BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 37.02

PRODUCTION PROCESS STANDARD

Resistance Welding of Non-Hardening Steels, Nickel Alloys and Titanium

Issue 19
- This standard supersedes PPS 37.02, Issue 18.
- Detail changes over the previous issue have not been noted as un-markable deletions have been made at this revision.
- This PPS is effective as of the distribution date.

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1 Scope

1.1 This PPS (Production Process Standard) specifies the procedure and requirements for the resistance welding of non-hardening steels and alloys and nickel alloys (Group (b) materials) and titanium and titanium alloys (Group (c) materials).

1.1.1 The term **non-hardening** means non-hardening by the welding process. Refer to PPS 37.11 for resistance welding requirements and for the definitions of spot welding, intermittent spot (stitch) welding and seam welding.

1.1.2 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.

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

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

2 Hazardous Materials

2.1 Before receipt at Bombardier Toronto (de Havilland), all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto (de Havilland) 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 (de Havilland) 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 (de Havilland) Specifications

3.2.1 DH5080 - Resistance Welding Test Form - *Bombardier Toronto (de Havilland) internal form*.

3.2.2 PPS 13.26 - General Subcontractor Provisions.

3.2.3 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.4 PPS 31.03 - Cleaning of Carbon and Low Alloy Steels.

3.2.5 PPS 31.05 - Surface Treatment of Corrosion Resistant Steels.

3.2.6 PPS 31.09 - Cleaning of Titanium and Titanium Alloys.

3.2.7 PPS 31.12 - Cleaning Nickel and Nickel Alloys.

3.2.8 PPS 37.11 - Requirements for Resistance Welding.

3.2.9 PPS 37.12 - Qualification and Certification: Resistance Welding Machines.

3.3 Industry Specifications

3.3.1 AWS D17.2/D17.2M - Specification for Resistance Welding for Aerospace Applications.

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 Only non-hardening steels and alloys, nickel alloys and titanium materials and gauges as listed on the appropriate welding schedules, established and certified in accordance with PPS 37.12, may be resistance welded according to the procedure specified herein. Test specimens must be of the same material specification and gauge as the parts they represent.

4.2 Equipment

4.2.1 Resistance welding machines employed in the welding of non-hardening steels and alloys, nickel alloys and titanium shall be qualified according to PPS 37.12.

4.2.2 Electrode wheels (for seam welding only) and electrode tips as specified on the welding schedules.

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 resistance welding of non-hardening steel, nickel and titanium alloys 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 (de Havilland) 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, approval of subcontractors to perform resistance welding of non-hardening steel, nickel and titanium alloys according to this PPS requires completion of a test program representative of the parts to be produced in production and submission of test samples as specified in section 5.6. Test samples must meet the requirements specified in section 5.6.

5 Procedure

5.1 General

5.1.1 Weld classifications shall be according to the engineering drawing requirements. If the engineering drawing does not specify a weld classification, Engineering shall be requested to designate the classification.

5.1.2 All resistance welding machines used in Bombardier Toronto (de Havilland) must be qualified to PPS 37.12. Subcontractors must show evidence that their machines have been qualified to either PPS 37.12 or AWS D17.2/D17.2M. Machines qualified to weld aluminum and aluminum alloys shall be considered qualified to weld materials within the scope of this standard. The reverse, however, shall not apply.

5.1.3 Welding schedules for each joint combination must be established and certified according to PPS 37.12.

5.1.4 Electrode tips and electrode wheels shall be as specified on the welding schedule.

5.1.5 Jigs and fixtures used for locating parts or assemblies to be welding shall be manufactured from non-magnetic materials.

5.1.6 Operate resistance welding machines according to the manufacturer's instructions.

5.2 Definitions

5.2.1 Group (a) materials: Aluminum and magnesium alloys.
Group (b) materials: Austenitic, ferritic and precipitation hardening steels, nickel alloys and cobalt base alloys.
Group (c) materials: Titanium and titanium alloys.

5.2.2 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.

5.2.3 Resistance spot welding is comprised of a series of non-lapping spots made at a pitch specified on the engineering drawing.

