**BOMBARDIER**
**Toronto Site**
**PROPRIETARY INFORMATION**

# PPS 37.12

## PRODUCTION PROCESS STANDARD

# QUALIFICATION AND CERTIFICATION OF RESISTANCE WELDING MACHINES

Issue 10 - This standard supersedes PPS 37.12, Issue 9.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 37.12 related questions to michael.wright@aero.bombardier.com.
- This PPS is effective as of the distribution date.

| | | | |
|---|---|---|---|
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## 1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for qualifying resistance welding machines and certifying resistance welding schedules.

1.2 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS must be followed to ensure compliance with all applicable specifications. In general, if this PPS conflicts with the engineering drawing, follow the engineering drawing. The requirements specified in this PPS are necessary to fulfil the engineering design and reliability objectives.

1.2.1 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

1.2.2 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. **do not** supersede the procedure or requirements specified in this PPS.

1.3 Refer to PPS 37.11 for the definitions of spot welding, stitch (intermittent spot) welding and seam welding.

## 2 Hazardous Materials

2.1 Before receipt at Bombardier (Toronto Site), all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier (Toronto Site) Environment, Health and Safety Department. Refer to the manufacturer's MSDS for specific safety data on any of the materials specified in this PPS. If the MSDS is not available, contact the Bombardier (Toronto Site) Environment, Health and Safety Department.

## 3 References

### 3.1 General

3.1.1 Unless a specific issue is indicated, the issue of the reference documents specified in this section in effect at the time of manufacture shall form a part of this specification to the extent indicated herein.

### 3.2 Bombardier (Toronto Site) Specifications

3.2.1 PPS 13.26 - General Subcontractor Provisions.

3.2.2 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.3 PPS 20.10 - Radiographic Inspection.

3.2.4 PPS 37.01 - Resistance Welding Aluminum Alloys.

3.2.5 PPS 37.02 - Resistance Welding Non-Hardening Steels and Alloys, Nickel Alloys and Titanium.

3.2.6 PPS 37.11 - Requirements for Resistance Welding.

### 3.3 Bombardier (Toronto Site) Internal Welding Schedules (Forms)

3.3.1 DH5344 - Resistance Spot Welding Schedule.

3.3.2 DH5345 - Resistance Seam Welding Schedule

## 4 Materials, Equipment and Facilities

### 4.1 Materials

4.1.1 Unless otherwise specified in this section, use only the materials specified; use of superseding or alternative materials is not allowed.

4.1.2 Test specimens, prepared according to Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5, of the materials specified herein.

### 4.2 Equipment

4.2.1 Resistance welding machines, as used in production.

### 4.3 Facilities

4.3.1 This PPS has been categorized as a “Controlled Critical Process” according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform qualification of resistance welding machines and certification of resistance welding schedules according to this PPS.

4.3.2 Bombardier subcontractors must direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities must direct requests for approval to the appropriate internal Quality Manager.

4.3.3 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program, if required. The facility report must detail the materials and equipment to be used, the process sequence to be followed and the laboratory facilities used to show compliance with the requirements of this PPS. Any deviation from the procedure or requirements of this PPS must be detailed in the facility report. Based upon the facility report, Bombardier (Toronto Site) Materials Technology may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification must be prepared to demonstrate their capability. Once approved, no changes to subcontractor facilities may be made without prior written approval from Bombardier Aerospace Supplier Quality Management.

4.3.3.1 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, for approval of subcontractor facilities to perform qualification of resistance welding machines and certification of resistance welding schedules according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples must meet the requirements specified in section 6.

## 5 Procedure

### 5.1 General

5.1.1 Materials are grouped as follows for the purposes of resistance welding machine qualification:

- Group (a) - Aluminum, aluminum alloys and magnesium alloys.
- Group (b) - Non-hardening steels; austenitic, ferritic and precipitation hardening steels; nickel alloys and cobalt base alloys.
- Group (c) - Titanium and titanium alloys.

5.1.2 Spot welding is defined as a resistance welding process wherein fusion of 2 or more metal parts is produced by the heat obtained from resistance to the flow of electrical current through the parts held together under pressure.

