BOMBARDIER

Toronto Site

PROPRIETARY INFORMATION

PPS 32.09

PRODUCTION PROCESS STANDARD

APPLICATION OF DRY FILM LUBRICANTS (C3, C7 AND C8)

Issue 21
- This standard supersedes PPS 32.09, Issue 20.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to christie.chung@aero.bombardier.com or (416) 375-7641.
- 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 the application of C3, C7 and C8 dry film lubricant coatings to metal surfaces.

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 PPS are necessary to fulfil 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. Similarly, the procedure and requirements specified in this PPS are not applicable when use of a BAPS, MPS, LES or P. Spec. is specified.

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 ASTM D2625 - Standard Test Method for Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vee Method).

3.2 DHLPM Procedure No. 6053 - Dry Film Lubricant Testing - *Bombardier Toronto internal operating procedure*.

3.3 PPS 13.13 - Personal Protective Respiratory Equipment.

3.4 PPS 13.26 - General Subcontractor Provisions.

3.5 PPS 13.28 - Storage Life of Adhesives, Sealants, Paints and Composite Products.

3.6 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.7 PPS 17.02 - Abrasive Blasting.

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

3.9 PPS 31.06 - Cleaning of Copper and Copper Alloys.

3.10 PPS 31.12 - Cleaning Nickel and Nickel Alloys.

3.11 PPS 31.17 - Solvent Usage.

3.12 PPS 32.06 - Application of Manganese Phosphate (C2) to Steel Parts.

3.13 PPS 32.08 - Application of Zinc Phosphate Coatings to Plated Parts (C5).

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Dry film lubricant (C3), oven cure, Dow Corning Molykote 106 and Everlube Products Kal-Gard KG 200 (high temperature type).

4.1.2 Dry film lubricant (C7), air dry, fluid resistant, Dow Corning Molykote D-321R.

4.1.3 Dry film lubricant (C8), air dry, corrosion resistant, to MIL-L-23398 or Everlube Products Perma-Slik GLF (ready to apply form) to SAE AS 1701 Class II or Dow Corning Molykote 3402 or Sandstrom 26A (Molykote 3402 and Sandstrom 26A shall only be used if specified on the engineering drawing).

4.2 Equipment

4.2.1 Dip tanks with agitation equipment to prevent solids from settling out of the mixture.

4.2.2 Spray equipment, constant agitation type (e.g., Binks #80-601 or #80-651 cup gun).

4.2.3 Rubber gloves (e.g., DSC 422-2).

4.2.4 Abrasive paper, aluminum oxide, 120 - 180 grit.

4.3 Facilities

4.3.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform the application of C3, C7 and C8 dry film lubricant coatings to metal surfaces 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 C3, C7 and C8 dry film lubricant coatings to metal surfaces 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 Refer to Table I for selecting the dry film lubricants from the engineering drawing's specification of surface finish code.

5.1.2 Take care when handling dry film lubricated parts. Always wear clean cotton gloves when handling lubricated parts.

5.1.3 Securely wrap parts in clean wax-free paper for transporting or shipping. Kal-Gard KG 200 is hygroscopic (having a tendency to absorb moisture) and it is recommended that coated parts be packaged in polyfilm bags with desiccants to prevent contamination before assembly.

5.1.4 Do not apply oil, grease or corrosion preventive compound to dry film lubricated surface.

TABLE I - SELECTION OF DRY FILM LUBRICANTS FROM SURFACE FINISH CODE

SURFACE FINISH CODE	DESCRIPTION OF SURFACE FINISH CODE	DRY FILM LUBRICANT
C3	Oven Cure, wear resistant coating	Molykote 106
C3 (High Temperature)	Oven Cure, wear resistant coating for high temperature	Kal-Gard KG 200
C7	Air dry, wear and fluid resistant coating	Molykote D-321R (Note 1)
C8	Air dry, corrosion resistant coating	MIL-L-23398, Perma-Slik GLF to SAE AS 1701 Class II
		Molykote 3402 or Sandstrom 26A (Note 2)

Note 1. If the engineering drawing specifies C7 or Molykote 321R, use Molykote D-321R. Only use this lubricant for C7 surface finish code or to repair damaged oven-cured coatings. Dow Corning 321 has been replaced with Molykote D-321R. It is acceptable to use Dow Corning 321 to stock depletion provided that the storage life has not been exceeded.

Note 2. Only use Molykote 3402 or Sandstrom 26A if specified on the engineering drawing.

5.2 Preparation of Parts

5.2.1 Complete all fabrication operations such as heat treatment, forming, welding, machining and magnetic particle inspection before applying any surface treatment.

5.2.2 If possible, treat the surfaces of assemblies of dissimilar metals according to Table II before assembly. If surface treatment before assembly is not possible due to further fabrication after assembly (e.g., bushes reamed after installation) treat one metal at a time while masking all others.