5.2.4 Seam welding is performed using a seam welding machine utilizing electrode wheels and is similar to spot welding in that the resultant weld is comprised of a series of overlapping spot welds effecting a pressure tight joint. Overlapping spot welds prepared using a spot welding machine are not an acceptable substitute for seam welds, unless specifically permitted by the engineering drawing.

5.3 Material Cleaning

5.3.1 Clean materials according to PPS 31.03, PPS 31.05, PPS 31.09 or PPS 31.12, as applicable.

5.3.2 Wear clean cotton gloves at all times when handling cleaned material.

5.3.3 For routine production tests (see section 5.6), attach test panels (and simulated parts, if required) with each batch of production parts and clean and identify the test panels (and simulated parts, if required) with such parts.

5.4 Preparation of Work for Welding

Step 1. Assemble the parts according to the engineering drawing. Ensure that mating parts fit in such a way that, the surfaces to be joined by the weld are in contact with each other or can be made to contact each other using light manual pressure on the area where the weld is to be made.

Step 2. Use approved jigs, fixtures or clamps as necessary to locate parts.

5.5 Preparation of Resistance Welding Machines

5.5.1 Prepare resistance welding machines using Spot Weld Electrodes as follows:

Step 1. Fit and line up the electrodes specified on the welding schedule.

Step 2. Lightly smooth off the sharp edges with abrasive cloth.

Step 3. Lightly clean the tapered portion of the tip with a very fine emery cloth. Take care to avoid excessive cleaning, which would reduce the size of the tapered portion and cause fitting problems in the holder.

Step 4. Insert the tapered portion of the tip of the electrode onto the electrode holder. If lateral adjustments of the upper electrode are necessary, slacken the bolts securing the upper electrode holder to the ram before adjusting the position of the electrode. Carry out adjustments by gently tapping the electrode holder using a suitable mallet. Do not use force on a holder without slackening the securing bolts.

Step 5. Ensure that the electrode tips are in alignment.

Step 6. Extend the water cooling tube to come into contact with the end of the electrode tip.

Step 7. Dress the electrode tips at suitable intervals to prevent surface roughness or tip pick-up. Use a steel paddle, having machined recesses of the same contours as the tips to be cleaned, wrapped in abrasive cloth no coarser than number 150. Do not use damaged or bent electrodes.

5.5.2 Prepare resistance welding using seam weld electrode wheels as follows:

Step 1. Install electrode wheels specified on the welding schedule.

Step 2. Ensure that the cooling channel in the wheel is properly aligned with the shaft of the electrode head.

Step 3. Align the scribe mark on the wheel with the associated scribe mark on the face of the shaft. If the wheels are out of alignment, contact the Welding Specialist (or Welding Engineer).

Step 4. At Bombardier Toronto (de Havilland) tighten the bolts as follows:

- 1/2" bolts - to a torque value of 45 ft. lbs.
- 3/8" bolts - to a torque value of 35 ft. lbs.

Step 5. Clean the wheel faces using very fine emery cloth.

Step 6. Dress electrode wheels at suitable intervals to prevent surface roughness or wheel face pick-up. Use a steel paddle, having machined recesses of the same contour as the wheel face to be cleaned, wrapped with 240 grit or finer abrasive cloth and used for wheel dressing. Do not use damaged electrode wheels.