5.1.3 Resistance spot welding is comprised of a series of non-lapping spots made at a pitch specified on the engineering drawing. Seam welding is similar to spot welding in that the resultant weld is comprised of a series of overlapping spot welds effecting a pressure tight joint.

5.1.4 In order to ensure reliability of the welding process **both** resistance welding machine qualification **and** resistance welding schedule certification are required. Resistance welding machine qualification ensures repeatability and capability of the machine. Resistance welding schedule certification ensures specific part/weld acceptability.

### 5.2 Qualification of Resistance Welding Machines

5.2.1 Resistance welding machines may be qualified to weld either group (a), group (b) and/or group (c) materials or to weld only group (b) and/or group (c) materials. Refer to paragraph 5.1.1 for materials applicable to each group. To qualify a machine to weld group (a), group (b) and/or group (c) materials, use clad 2024-T3 test specimens. To qualify a machine to weld only group (b) and/or group (c) materials, use 300 series corrosion resistant steel test specimens. For either qualification, only one set of test specimens as specified herein (including spot welding and/or seam welding test specimens, as applicable) are required.

5.2.2 Qualify resistance welding machines for Class A, Class B and/or Class C welding, as applicable. The Class of weld required is specified by the engineering drawing. Qualify resistance welding machines to meet the weld requirements of the highest weld class for which they are intended to be used in production.

5.2.3 Only one machine of each distinctive type is required to pass the qualification tests specified herein, and all other machines of the same type may be considered qualified. Distinctive types of machines are those differing in any of the following respects:

- Manufacturer of machine or control panel or type of machine or model number.
- Electrical rating or capacity.
- Type of electrical energy.
- Type of pressure application.

5.2.4 The material, diameter and tip radius of the electrode tip (spot welding machines) or the material, diameter, width and cross sectional radius of the electrode wheel (seam welding machines), as well as the pressure and current settings, used for qualification shall be based on the specification and gauges of the alloys used for the qualification test.

5.2.5 To qualify machines for spot welding, prepare two sets of specimens, one at each limit of the material thickness range for which qualification is sought. Each set must consist of 105 consecutive spots conforming to Figure 1. Sets may comprise more than 1 pair of panels, provided that each pair of panels contains not less than 30 spots and the panels are welded so that all spots are consecutive. Also, do not include the first spot in each panel in the 105 spots.

5.2.6 To qualify machines for seam welding, prepare each set of specimens according to Figure 4 or Figure 5, as applicable.

5.2.7 A machine qualified for spot, roll spot or seam welding is also considered qualified for intermittent spot welding.

5.2.8 Clean and weld the panels according to normal production procedure, except that no maintenance attention or control adjustments may be carried out during the welding of a set of specimens.

5.2.9 If machines are being qualified for Class A welding, radiographically examine the welds in each set of specimens according to PPS 20.10 to ensure the applicable requirements of PPS 37.11 are met. To qualify a machine for Class B and Class C welding radiographic examination is not required.

5.2.10 Check all welds for external defects, sheet separation and surface indentation, as well as the requirements of PPS 37.11.

5.2.11 Section five of the welds from each set of 105 spot welds as closely as possible through the centre of the welds and then polish and etch the sections for metallographic examination. Polish and etch longitudinal and transverse sections of seam weld test specimens for metallographic examination. Examine Class A welds as micro-sections at 25X to 40X magnification. Examine Class B and Class C welds as macro-sections at 7X to 10X magnification. In all cases, ensure that welds meet the applicable requirements of PPS 37.11.

5.2.12 Cut the remaining 100 spots from each set of 105 spot welds into single spot specimens, according to Figure 2, and test in shear with the joints unrestricted. Refer to PPS 37.11 for the acceptability limits for minimum shear strength, average shear strength and shear strength consistency. Visually (macroscopically) examine test specimens for all classes of welds, after having been tested in shear, for fusion and obvious defects such as cracks, porosity, spits and cladding inclusions.

5.2.13 Maintain copies of laboratory qualification test reports on file.

5.2.14 Upon receiving qualification approval for a particular machine, post the material groups, basic material thickness combinations, class of welding and date on which the machine was qualified in the vicinity of the machine and keep approval records on file.

