BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 24.02

PRODUCTION PROCESS STANDARD

ION VAPOUR DEPOSITED ALUMINUM COATINGS (M2)

Issue 13
- This standard supersedes PPS 24.02, Issue 12.
- Vertical lines in the left hand margin indicate changes over the previous issue.
- Direct PPS related questions to christie.chung@aero.bombardier.com or (416) 375-7641.
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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the application of ion vapour deposited (IVD) aluminum coatings onto ferrous and non-ferrous alloy parts.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS shall 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 standard are necessary to fulfill the engineering design and reliability objectives.

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

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

1.2 IVD aluminum coatings are identified by Protective Treatment Code M2 according to PPS 23.02.

2 HAZARDOUS MATERIALS

2.1 Before receipt at Bombardier Toronto, all materials shall be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto 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 Environment, Health and Safety Department.

3 REFERENCES

3.1 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.2 BAERD GEN-023 - Contamination Control for Compressed Air.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.5 PPS 17.02 - Abrasive Blasting.

3.6 PPS 23.02 - Protective Treatment and Decorative Surface Finish Code System.

3.7 PPS 30.04 - Steel Heat Treatment - Carbon and Low Alloy Steels.

3.8 PPS 30.06 - Steel Heat Treatment of Precipitation Hardenable (PH) Stainless Steels.

3.9 PPS 30.08 - Steel Heat Treatment of Martensitic Stainless Steels.

3.10 PPS 31.02 - Cleaning Processes for Aluminum and Aluminum Alloys.

3.11 PPS 31.04 - Degreasing Processes.

3.12 PPS 31.17 - Solvent Usage.

3.13 PPS 32.01 - C1 Chemical Conversion Coating of Aluminum Alloys by Immersion.

3.14 PPS 32.35 - Chemical Conversion Coating for Low Electrical Resistance (C10).

3.15 PPS 33.02 - Removal of Metallic Coating.

3.16 PPS 33.12 - Low Hydrogen Embrittlement Stylus Cadmium Plating.

3.17 ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

3.18 ASTM E290 - Standard Test Methods for Bend Testing of Material for Ductility.

3.19 DH Form #4709, Type II IVD Aluminum Parts Identification Card - *Bombardier Toronto internal Quality procedure*.

3.20 DH Form #4721, IVD Parameter Set-Up Card - *Bombardier Toronto internal Quality procedure*.

3.21 DH Form #5347R1, IVD Process Control Card - *Bombardier Toronto internal Quality procedure*.

3.22 DH Form #5370, Materials Laboratory IVD Process Corrosion Resistance Test - *Bombardier Toronto internal Quality procedure*.

3.23 DHLPM Procedure No. 6011 - Description of Operation and Conditions Required For Salt Spray (Fog) Testing For Specification Purposes - *Bombardier Toronto internal operating procedure*.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Aluminum wire to AMS-QQ-A-225/1, 1100 series alloy, commercial.

4.1.2 Aluminum foil, commercial.

4.1.3 Aluminum tape, adhesive backed.

4.1.4 Grafoil tape, GTB flexible graphite, GrafTech International Ltd.

4.1.5 Cold galvanize compound, Crown 7007 or ZRC Cold Galvanizing Compound.

4.1.6 Evaporation source (e.g., DSC 461).

4.1.7 Argon gas to MIL-A-18455.

4.1.8 Nitrogen gas to A-A-59503.

4.2 Equipment

4.2.1 IVD aluminum coating equipment consisting of a vacuum chamber, a pumping system and a high voltage power source. The set-up, operation and maintenance procedures specified herein refer to the Abar Ipsen Industries HR-72X144-1252-IVD GLO Ivadizer in use at Bombardier Toronto. At Bombardier Toronto, mount part racks and barrel coaters (for small parts, such as fasteners, washers and bushings) on air pad dollies that marry up to the Ivadizer vacuum chamber for loading and unloading.

4.2.2 Thickness gauge, measuring device base on eddy current (e.g., calibrated elcometer) capable of measurement of ± 0.05 mil (± 0.00005 inch).

4.2.3 Compressed air shall meet the requirements of BAERD GEN-023.

4.2.4 Cotton gloves (e.g., DSC 422-1).

4.2.5 Protective gloves, rubber (e.g., DSC 422-2), nitrile (e.g., DSC 422-8), or polyethylene.

4.3 Facilities

4.3.1 This PPS has been identified as a “Critical or Special” process according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform application of ion vapour deposited (IVD) aluminum coatings onto ferrous and non-ferrous alloy parts according to this PPS.

4.3.2 Bombardier subcontractors shall direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities shall 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 shall 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 shall be detailed in the facility report. Based upon the facility report, Bombardier Toronto Engineering may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification shall 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 For approval of subcontractor facilities to perform the application of ion vapour deposited (IVD) aluminum coatings onto ferrous and non-ferrous alloy parts according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples shall meet the requirements specified in section 6.

4.3.3.2 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

5 PROCEDURE

5.1 General

5.1.1 For the purposes of this PPS, the term “MRB” (Material Review Board) shall be considered to include Bombardier Toronto MRB and Bombardier Toronto delegated MRB.

5.1.2 IVD aluminum coatings provide corrosion protection for high strength steel parts (without hydrogen embrittlement) and galvanic compatibility with aluminum structure for stainless steel, titanium and other ferrous and non-ferrous alloys.

5.1.3 The use of the IVD Set-Up Card specified in this PPS is only a recommendation. It is not necessary to use such a card provided that the requirements of section 6 are met and necessary precautions are taken to ensure that the temperature specified in Table I is not exceeded during processing.

5.1.4 IVD aluminum coating consists of the following process steps, performed while parts are inside the coating chamber:

- Evacuation of the coating chamber - *Pumps the coating chamber down to a vacuum of 9.0 X 10^{-5} torr (0.09 microns) maximum and then backfills with argon to create the optimum atmosphere for glow discharge cleaning and coating.*
- Glow discharge cleaning of the part surfaces - *Glow discharge cleaning prepares part surfaces for IVD aluminum coating and consists of the impingement of ionized argon on the parts.*
- Nitrogen cooling of heat sensitive alloys - *If specified by the IVD Set-Up Card or Process Sheet, aluminum alloys and other heat sensitive parts shall be convection cooled by nitrogen gas flow after glow discharge cleaning and/or during coating cycles.*
- Aluminum evaporation.
- Coating cycle - *Refer to the IVD Set-Up Card for coating parameters, such as evaporation source (boat) speed, number of passes, etc. If the IVD Set-Up Card is not available, set coating parameters as necessary to achieve the requirements specified in section 6.*

5.1.5 Use caution during IVD aluminum processing to ensure that all parts are not processed greater than the temperature specified by Table I.