5.6 Routine Tests

5.6.1 General

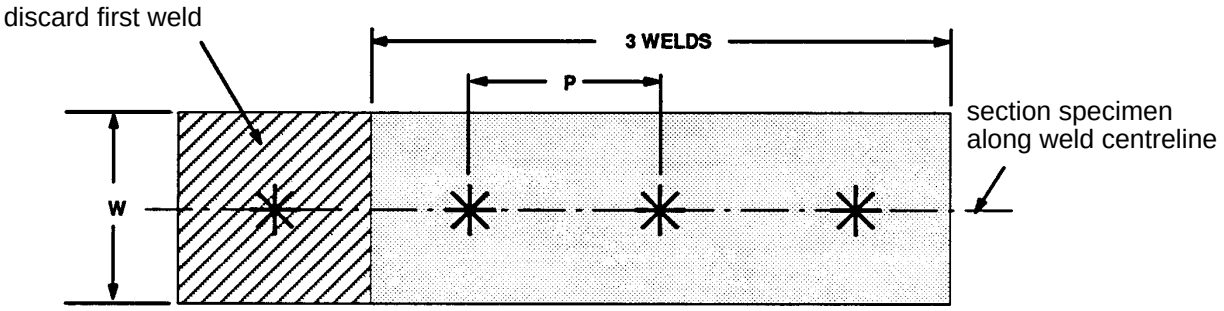
5.6.1.1 Carry out routine tests according to section 5.6.2 (intermittent spot and seam welds) or section 5.6.3 (spot welds) and section 5.6.4 (spot, intermittent spot and seam welds). Test specimens specified for each routine test must conform to the material type, gauge, temper, thickness combination and surface preparation of the parts they represent and shall be processed according to paragraph 5.3.3.

5.6.1.2 If requested by the Welding Specialist (or Welding Engineer), prepare a test specimen to represent production parts which have been subjected to severe forming operations such as stretching, spinning, rolling, hammering, etc. The test specimen shall contain 3 spot welds or intermittent spot welds or 3 inches of seam weld, as applicable. The test specimen must be of the same material, and must have undergone forming processes identical to the parts it represents.

5.6.2 Nugget Diameter Measurements (Intermittent Spot and Seam Welds)

5.6.2.1 At each of the following times or intervals, prepare 1 specimen according to Figure 1 or Figure 2, and examined to determine compliance with the nugget diameter requirements specified in PPS 37.11.

- at the beginning of each production run.
- upon replacement of the welding electrodes.
- at intervals of 1 hour during a production run.
- at the end of a production run if more than 1/2 hour has elapsed since the previous test.



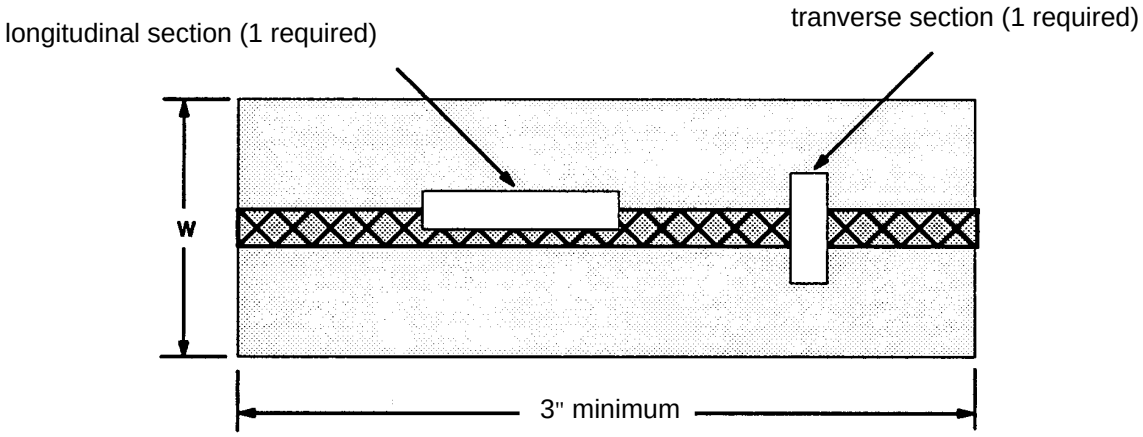
NOMINAL THICKNESS OF THINNER SHEET	MINIMUM WIDTH (W)
0.030" and under	5/8"
0.031" - 0.050"	1"
0.051" - 0.100"	1"

NOMINAL THICKNESS OF THINNER SHEET	MINIMUM WIDTH (W)
0.101" - 0.130"	1 1/4"
0.131" and over	1 1/4"

Note 1. Make spot spacing (P) representative of the production parts.
Note 2. For nugget diameter measurements, macro examine welds.
Note 3. For macroscopic tests, macro examine welds for internal weld quality.
Note 4. Do not use the first weld in each specimen but identified it as such and discard.