5.2.15 Re-qualification of qualified resistance welding machines is only required under the following circumstances. It is the responsibility of **all** departments and personnel involved to ensure that if any of the following circumstances apply, the machine in question is requalified before resumption of production welding.

- Requalification is required if a resistance welding machine previously only qualified to weld group (b) and/or group (c) material is to be used to weld group material.
- Requalification is required if the thickness range for which a machine was qualified for is changed (e.g., if it is necessary to weld thicker or thinner material than the machine was previously qualified to weld).
- Requalification is required if a machine qualified only for a lesser class (i.e., Class B or Class C) is to be used for higher class welding (e.g., Class A).
- Requalification is required if the machine is rebuilt (not including regular maintenance or replacement of parts which would not affect the weld acceptability),
- Requalification is required if significant operational changes (i.e., programming or production process changes) are made to the machine.
- Requalification is required if there is a change in power (note: a change of location which does not involve a change in power does not necessitate requalification).
- Requalification is required in the case of unsatisfactory machine performance as described in PPS 37.01 and PPS 37.02.

## 5.3 Certification of Resistance Welding Schedules

5.3.1 Welding schedules must indicate the material combination, cleaning method, roll thickness, or electrode type and radius, settings of all variable controls, primary voltage and class of certification. If a special welding schedule is required, the schedule must contain, in addition, the part number to which the schedule applies and any special tests which may be required. For Class A welds, include the average shear strength (or nugget diameter) obtained during certification on the welding schedule.

5.3.2 Establish and certify welding schedules for each gauge and material combination and electrode set-up before production parts are welded. Establish a separate schedule for spot, intermittent spot and seam welding, as applicable.

5.3.3 Certify welding schedules by making and testing not less than the number of welds listed in Table 1 for the welding class for which certification is desired. For Class A welds, radiographically examine the weld according to PPS 20.10, before testing, for determination of internal defects.

**Table 1. Test Specimens for Certification of Welding Schedules**

| Weld Method | Class of Weld | Group (a) Material | | Groups (b) and (c) Material | |
|---|---|---|---|---|---|
| | | Ultimate Shear Strength Specimen | Metallurgical Specimen | Ultimate Shear Strength Specimen | Metallurgical Specimen |
| Spot Weld | A | 20 shear | 5 welds micro section | 10 shear | 3 welds micro section |
| | B | 10 shear | 5 welds macro section | 5 shear | 3 welds macro section |
| | C | 3 shear | 2 welds macro section | 3 shear | 5 welds macro section |
| Intermittent Spot Weld | A | 10 nugget diameter measurements (Note 1) | 20 welds 10 micro sectioned | 10 nugget diameter measurements (Note 1) | 20 welds 10 micro sectioned |
| | B | 5 nugget diameter measurements (Note 1) | 10 welds 5 macro sectioned | 5 nugget diameter measurements (Note 1) | 10 welds 5 macro sectioned |
| | C | 3 nugget diameter measurements (Note 1) | 3 welds macro sectioned | 3 nugget diameter measurements (Note 1) | 3 nugget diameter measurements |
| Seam Weld (Note 2) | A | n/a | 12 inches of weld (see Figure 4) | n/a | 12 inches of weld (see Figure 4) |
| | B | n/a | | n/a | |
| | C | n/a | 3 inches of weld (see Figure 5) | n/a | 3 inches of weld (see Figure 5) |

Note 1. Obtain nugget diameter measurements from metallurgical specimens.

Note 2. Seam welds may be effected by the overlapping of spot welds with fixed type electrodes. Certify and control parts seam welded in this manner according to seam welding requirements.

5.3.4 If certifying welding schedules for group (a) materials, the ultimate strength shear test specimens must be first welded as multiple spot specimens conforming Figure 1 to be cut into single spot specimens according to Figure 2 for testing. If certifying welding schedules for group (b) or group (c) materials, the ultimate strength shear test specimens may be prepared directly as single spot specimens conforming to Figure 2.