TABLE I - MAXIMUM IVD PROCESSING TEMPERATURES

MATERIAL	CONDITION	MAXIMUM TEMPERATURE
Aluminum	Shot peened	200°F
	Hot joggled	Do not exceed the lower limit of the forming temperature specified in PPS 1.03
	Hot straightened	Do not exceed the lower limit of the forming temperature specified in PPS 1.38
	2000 series T3 and T4 tempers	200°F
	All other	300°F
Steel	Shot peened	475°F
	All other	See Note 1

Note 1. The maximum IVD processing temperature for steel which has not been shot peened is 100°F less than the minimum final heat treat temperature specified in PPS 30.04, PPS 30.06 or PPS 30.08, as applicable.

5.1.6 Use one IVD Set-Up Card (see paragraph 5.1.3) for each part number and coating thickness class. It is recommended that the IVD Set-Up Card specifies part material characteristics, total load part surface area and processing parameters, including cleaning, coating, convection cooling, etc. Different part numbers may be mixed in one load, provided that the process parameters are the same and the processing parameters for the most heat sensitive part is selected to ensure adequate cooling of the load. If mixing of coating thickness classes is required for a production run, interrupt the run to remove the parts requiring the thinner coating before continuing for the parts requiring the thicker coating.

5.2 Preparation of Parts

5.2.1 IVD aluminum coating is deposited directly onto the base metal without any preliminary coating.

5.2.2 Except for hole drilling and countersinking, perform all manufacturing operations, including welding, brazing, soldering, machining, forming, shot peening and heat treatment before IVD aluminum coating.

5.2.3 If applicable, perform magnetic particle inspection and fluorescent penetrant inspection before IVD aluminum coating.

5.2.4 For ferrous parts that have been heat treated to a tensile strength of 200 ksi or greater, which have been straightened, ground or machined in the finish condition, stress relieve according to PPS 30.04, PPS 30.06 or PPS 30.08, as applicable, immediately after such operations and before IVD aluminum coating. For similar parts that have been etch inspected in the finish condition, embrittlement relieve according to PPS 30.04, PPS 30.06 or PPS 30.08, as applicable, immediately after etch inspection and before IVD aluminum coating.

5.2.5 Vapour degrease all parts according to PPS 31.04. After vapour degreasing, only handle parts while wearing protective gloves (see paragraph 4.2.5) inside clean white cotton gloves, through all subsequent processing stages. It is recommended that abrasive blast cleaning according to paragraph 5.2.6 is performed as soon as possible following degreasing (i.e., ideally a maximum suggested delay of 4 hours).

5.2.6 Abrasive blast clean parts using aluminum oxide grit according to PPS 17.02 and the IVD Set-Up Card, if applicable. Begin IVD aluminum coating as soon as possible after abrasive blast cleaning with a maximum delay of 4 hours. If the delay exceeds 4 hours, re-clean the parts. After abrasive blast cleaning, ensure that parts are kept in a clean dry area and are free of any surface contamination.

5.2.7 Mask all areas not to be coated (as specified on the engineering drawing) using aluminum foil, adhesive backed aluminum tape or suitable metal masks or fixtures. Mask either before or after abrasive blast cleaning as dictated by the part surface finish requirements.

5.3 Racking of Parts

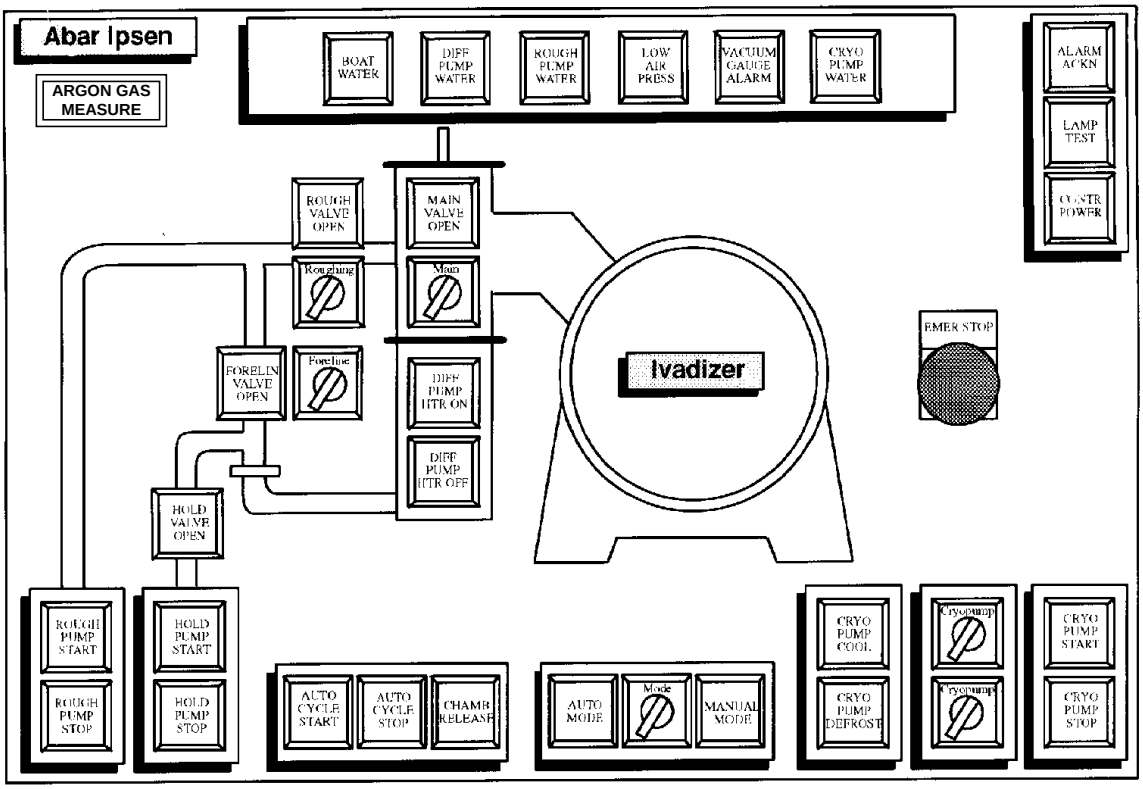
5.3.1 Load the parts onto racks in a manner that best minimizes free electrical contact between the part surfaces and the contact points. At Bombardier Toronto:

