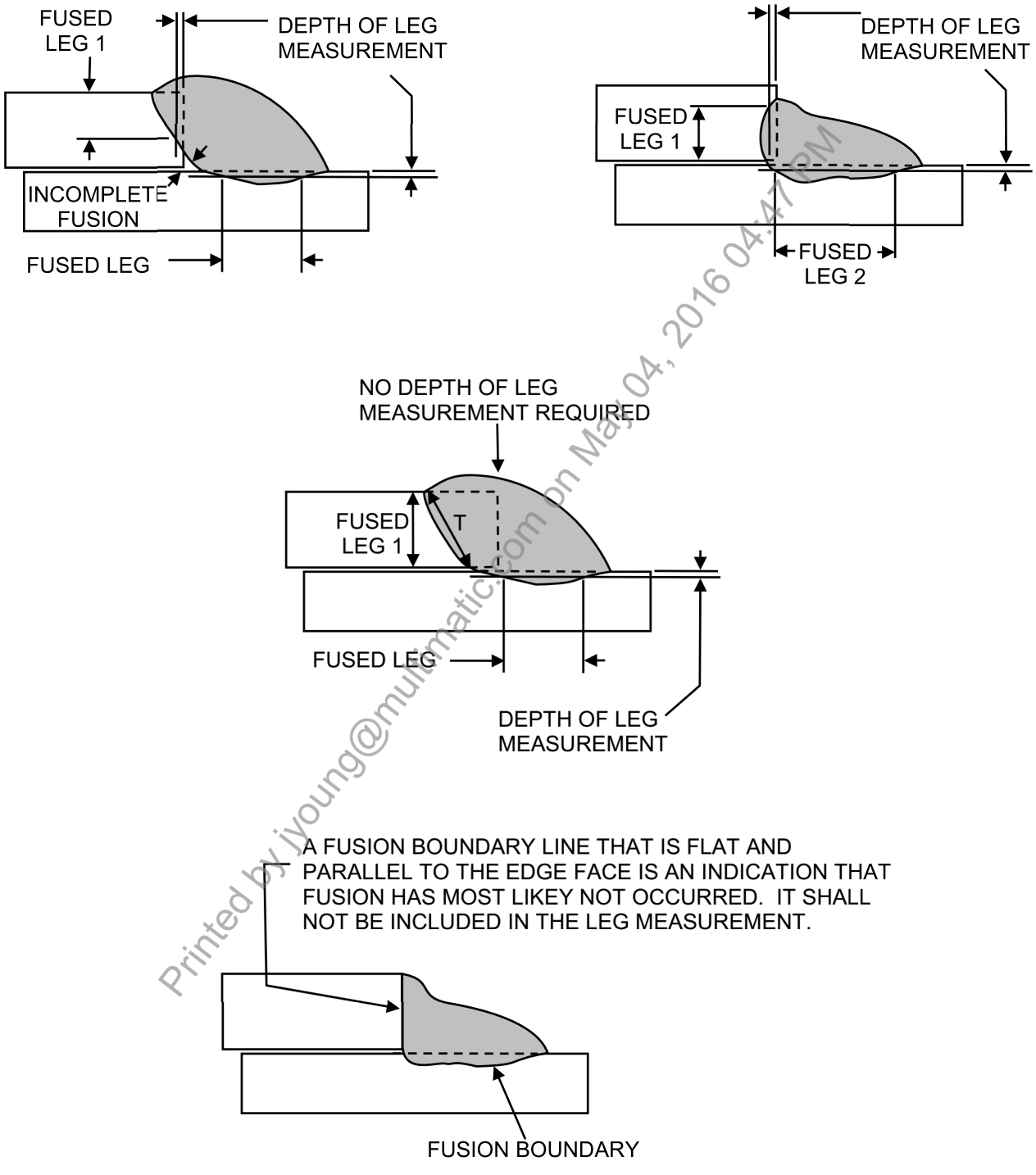

Figure 11 - Examples Of Lap Weld Measurement