5.3.5 For welds in multiple thickness combinations of 4 or more thicknesses, evaluate weld diameter at the intermediate planes (i.e., planes not involving an outer plane) on the basis of its nugget diameter, instead of shear test loading.

5.3.6 Refer to PPS 37.11 for weld shear strength requirements.

5.3.7 For intermittent spot welds, intermediate planes of 4 or more thickness joints and if nugget diameter measurements are used in place of shear strength tests, obtain nugget diameter measurements from the metallurgical specimens. Refer to PPS 37.11 for nugget diameters requirements.

5.3.8 Metallurgical specimens must conform to the requirements of Figure 3, Figure 4 or Figure 5, as applicable. Cross-section specimens as closely as possible through the centres of the welds before polishing and etching for metallurgical examination. Examine micro sections for Class A welds at 25X to 40X magnification. Visually examine macro sections for Class B or Class C welds with the naked eye or at 7X to 10X magnification. Refer to PPS 37.11 for weld quality requirements.

5.3.9 Maintain a copy of each test report regarding certification of welding schedules on file.

5.3.10 For parts which have been subjected to severe forming operations, such as rolling, drop hammer working or spinning, or extrusions, which cannot be satisfactorily welded using the settings established for flat, unworked sheet of the same material, certify a special welding schedule. Establish and certify special welding schedules using material which has been subjected to the same forming operations in order to reflect production conditions. Nugget diameter measurements may be used in place of testing shear requirements if special welding schedules have been certified.

5.3.11 If the engineering drawing specifies welds with shear strengths greater or less than the requirements of PPS 37.11, establish and certify a special welding schedule for each of the affected parts, unless the drawing requirements can be met using the normal welding schedule certified for the same material combination.

5.3.12 It is recommended that certified resistance welding schedules be kept in the resistance welding area, available for reference by machine operators and other authorized personnel.

5.3.13 Recertification of a welding schedule may be required if unsatisfactory performance, as described in PPS 37.01 or PPS 37.02, occurs.