- Attach the parts to stainless steel wire suspended from the upper mesh part rack through the approximate centres of holes in the lower sheet part rack. Ensure that the wire does not touch the sides of the holes in the rack. It is recommended that parts be racked according to the racking configuration specified on the IVD Set-Up Card.
- Ensure that the distance between the lower part rack surface and the bottom of the parts does not exceed 16.5", so that there is adequate clearance in the coating chamber.
- If the total part surface area of the load is less than the optimum (i.e., the amperage meter should be between 0.3 to 0.5 amps during operation), load dummy metal panels with the load to account for the difference. If available, refer to the IVD Set-Up Card for the optimum total part surface area.

5.3.2 Load small parts in barrel coaters in sufficient quantities to ensure coatings meet the requirements specified herein.

5.4 Set-Up and Operation of IVD Aluminum Coater

5.4.1 Refer to Figure 1 and Figure 2 for a general description of the control panel for the Abar Ipsen Industries IVD GLO Ivadizer used at Bombardier Toronto.



DIGITAL PROCESS REPORTER

FIGURE 1 - CONTROL PANEL FOR VACUUM PUMPING SYSTEM

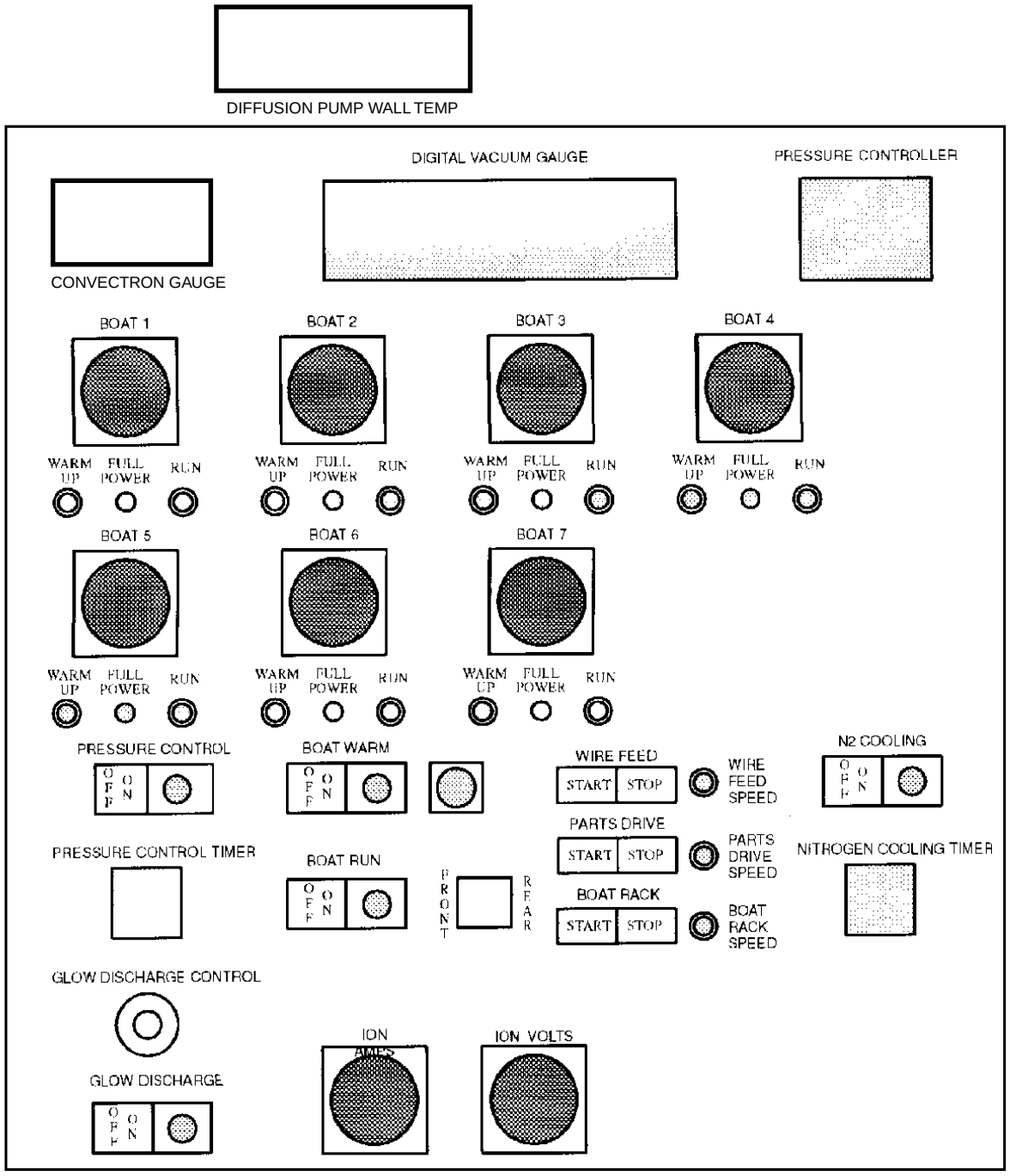


FIGURE 2 - HIGH VOLTAGE POWER CONTROLS

5.4.2 Set-up and operate the Ivadizer in use at Bombardier Toronto as follows:

Step 1. Inspect the boats and wire tip guides according to paragraph 9.3.

Step 2. Ensure the compressed air flow valve is on. Open the system cooling water flow valve, the argon flow valve and the nitrogen flow valve at the rear of the vacuum chamber.

Step 3. Turn on the control panel main throw switch and turn the CONTROL PANEL POWER button ON.