Figure 1 - Routine Nugget Diameter and Macroscopic Examination Test Specimen (Spot and Intermittent Spot Welds)

5.6.2.2 For seam welds, use the transverse section indicated in Figure 2 to ascertain the nugget diameter.



NOMINAL THICKNESS OF THINNER SHEET	MINIMUM WIDTH (W)
0.030" and under	5/8"
0.031" - 0.050"	1"
0.051" - 0.100"	1"

NOMINAL THICKNESS OF THINNER SHEET	MINIMUM WIDTH (W)
0.101" - 0.130"	1 1/4"
0.131" and over	1 1/4"

Note 1. Prepare 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. Macro examine the sections.

Figure 2 - Routine Nugget Diameter and Macroscopic Examination Test Specimen (Seam Welds)

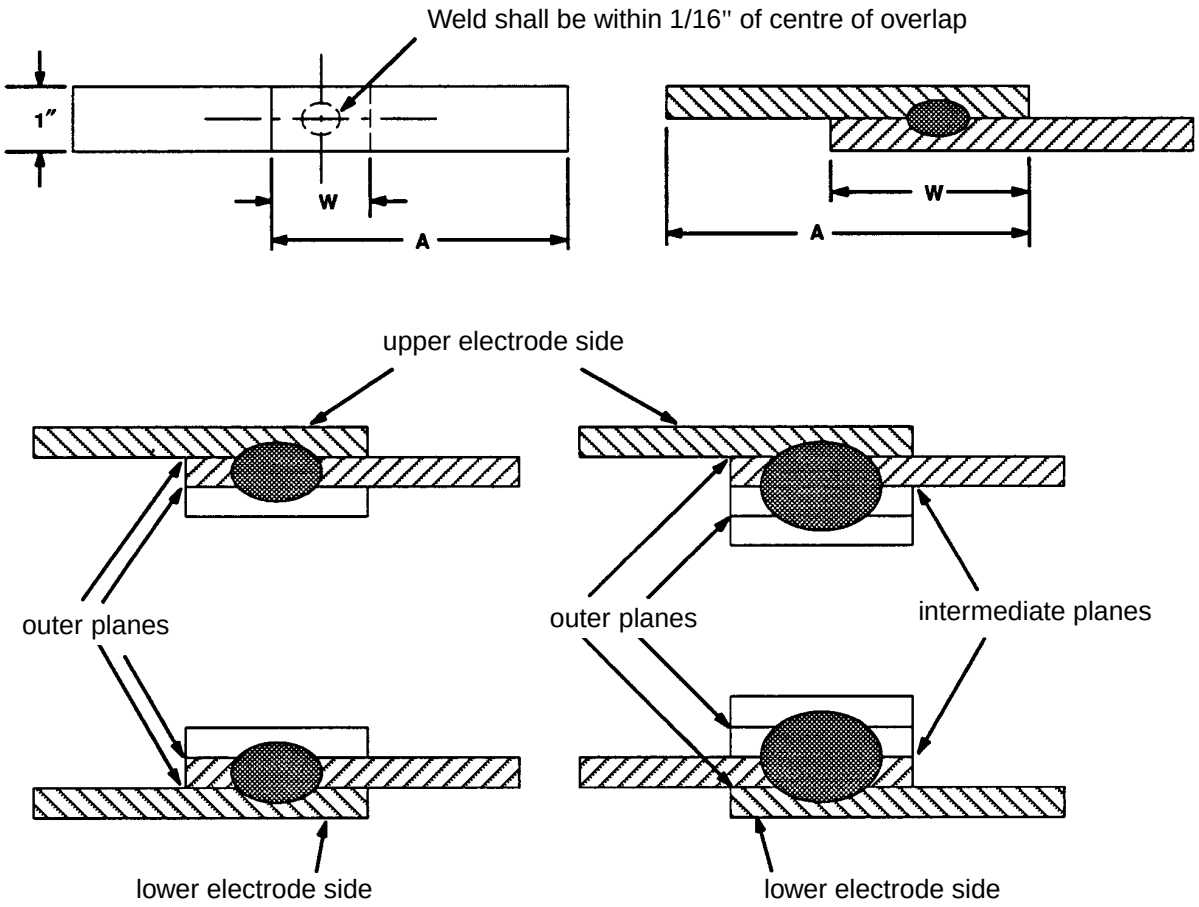
5.6.2.3 If specified on the welding schedule, nugget diameter measurements may be used, in lieu of shear strength tests, for specimens prepared according to paragraph 5.6.1.2.