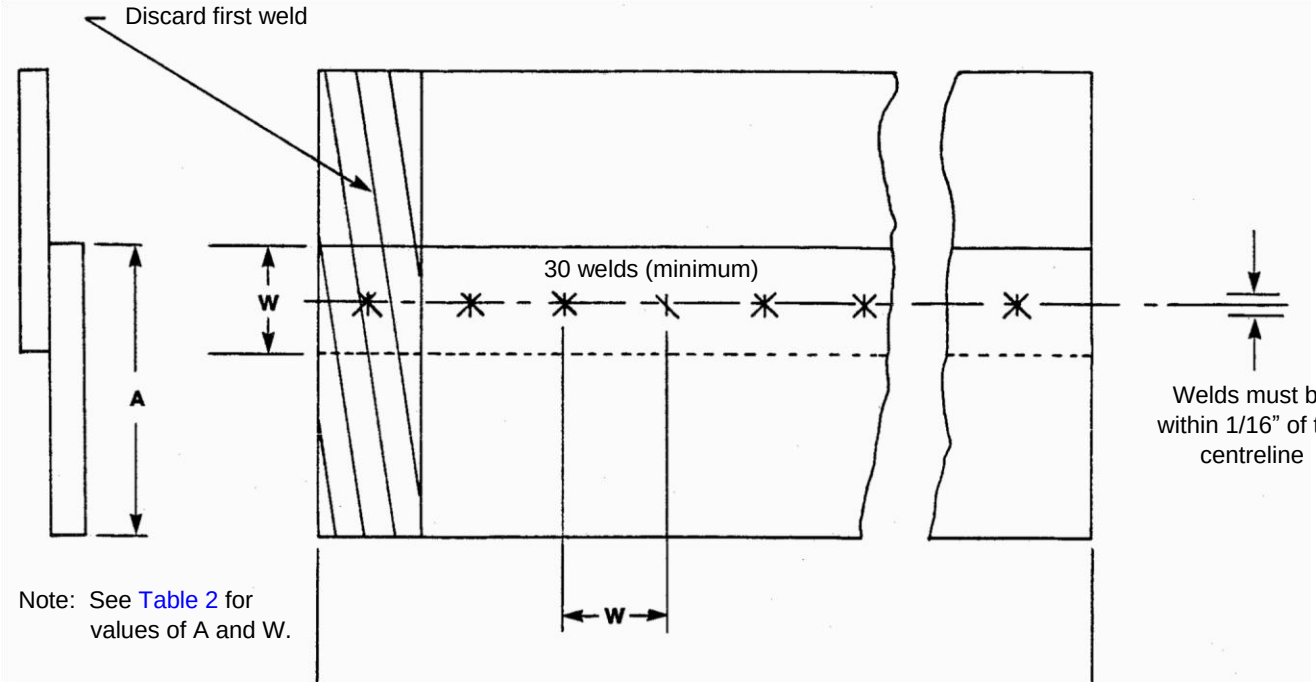
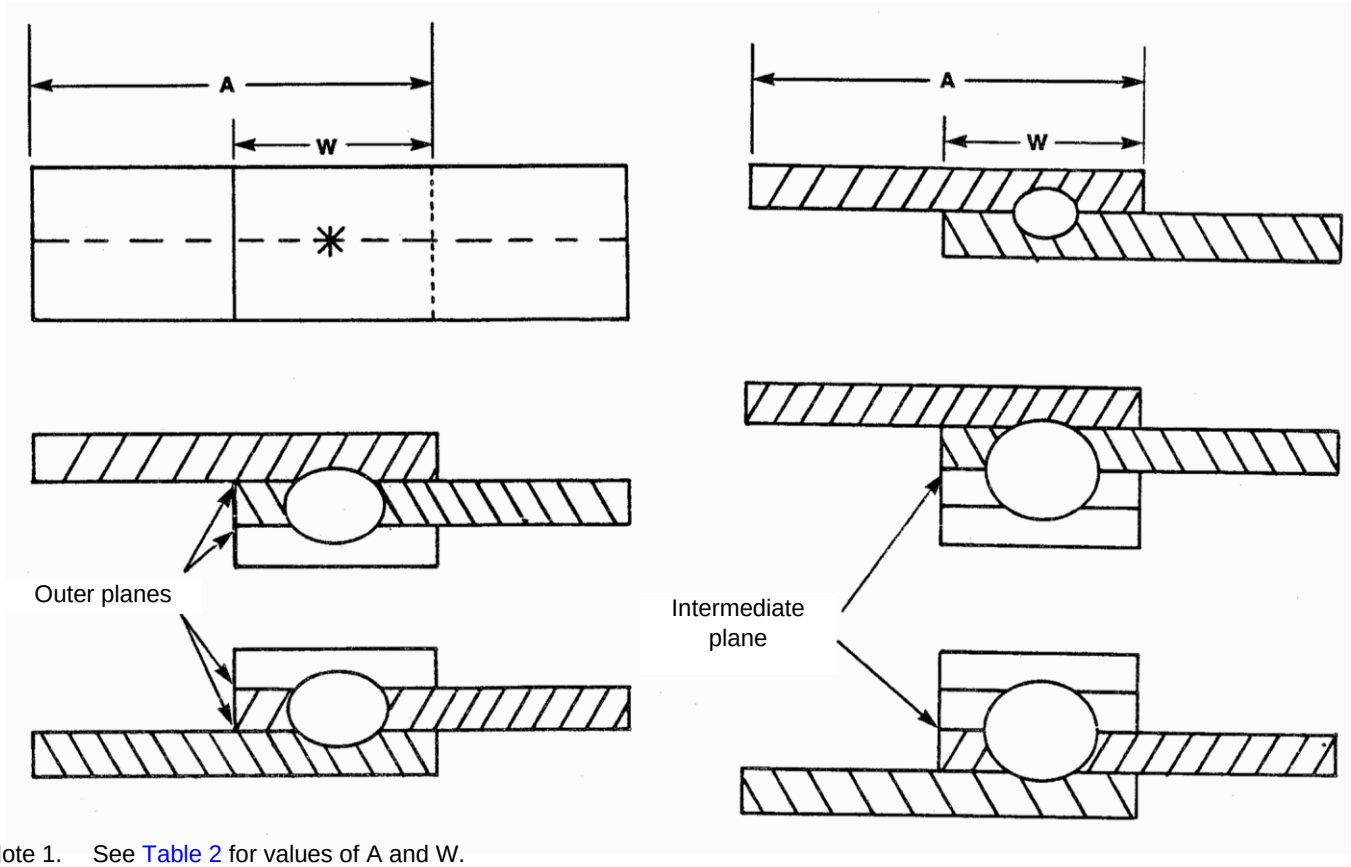