Step 4. Press the ROUGHING PUMP START button.

Step 5. Press the HOLDING PUMP START button, wait 10 seconds and press the DIFF PUMP HTR ON button.

Step 6. Press the CRYO PUMP START button.

Step 7. Allow the system pumps to warm up for a minimum of 1 hour before proceeding.

Step 8. Ensure the ROUGHING VALVE, FORELINE VALVE and MAIN VALVE are CLOSED.

Step 9. Switch the key selector to AUTO.

Step 10. Set the CRYO PUMP switch to AUTO.

Step 11. Load the parts into the coating chamber. If using a barrel coater, ensure that the gear drive on the barrel rack is chain connected to the motor drive inside the vacuum chamber before closing the chamber door. If barrel coating, to avoid excess aluminum vapour in the coating chamber, disconnect the wire feed to the evaporation boats at each end (boats #1 and #7) according to paragraph 9.2 and set the corresponding BOAT RUN controls at 0%.

Step 12. Close the chamber door, ensuring an air-tight seal.

Step 13. Press AUTO CYCLE START to pump the coating chamber down to vacuum.

Step 14. Set the GLOW DISCHARGE CONTROL at 10%.

Step 15. Turn the GLOW DISCHARGE toggle ON.

Step 16. Perform a short circuit test by pressing the AUTO CYCLE START and ALARM ACKN buttons simultaneously while observing the ION AMPS and ION VOLTS gauges. A short circuit in the part racking system will cause **high amperage** and **low voltage** to be displayed. If a short circuit is detected, remove the parts and correct the short.

Step 17. Turn the GLOW DISCHARGE toggle OFF.

When the vacuum reaches 9.0 X 10^{-5} torr (the vacuum level inside the chamber is shown on the DIGITAL VACUUM GAUGE), the pressure control system will engage, allowing the chamber to be backfilled with argon to 1.0 X 10^{-2} torr, the optimal atmosphere for glow discharge cleaning and coating. The PRESSURE CONTROLLER gauge will read 6 microns when the chamber is properly backfilled with argon.

Step 18. Allow the glow discharge pressure to stabilize between 6 and 7 microns as shown on the PRESSURE CONTROLLER gauge.

Step 19. Unless otherwise specified on the IVD Set-Up Card, set the glow discharge PRESSURE CONTROL TIMER (duration of cleaning cycle) to 15 minutes. If using a barrel coater, set the PARTS DRIVE SPEED control to the appropriate value and press PARTS DRIVE START to ensure barrel rotation during glow discharge cleaning.

Step 20. Turn the GLOW DISCHARGE toggle ON.

Step 21. Slowly turn the GLOW DISCHARGE control clockwise until the movement causes no further increase in the ION AMPS or ION VOLTS gauges (do not exceed 2 amps or 1400 volts). Jumping gauge needles indicates excessive arcing; should this occur, back off the GLOW DISCHARGE control counterclockwise and increase it again slowly. Note that sparking of the parts indicates cleaning.

Step 22. Allow glow discharge cleaning to continue for the time set on the PRESSURE CONTROL TIMER. A purple glow should be evident in the vacuum chamber during glow discharge cleaning. Failure to achieve this glow indicates a short circuit in the system, which shall be corrected before proceeding.

Step 23. If specified on the IVD Set-Up Card or Process Sheet, subject the parts to nitrogen cooling as follows:

(a) Set the N_2 COOLING timer to 5 minutes.

(b) Turn the GLOW DISCHARGE toggle OFF.

(c) Turn the N_2 COOL toggle ON.

(d) Set the PRESSURE CONTROL TIMER to 2 minutes and turn the GLOW DISCHARGE control to 0.

(e) At the end of the nitrogen cooling cycle, turn the N_2 COOL toggle OFF.

(f) Turn the GLOW DISCHARGE toggle ON.

(g) Switch the BOAT WARM toggle to AUTO.

(h) Turn the BOAT RUN toggle ON.

(i) Once the evaporation boats are glowing brightly, adjust the WIRE FEED SPEED control to achieve a rate of 27 inch/min or 3.5 g/min and press WIRE FEED START. This will cause the spools to feed the wire to the boats at the specified rate. All the active boat ammeters should read approximately the same amperage. It is recommended to adjust the WIRE FEED SPEED to that specified on the IVD Set-Up Card.

Step 24. Set the BOAT WARM toggle to AUTO.

This will gradually warm the evaporation boats (as indicated by flashing of the BOAT RUN button) to a temperature at which the BOAT RUN cycle will engage (the BOAT RUN button will remain lit).

Step 25. Pre-set the BOAT RUN controls to the values determined during wetting of new boats as specified in paragraph 9.4. All the active boat ammeters should read approximately the same amperage. Turn the BOAT RUN toggle ON.

Step 26. Ensure the boats are melting the wire. If not, press WIRE FEED STOP to avoid aluminum build-up in the boats and wait until the boats are warm enough before re-starting the wire feed.

Step 27. Slightly reduce the Glow Discharge output by turning the GLOW DISCHARGE control counterclockwise.

Step 28. Set the BOAT RACK SPEED control to the appropriate value to ensure the applicable part number meets the coating thickness requirement. If using a barrel coater, set the PARTS DRIVE SPEED control to ensure the applicable part number meets the coating thickness requirement.

Step 29. Press the BOAT RACK START button or, when using a barrel coater, press PARTS DRIVE START. During barrel coating, the boat rack remains stationary and shall be manually moved directly below the centre of the barrel rack to ensure a uniform coating is achieved.

Step 30. Allow the coating process to continue for the number of passes of the boat rack, or the length of barrel coating cycle as necessary for the part being coated to meet the coating thickness requirement or as specified on the IVD Set-Up Card. If specified on the IVD Set-Up Card or Process Sheet, subject the parts to nitrogen cooling during coating as follows:

(a) Press WIRE FEED STOP.

(b) Turn the BOAT WARM toggle OFF.

(c) Turn the BOAT RUN toggle OFF.

(d) Allow the boats to cool for 2 minutes.

(e) Set the N_2 COOLING timer to 5 minutes.

(f) Turn the GLOW DISCHARGE toggle OFF.

(g) Turn the N_2 COOL toggle ON.