5.6.3 Shear Tests (Spot Welds)

5.6.3.1 Prepare 3 specimens according to Figure 3 and must be subjected to shear testing to determine their compliance with the strength requirements specified in PPS 37.11, at each of the following times or intervals:

- at the beginning of each production run.
- upon replacement of the welding electrodes.
- at intervals of 1 hour during a production run.
- at the end of a production run if more than 1/2 hour has elapsed since the previous test.

5.6.3.2 If specified on the welding schedule, nugget diameter measurements may be used, in lieu of shear strength tests, for specimens prepared according to paragraph 5.6.1.2.



NOMINAL THICKNESS OF THINNER SHEET	MINIMUM WIDTH (W)	LENGTH (A)
0.030" and under	5/8"	Minimum required to perform shear test
0.031" - 0.050"	1"	
0.051" - 0.100"	1"	
0.101" - 0.130"	1 1/4"	
0.131" and over	1 1/4"	

Note 1. Test strips not loaded (unshaded) may be laid crosswise or parallel with loaded specimen or may be short or bent out of the way. However, the required overlap (W) shall be maintained.

Note 2. Where 3 or 4 thicknesses are being welded in production, 2 sets of multiple thickness, single spot shear test specimens shall be prepared so that both outer planes (upper and lower electrode) may be shear tested.

Note 3. The intermediate plane (the plane not involving an outer sheet) of a 4 thickness joint shall not be subjected to shear testing, but shall be evaluated on the basis of its nugget diameter.

Note 4. After shear testing, each fractured weld shall be visually examined for fusion and evidence of defects such as cracks, porosity, pits and cladding inclusion.

Figure 3 - Single Spot Shear Test Specimen (Spot Welding)

5.6.4 Macroscopic Examination (Spot, Intermittent Spot and Seam Welds)

5.6.4.1 At the beginning of a production run and at intervals of 2 hours during the run, prepare 1 test specimen according to Figure 1 (for spot and intermittent spot welds) or according to Figure 2 (for seam welds) and examine to determine compliance with the internal weld quality requirements specified in PPS 37.11. If applicable, prepare test specimens according to paragraph 5.6.1.2.

5.6.5 Test Results

5.6.5.1 Record the test results on a resistance welding test form (e.g., DH5080). If the results of any of the tests specified herein fail to meet the requirements of PPS 37.11, consider all parts produced since the previous successful test unacceptable and action such parts according to PPS 37.11 and adjust the machine according to section 5.9.

5.7 Production Welding

5.7.1 Use only the certified machine settings according to the welding schedule for each applicable machine and for the combination of materials and gauges to be welded, except that variation up to 0.003" in the overall thickness of the joint to be welded is permissible and variation from certified machine settings shall only be according to section 5.9.1.

5.7.2 Before each production run, check the machine set-up to ensure that the settings are according to the certified welding schedule and that the schedule is correct for the particular material combination to be welded.

5.7.3 When welding bulky components, ensure that the parts do not make contact with the secondary circuit other than at the electrode tips or wheel faces.