**Figure 1. Multiple Spot Shear Test Specimen**

**Table 2. Dimensions of Shear Test Specimens**

| Nominal Thickness Of Thinner Sheet | Width W (Minimum) | | Length A |
|---|---|---|---|
| | Group (A) Materials | Groups (B) and (C) Materials | |
| 0.030" and under | 5/8" | 5/8" | Minimum required to perform shear test |
| 0.031" - 0.050" | 3/4" | 1" | |
| 0.051" - 0.100" | 1" | 1" | |
| 0.101" - 0.130" | 1 1/4" | 1 1/4" | |
| 0.131" and over | 1 1/2" | 1 1/4" | |




Note 1. See Table 2 for values of A and W.

Note 2. Test strips not loaded (unshaded) may be laid crosswise or parallel with loaded specimen or maybe short or bent out of the way. However, the required overlap W must be maintained.

Note 3. If 3 or 4 thicknesses are being welded in production, prepare 2 sets of multiple thickness, single spot, shear test specimens so that both outer planes may be subjected to shear test

**Figure 2. Single Spot Shear Test Specimen**

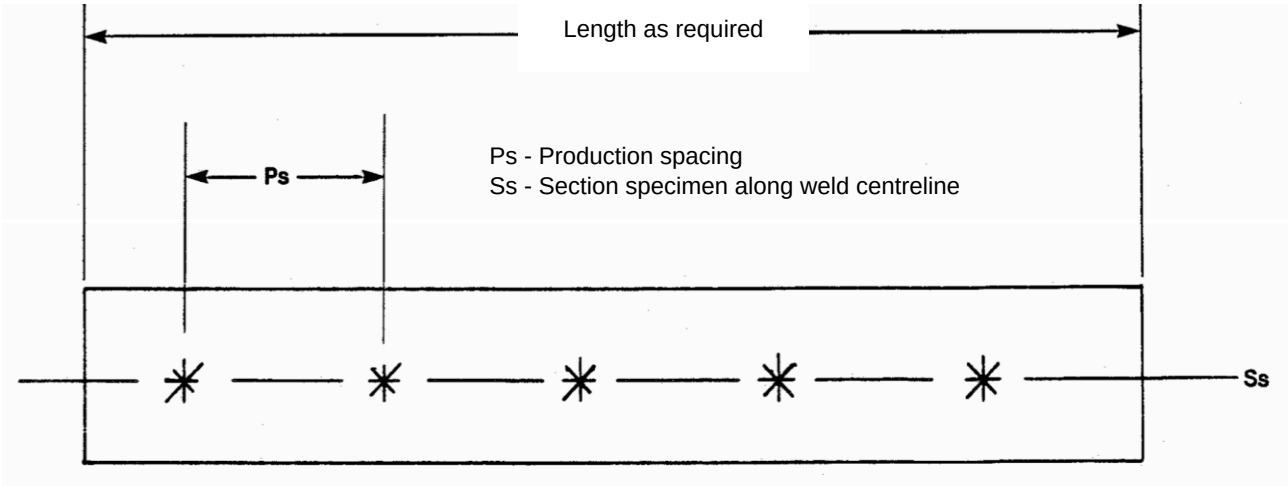
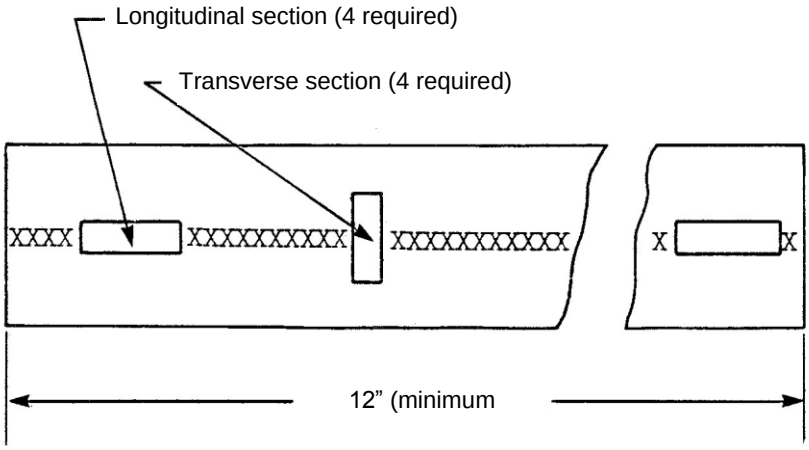