(h) Set the PRESSURE CONTROL TIMER to 2 minutes and turn the GLOW DISCHARGE control to 0.

(i) At the end of the nitrogen cooling cycle, turn the N_2 COOL toggle OFF.

(j) Turn the GLOW DISCHARGE toggle ON.

(k) Switch the BOAT WARM toggle to AUTO.

(l) Turn the BOAT RUN toggle ON.

(m) Once the evaporation boats are glowing brightly, adjust the WIRE FEED SPEED control to achieve a rate of 27 inch/min or 3.5 g/min and press WIRE FEED START. This will cause the spools to feed the wire to the boats at the specified rate. All the active boat ammeters should read approximately the same amperage. It is recommended to adjust the WIRE FEED SPEED to that specified on the IVD Set-Up Card.

Step 31. Turn the GLOW DISCHARGE toggle OFF.

Step 32. Press WIRE FEED STOP.

Step 33. Turn the BOAT WARM toggle OFF.

Step 34. Turn the BOAT RUN toggle OFF.

Step 35. When the glow from the boats disappears, press AUTO CYCLE STOP and the cryo pump will begin to defrost automatically.

Step 36. Wait until the FORELINE VALVE opens (this should take about 3 minutes) before pressing and holding CHAMBER RELEASE until the vacuum chamber is completely vented to the atmosphere.

Step 37. Remove parts from the coating chamber.

Step 38. Immediately close the chamber door after removing the parts, switch the key selector to MANUAL and press ROUGHING Valve to restore vacuum in the chamber and prevent contamination of the interior.

5.5 Post Coating Procedure

5.5.1 After coating, process parts as follows:

Step 1. Lightly glass bead peen all parts over the coated area according to PPS 17.02 and the IVD Set-Up Card, if applicable, to remove loose particles and improve the surface appearance. If glass bead peening removes sections of the IVD aluminum coating to expose the bare metal substrate, the affected parts are not acceptable and all parts of the production lot shall be inspected for visual appearance according to section 6.2.4.

Step 2. Except for small barrel coated parts, individually wrap parts in neutral Kraft paper and place them in suitable boxes for protection against damage. Place quantities of small barrel coated parts in suitable plastic bags for protection against damage.

Step 3. If the engineering drawing, IVD Set-Up Card or Process Sheet specifies M2 Type II coating, enter the date and time of IVD aluminum coating on a Type II IVD Aluminum Parts Identification Card (e.g., DH Form #4709) and attach it to the batch of Type II parts. These parts shall be chemical conversion coated according to PPS 32.01 or to PPS 32.35 if the engineering drawing specifies a protective treatment code C10 (i.e., where low electrical resistance is required) within 48 hours of glass bead peening. If the delay between glass bead peening and conversion coating exceeds 48 hours, alkaline clean the parts (do not deoxidize) according to PPS 31.02 before conversion coating.

5.6 Rework of Defects

5.6.1 Rework of parts with tensile strength of 180 - 200 ksi or greater shall be referred to MRB for disposition. For all other parts, rework defects according to paragraph 5.6.2.

5.6.2 For parts having scratches, nicks or non-coated areas more than 1/16 in^2 (0.0625 in^2) in the IVD aluminum coating, strip the coating according to PPS 33.02 and re-coat as specified herein. If the ivadized parts fails to meet the requirements a second time after having already been stripped and re-processed once, refer the part to MRB for disposition.

5.6.3 For parts having scratches, nicks or non-coated areas less than 1/16 in^2 (0.0625 in^2) in the IVD aluminum coating, it is acceptable to touch-up the areas by stylus cadmium plating according to PPS 33.12 or with cold galvanize compound (see Materials section, paragraph 4.1.5) according to paragraph 5.6.3.1 or paragraph 5.6.3.2. Apply cold galvanize compound at temperatures between 64˚F and 86˚F (18˚C to 30˚C).

5.6.3.1 Spray apply aerosol can as follows:

Step 1. Solvent clean the area of the defect according to PPS 31.17.

Step 2. Mask off surrounding areas not to be coated with masking tape.

Step 3. Align spray head with black mark on valve rim to ensure complete evacuation of contents.

Step 4. Vigorously shake can for two minutes after hearing the rattle of agitator ball (ball should release in 10 to 30 seconds), and intermittently (1 to 2 seconds) during use.

Step 5. Apply compound from a distance of 10 to 12 inches. Spray in light, sweeping strokes to avoid run and sags. The preferred application method is to apply a coating of 3 to 4 mils wet thickness in one application. One coat will be satisfactory. If a second coat is required, allow to cure to re-coat according to Table II prior to applying a second coat.

Step 6. Remove masking that was applied in Step 3.

Step 7. Allow coating to dry according to Table II before further working the part or wrapping for transport or storage.

5.6.3.2 Brush apply cold galvanize compound as follows:

Step 1. Solvent clean the area of the defect according to PPS 31.17.

Step 2. Mask off surrounding areas not to be coated with masking tape.

Step 3. Brush apply a thin even coat of cold galvanize compound onto surface to be treated.

Step 4. Remove masking that was applied in Step 2.

Step 5. Allow to dry according to the manufacturer's instructions before further working the part or wrapping for transport or storage.

TABLE II - COLD GALVANIZING COMPOUND CURE DATA

PRODUCT NAME	CURE TIME AT 75 ±10°F (24 ±5°C) AND 50 ±15% R.H.			
	Method	Cure to Re-coat	Cure to Handle	Full Cure
CROWN 7007	Brush	After 2 hours or Before 2 days	2 hours	2 days
	Aerosol			
ZRC Cold Galvanizing Compound	Brush	After 2 hours or Before 2 days	2 hours	2 days
	Aerosol			

5.7 Shut-Down of IVD Aluminum Processing Equipment

5.7.1 At Bombardier Toronto, if the equipment is to remain idle for several hours, shut it down as follows:

Step 1. Switch the key selector to MANUAL.

Step 2. Switch the ROUGHING toggle to OPEN.

Step 3. Press DIFF PUMP HTR OFF and open the QUICK COOL valve on the water manifold. The diffusion pump will require 45 minutes to cool.

Step 4. Press CRYO PUMP STOP.

Step 5. After 45 minutes, close the QUICK COOL valve.