5.7.4 If necessary, use tables or approved jigs to hold the surfaces to be welded, at right angles to the electrodes.

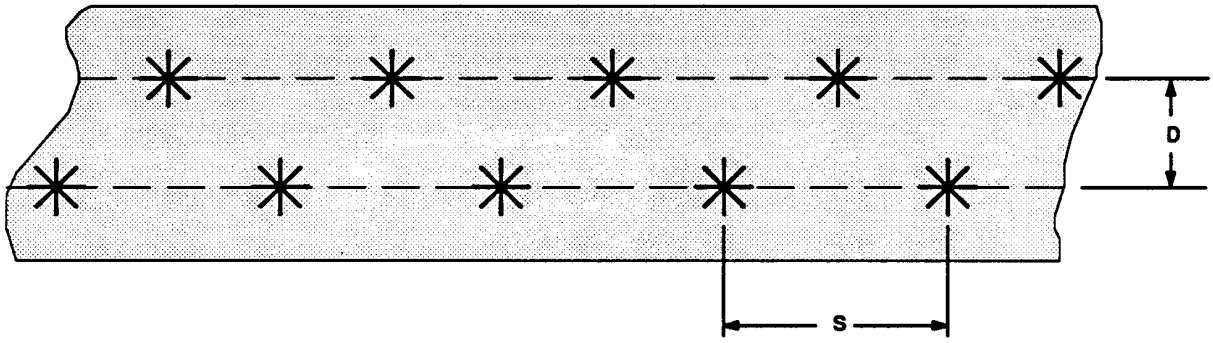
5.8 Weld Location

5.8.1 Locate welds according to the engineering drawing.

5.8.2 Maintain edge distance so that is no deformation or bulging at the edge of the sheet.

5.8.3 If spot spacing requirements are not specified on the engineering drawing, refer to the Table 1 for spot facing requirements.

Table 1 - Spot Spacing (Production Parts)



SINGLE SHEET THICKNESS (NOTE 1)	MINIMUM SPOT SPACING (S) (INCHES)	MINIMUM DISTANCE BETWEEN ROWS OF STAGGERED WELDS (D) (INCHES)
0.016 to 0.071	1/2	.43
0.072 to 0.089	5/8	.55
0.090 to 0.100	3/4	.65
0.101 to 0.125	1	.86
Note 1 – In the case of a combination of different thicknesses, the thinner gauge shall be the governing sheet thickness.		

5.9 Control Adjustments

5.9.1 If the routine test checks indicate that adjustment of the control settings is desirable, pressure and current (weld phase shift) settings may be varied by 5% from the certified values, or by 10% where only 1 setting is adjusted. If a particular welding schedule persistently requires adjustment, carry out recertification according to PPS 37.12. If satisfactory welding cannot be maintained within the limits of adjustment, stop welding and check for faulty operation. If it is determined that conditions other than the certified welding schedule requirements were the cause of faulty welding and, with the correction of these conditions, the original welding schedule is capable of producing acceptable welds, the establishment of a new welding schedule is not required.

5.9.2 If satisfactory welds cannot be obtained by adjustments specified in paragraph 5.9.1 using the previously certified welding schedule, **recertify the welding schedule** for the new settings according to PPS 37.12. If the situation involves the majority of settings of a welding schedule, **re-quality the machine** according to PPS 37.12; in addition, discard all previously certified Class A settings and all unsatisfactory Class B and Class C settings must be discarded and new settings certified according to PPS 37.12.

6 Requirements

6.1 The requirements for spot welds, intermittent spot welds and seam welds shall be according to PPS 37.11.

7 Safety Precautions

7.1 The safety precautions specified herein are specific to Bombardier Toronto 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 to protect the eyes 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.

9 Maintenance of Equipment

9.1 It is recommended that a suitable maintenance program be established for resistance welding machines.

9.2 Submit electrode holders for cleaning and repair, as required.

9.3 Periodically check electrode tip and wheel cleaning paddles for contour.

9.4 Rework or alteration of electrodes and holders must only be performed if appropriately authorized.

10 Special Points to Note

10.1 All resistance welding operations must be performed before surface treatments such as anodizing, alodining, priming, etc.

10.2 Do not tack weld Class A welding unless completely covered by subsequent production welds. Tack welds require no test specimens and must be of sufficient strength to fulfill a temporary fastening function. Defects which may be detrimental to production parts shall not exceed the limits specified in PPS 37.11.