**Figure 3. Metallurgical Specimen (Spot and Intermittent Spot Welds)**



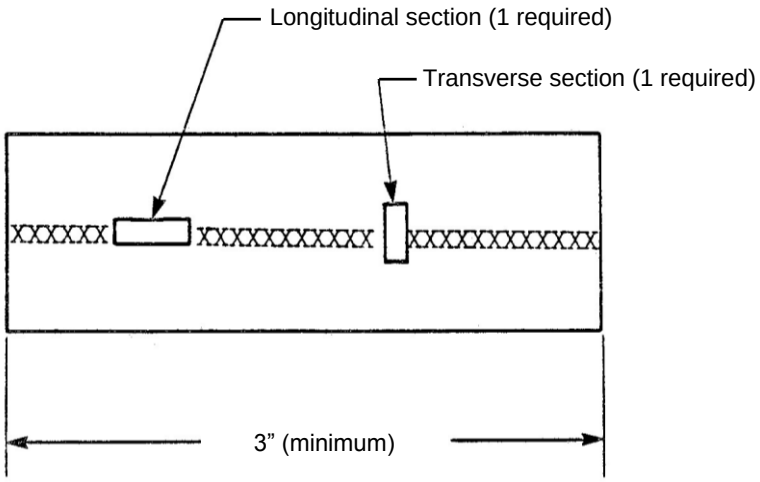

Note 1. Prepare each longitudinal section so that a minimum of 1 inch of seam weld is examined.

Note 2. Ensure that transverse sections include the weld nugget, the heat affected zone and portions of the unaffected parent metal at each end.

Note 3. Refer to Table 2 for the width of the test strip for the applicable thickness and group of material.

Note 4. Micro examine sections for Class A welds and macro examine sections for Class B welds

**Figure 4. Metallurgical Specimen for Qualification and Certification of Seam Welding (Class A and Class B Welds)**




Note 1. Prepared the longitudinal section so that a minimum of 1 inch of seam weld is examined.

Note 2. Ensure that the transverse section includes the weld nugget, the heat affected zone and portions of the unaffected parent metal at each end.

Note 3. Refer to Table 2 for the width of the test strip for the applicable thickness and group of material.

Note 4. For Class C welds, macro examine sections.

**Figure 5. Metallurgical Specimen for Qualification and Certification of Seam Welding (Class C Welds)**

## 6 Requirements

6.1 Refer to PPS 37.11 for weld requirements.

## 7 Safety Precautions

7.1 **The safety precautions specified herein are specific to Bombardier (Toronto Site) to meet Canadian Federal and Provincial government environmental, health and safety regulations. It is recommended that other facilities consider these safety precautions; however, suppliers, subcontractors and partners are responsible for ensuring that their own environmental, health and safety precautions satisfy the appropriate local government regulations.**

7.2 **Observe general shop safety precautions when performing the procedure specified herein.**

7.3 **Wear goggles or face shields during resistance welding operations.**

## 8 Personnel Requirements

8.1 This PPS has been categorized as a “Controlled Critical Process” by PPS 13.39. Refer to PPS 13.39 for personnel requirements.

8.2 Personnel responsible for resistance welding must meet the personnel requirements specified in PPS 37.01 or PPS 37.02, as applicable.