Step 6. Switch the ROUGHING toggle to CLOSE and press HOLDING PUMP STOP.

Step 7. Shut off the air, water, nitrogen and argon flow valves.

6 REQUIREMENTS

6.1 Process Qualification

6.1.1 For process qualification, process panels as specified in Table III through the complete ivadizing process as specified herein. All panels shall meet the requirements specified prior to commencing processing of parts for Bombardier Toronto.

6.1.2 Process qualification test panels shall be submitted to a Bombardier approved laboratory according to paragraph 4.3.3.2. Additional tests may be requested at any time at the discretion of Bombardier.

6.2 Production Parts

6.2.1 General

6.2.1.1 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

6.2.1.2 If monthly and/or quarterly corrosion resistance panels were tested by a Bombardier approved laboratory and not the Bombardier Toronto Materials Laboratory, once a year, subcontractors shall submit monthly and/or quarterly results along with test panels to Bombardier Toronto for verification of test results.

6.2.1.3 In order to maintain qualified status, all facilities processing parts for Bombardier Toronto according to this PPS shall maintain records of all testing. If these records cannot be produced, then the facility may be required to re-qualify.

6.2.2 Testing Requirements

6.2.2.1 Refer to Table III for a summary of test requirements.

TABLE III - SUMMARY OF TESTING REQUIREMENTS

TEST	TESTING FREQUENCY	NUMBER OF PANELS	TEST SPECIMENS	TESTING PROCEDURE (NOTE 1)
Visual Inspection	According to Table IV	According to Table IV	Production parts	Visual (according to section 6.2.4)
Corrosion Resistance	According to section 6.2.3	3 per Thickness Class	LAB 064-5	ASTM B117 (according to section 6.2.5)
Adhesion	According to section 6.2.3	2	According to section 6.2.6	According to section 6.2.6
Coating Thickness	According to Table IV	According to Table IV	According to section 6.2.7	According to section 6.2.7

Note 1. Refer to the appropriate sections for details regarding test requirements.

6.2.2.2 For visual examination according to section 6.2.4 and coating thickness according to section 6.2.7, select a sample from each lot by taking at random from the lot, not less than the number of items indicated in Table IV. If the number of non-conforming items in any sample exceeds the acceptance number specified in Table IV, reject the represented lot and disposition according to section 6.2.8.

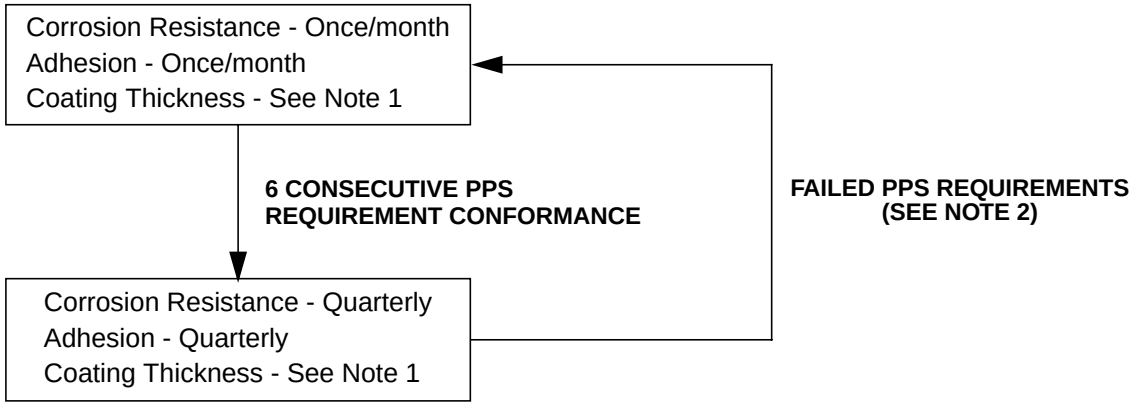
TABLE IV - VISUAL AND COATING THICKNESS SAMPLING SCHEDULE

NUMBER OF ITEMS IN LOT	NUMBER OF ITEMS IN SAMPLE (SELECTED AT RANDOM) SEE NOTE 1	ACCEPTANCE NUMBER SEE NOTE 2
1 to 5	All	0
6 to 25	5	0
26 to 50	8	0
51 to 90	13	0
91 to 150	20	1
151 to 280	32	1
281 to 500	50	2
501 to 1200	80	3

Note 1. If coating thickness cannot be determined using production parts, perform coating thickness check according to paragraph 6.2.7.3.
Note 2. Any defective items within the permitted number of defectives shall not be accepted with the lot but stripped, re-coated and re-inspected as specified herein.

6.2.3 Test Frequency

6.2.3.1 Process control requirements for adhesion, coating thickness and corrosion resistance shall be tested on a periodic basis. The testing frequency shall be as follows:



Note 1. According to Table IV or paragraph 6.2.7.3.
Note 2. Refer to MRB for disposition of parts processed since the last successful testing.

6.2.4 Visual Inspection

6.2.4.1 Inspect parts for visual appearance as follows:

- Ensure that the IVD aluminum coating is smooth, adherent and uniform in appearance.
- Ensure that the coating is free from staining, pits, burns and porosity.
- Ensure that there is no indication of contamination or improper operation of deposit producing equipment, such as an excessively powdered or darkened coating.
- Ensure that the coating is continuous over the entire surface of the part including holes and recesses to a depth at least equal to the diameter of the hole or recess. Minor nicks, scratches or uncoated areas of less than 1/16 in^2 (0.0625 in^2) may be touched up with cold galvanize compound according to section 5.6.

6.2.5 Corrosion Resistance Tests

6.2.5.1 Process three LAB 064-5 test panels, together with the representative production load, to each of the three thickness class designations and to Type II requirements as specified in section 6.2.7. Process applicable panels representative of the Bombardier Toronto parts being processed (e.g., if only processing Class 3 parts, then Class 1 and Class 2 test panels are not required) through the full IVD process and submit to a Bombardier approved laboratory according to paragraph 4.3.3.2 for testing as specified herein.

6.2.5.2 Check corrosion resistance by exposing the test panels to a 5% salt spray according to ASTM B117, except the test surface shall be inclined 15 to 30° from the vertical. Depending on the class of coating, expose the panels to salt spray for the following durations:

- Class 1, Type II - 672 hours
- Class 2, Type II - 504 hours
- Class 3, Type II - 336 hours

6.2.5.3 If there is evidence of corrosion on the substrate metal of the test panel (ignore corrosion within 0.25" of identification markings, holding points or panel edges), refer to MRB for disposition of parts processed since the last successful corrosion resistance test. Note that the appearance of white corrosion products on the aluminum coating is acceptable. Suspend the ivadizing process until the cause of failure has been established and corrective action taken.

6.2.6 Adhesion Test

6.2.6.1 Process two adhesion test strips (1" X 4" X 0.040") with each lot of production parts through the entire cleaning and coating procedure. Ensure that the test strip material is of a base metal equivalent to that of the articles represented as listed below. Clamp both test strips in a vise and bend them back and forth until the strip ruptures. If the edge of the coating peels back or if the separation between the coating and the substrate shows at the point of fracture on either sample, when examined at 4X magnification, adhesion is not satisfactory. If adhesion on either of the test strips is unacceptable, disposition the entire production lot according to section 6.2.8.

- Steel Parts - LAB 051-3 or SAE 4130 (SAE AMS6350)
- Stainless Steel Parts - LAB 051-11 or PH 17-4 CRES (SAE AMS 5604)
- Titanium Parts - Ti-6Al-4V (SAE AMS-T-9046)
- Aluminum and Copper Parts - 2024-T81 or 2024-T3 (SAE AMS QQ-A-250/4)

6.2.6.2 Alternatively, it is acceptable to perform adhesion testing according to ASTM E290.

6.2.7 Coating Thickness

6.2.7.1 Except in holes, recesses, internal threads and other areas where a controlled deposit cannot normally be obtained, ensure that part coating thickness specified in Table V is met. Holes, recesses, internal threads and other areas where a controlled deposit cannot normally be obtained are not subject to a thickness requirement; however, ensure that there is visual evidence of coating in holes and recesses to a depth at least equal to the diameter of the hole or recess.

6.2.7.2 If possible, determine the coating thickness by direct measurement at 5 locations on the part using a calibrated thickness gauge (see paragraph 4.2.2). For every part that does not meet the required coating thickness specified, reject the part and disposition according to section 6.2.8.

6.2.7.3 If coating thickness cannot be determined using production parts, process 3 coating thickness test panels (either 6" X 3" X 0.040" or 1" X 4" X 0.040") with the production parts through the entire cleaning and coating procedure and use them to verify the coating thickness. Ensure that the test strip material is of a base metal equivalent to that of the articles represented as listed below:

- Steel Parts - LAB 051-3 or SAE 4130 (SAE AMS6350)
- Stainless Steel Parts - LAB 051-11 or PH 17-4 CRES (SAE AMS 5604)
- Titanium Parts - Ti-6Al-4V (SAE AMS-T-9046)
- Aluminum and Copper Parts - 2024-T81 or 2024-T3 (SAE AMS QQ-A-250/4)

6.2.7.3.1 After coating, measure 5 locations on each test strip using a calibrated thickness gauge (see paragraph 4.2.2). If using 6" X 3" X 0.040" test specimens, take the measurements at a minimum of 1.5" away from any panel edge. If one or more of the test strips fail to meet the coating thickness requirements specified in Table V, reject the represented lot and disposition according to section 6.2.8.

TABLE V - IVD ALUMINUM COATING CLASS AND TYPE DESIGNATION

CLASS/TYPE	COATING THICKNESS PER SURFACE (Note 1)
Class 1	0.0010" - 0.0020"
Class 2	0.0005" - 0.0009"
Class 3	0.0003" - 0.0005"
Type I	as coated
Type II	With supplementary conversion coating treatment according to PPS 32.01 or PPS 32.35, as specified by the engineering drawing (Note 2)

Note 1. The maximum coating thickness applies only when coating salt spray test panels according to section 6.2.5 or if the engineering drawing specifies a close tolerance (± 0.005" or less). In all other cases, a maximum coating thickness does not apply.
Note 2. Chemical conversion coat according to PPS 32.35 if the engineering drawing specifies a protective treatment code C10 (i.e., where low electrical resistance is required).

6.2.8 Disposition

6.2.8.1 Any rejected lots shall be 100% inspected. Accept all parts that meet the above requirements. For every part that does not meet the requirements, strip the coating according to PPS 33.02, re-coat and re-inspect the parts as specified herein. If the ivadized part fails to meet the requirements a second time after having already been stripped and re-processed once, refer the part to MRB for disposition. Determine the cause of failure and take corrective action prior to commencing processing production parts.

7 SAFETY PRECAUTIONS

7.1 Observe standard plant safety precautions when performing the procedure specified herein.

7.2 When loading a barrel coater into the vacuum chamber, ensure the part rack anchoring pins are in place before chain linking the parts drive and barrel coater gears to prevent hand injuries.

7.3 Before removing evaporation boats for replacement, ensure the power to the boats has been off for a minimum of 30 minutes to prevent severe burns.

7.4 Refer to PPS 31.17 for the safety precautions for handling and using solvents.

8 PERSONNEL REQUIREMENTS

8.1 This PPS has been categorized as a “Critical or Special” process according to PPS 13.39. Refer to PPS 13.39 for additional personnel requirements. Certified and/or qualified personnel shall have a good working knowledge of the following, as applicable:

- understand the function of the IVD aluminum coating on various substrates
- understand the advantages of IVD aluminum coating over conventional plating methods
- be familiar with the various IVD aluminum coating class and type designations and how they relate to coating parameters
- know the various substrates which may be effectively IVD aluminum coated
- understand the requirements for surface cleaning and pre-treatment
- understand the requirement to process in a vacuum environment
- be familiar with the theory of ion bombardment and glow discharge cleaning
- understand the relationship between part surface area or section thickness and coating parameters
- understand the requirement to convection cool certain alloys and thinner sections at various processing stages
- understand the requirement to glass bead peen the IVD aluminum coated part surfaces
- know material and part handling requirements
- be familiar with part racking and loading procedures
- know how to identify and operate valves controlling the flow of argon, air, nitrogen and cooling water
- know how to read and interpret vacuum pressure gauges and high voltage power gauges
- understand the function and sequence of the pumping system for evacuating the vacuum chamber
- know how to use all processing parameter controls to produce acceptable production parts
- know how to shut down the IVD aluminum coating system equipment
- know how to perform specified equipment maintenance functions
- know how to use a thickness gauge (see paragraph 4.2.2) to verify IVD aluminum coating thickness on parts
- be familiar with safety precautions
- know Quality Assurance requirements for IVD aluminum coating appearance, thickness, adhesion and corrosion resistance and how they are evaluated or measured
- be familiar with engineering drawing notations regarding IVD aluminum coatings
- know how to use IVD Set-Up Cards to produce acceptable parts

- be familiar with the procedure and requirements for the preparation of various material part surfaces for IVD aluminum coating
- be familiar with specification requirements for process materials
- know how to process production parts
- be familiar with post IVD aluminum coating procedure, including chromate treatment of Type II parts
- know how to identify and process required test specimens

9 MAINTENANCE OF EQUIPMENT - BOMBARDIER TORONTO

9.1 When the time required to perform vacuum pump-down (as specified in Step 13 of the Ivadizer operation sequence) increases by 30 minutes more than the time required to evacuate a clean vacuum chamber, strip coating chamber interior as follows:

Step 1. Remove the interior shields and the wire feed guides and strip them of deposited aluminum according to PPS 33.02.

Step 2. Check the aluminum wire spools and, if required, replace with new spools according to paragraph 9.2.

Step 3. Check the condition of the evaporation boats and the processing time that they have accumulated and, if necessary, replace the applicable boats according to section 9.3.

9.2 Replace spools with insufficient aluminum wire as follows:

Step 1. Remove the protective shield above the spools and clean the shield according to PPS 33.02.

Step 2. Tighten the corresponding knurled thumbwheel to disengage the wire feed gears.

Step 3. Pull the wire back through the wire feed guide and remove the spool. If required, remove the wire feed guides and clean according to PPS 33.02.

Step 4. Insert the new spool and feed the wire through the wire feed guide to expose approximately 1" of wire toward the evaporation boat.

Step 5. Loosen the knurled thumbwheel, ensuring the wire feed gears mesh.

9.3 Replace evaporation sources if the boats appear excessively worn (i.e., Check for cracked boat; Check for excessive aluminum build up; Check for eroded cavity; Check for tight connection). Install clean wire feed guide tips with all replacement evaporation boats. Use the following procedure to re-condition the boats:

Step 1. Ensure the BOAT WARM and BOAT RUN toggles have been in the OFF position for a minimum of 30 minutes before lifting the boat out of its copper clamps.

Step 2. Remove and discard the coated aluminum foil surrounding the copper boat clamps.

Step 3. Remove residual grafoil tape and debris from the copper clamps.

Step 4. Place a new strip of grafoil tape under and up the sides of the boat at each end where the boats seat in the clamps. Press the boats fully down into the grooves of the copper clamps.

Step 5. To mask off the copper boat clamps, fold 13" X 4 3/4" pieces of aluminum foil in half, lengthwise, to form 13" X 2 3/8" strips. Hold the centre of the strip under the copper boat clamp and carefully wrap the foil around all surfaces of the clamp. Ensure the foil is wrapped smoothly around the copper clamps with no sharp foil edges and no exposed copper. Remove any excess foil covering evaporation boat ends.

9.4 Once a new boat is installed, it shall be conditioned, or wetted, as follows:

Step 1. Ensure wire is being fed into the approximate centre of each new boat. Cut off three 1" pieces of wire and place them in the centre of the boat.

Step 2. Switch the BOAT WARM toggle to AUTO and the BOAT RUN toggle to ON.

Step 3. Set the BOAT WARM control to 0% and set the BOAT RUN control to 30%.

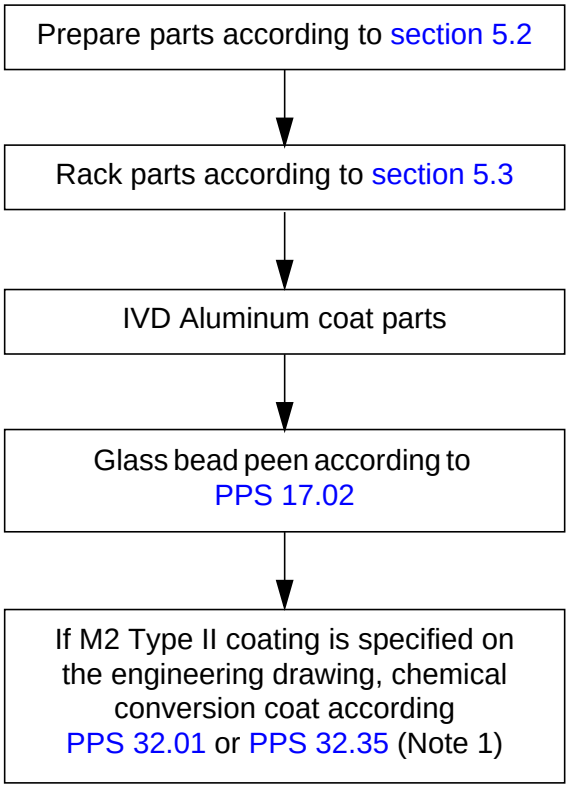
Step 4. Allow a 5 minute warm-up period and increase the BOAT RUN amperage in increments of 10% until the aluminum forms a molten puddle, which will form into a ball and move with a swirling motion to wet the entire cavity of the boat. During this period, the current on the boat ammeter will remain constant.

Step 5. Lock the BOAT RUN controls into the settings that achieve proper wetting and use these settings in production.

Step 6. Monitor the boat ammeters during the wetting period. Wetting is complete when there is a sudden rapid increase in the current.

Step 7. A properly wetted boat will have a very shiny appearance and no excess globules of aluminum on the underside of the boat.

FLOW CHART 1 - IVD ALUMINUM COATING ONTO FERROUS AND NON-FERROUS ALLOY PARTS



Note 1. Chemical conversion coat according to PPS 32.35 if the engineering drawing specifies a protective treatment code C10 (i.e., where low electrical resistance is required).