5.2.3 If surface treatment is not possible before applying Molykote D-321R, solvent clean parts according to PPS 31.17.

5.2.4 Observe extreme cleanliness when processing parts according to this PPS. During surface treatment or coating operations, or after cleaning, handle parts only while wearing clean white cotton gloves.

5.2.5 Wrap parts awaiting dry film lubricant treatment in clean wax-free paper. Do not remove wrapping until just before applying dry film lubricant. Apply dry film lubricant as quickly as possible after surface treatment.

5.2.6 After the part surface has been treated, if the parts are contaminated with oil or grease solvent clean according to PPS 31.17 before applying dry film lubricants.

TABLE II - SURFACE PRE-TREATMENT

MATERIALS	SURFACE PRE-TREATMENT
Aluminum alloy	As specified on the engineering drawing.
Carbon and low alloy steels	Step 1. Abrasive blast using 180 grit (or finer) aluminum oxide according to PPS 17.02. Step 2. Treat parts with manganese phosphate according to PPS 32.06. Unless otherwise specified on the engineering drawing, apply manganese phosphate only to areas to be dry film lubricated. Step 3. Remove loosely adhering particles using a clean soft bristle brush.
Copper and copper alloys	Clean parts according to PPS 31.06.
Cadmium plated parts	Treat parts with zinc phosphate according to PPS 32.08. Unless otherwise specified on the engineering drawing, apply zinc phosphate only to areas to be dry film lubricated.
Nickel and nickel alloys	Clean parts according to PPS 31.12.
Damaged oven cured coatings	Solvent clean according to PPS 31.17 before touch-up with Molykote D-321R.
Other surfaces	Abrasive blast clean corrosion resistant steel parts, titanium and titanium alloy parts and chromium and nickel plated parts using 180 grit (or finer) aluminum oxide according to PPS 17.02.

5.3 Masking

5.3.1 Mask areas of parts not to be dry film lubricated using Kraft paper, masking tape or Microstop, as required.

5.3.2 Press tape firmly into place, especially along edges, to prevent lubricant seepage and to establish a sharp dividing line between the coated and uncoated areas.

5.3.3 Take care to prevent contamination of surfaces during masking application.

5.4 Preparation of Dry Film Lubricant

5.4.1 If the dry film lubricant is supplied in an aerosol spray can, thoroughly shake the can before use. Prepare all other dry film lubricants as follows:

Step 1. Thoroughly stir the material in its original container to break up any molybdenum disulphide solids.

Step 2. Thin or reduce, as required, according to Table III.

Step 3. Agitate the material on a mechanical paint shaker for 30 to 60 minutes.

TABLE III - PREPARATION OF DRY FILM LUBRICANT

DRY FILM LUBRICANT	SOLVENT/THINNER	REDUCING RATIO
Molykote D-321R	As specified in PPS 31.17 (Note 1)	Note 2
Kal-Gard KG 200	N/A	N/A
MIL-L-23398	As specified by the manufacturer	Note 2
Molykote 106	As specified in PPS 31.17	Note 2
Molykote 3402 (Note 3)	N/A	N/A
Sandstrom 26A (Note 3)	N/A	N/A
Perma-Slik GLF (Note 4)	N/A	N/A

Note 1. Adding solvent/thinner is applicable only if applying lubricant by brush. Molykote D-321R can also be purchased as an aerosol spray.
Note 2. If use of a solvent/thinner is specified, reduce as necessary to obtain the required viscosity for dip or spray application.
Note 3. Lubricant is supplied as aerosol spray only.
Note 4. For brush applications, purchase Perma-Slik GLF in the ready to apply condition (i.e., no thinning of the coating is required).

5.5 Application of Dry Film Lubricant (See Flow Chart 1)

5.5.1 Dip application of oven curing coatings is for parts that are not suitable for spray coating such as small items and parts with internal bores and pockets. Apply oven curing coatings using the dip application method as follows:

Step 1. Agitate dip tanks for a minimum of 15 minutes before dipping the first part. Lift the tank cover only when dipping parts to minimize solvent evaporation.

Step 2. Immerse parts in the mixture long enough to ensure complete coverage and before removing these parts with a smooth even motion.

Step 3. Bake parts at 300 ± 10°F for 30 minutes between coats to prevent the solvent in the mixture from removing previous coats.

Step 4. Repeat dipping to obtain a dry film thickness of 0.0002" to 0.0004".

5.5.2 Apply oven curing coatings using the spray application as follows:

Step 1. Apply lubricant using a spray gun with a set air pressure as recommended by the spray gun manufacturer (if no value can be obtained, then use 20 to 30 psi).

Step 2. Make 2 to 4 passes over each surface to obtain a dry film thickness of 0.0002" to 0.0004". Apply each pass lightly to attain a glossy sheen with no evidence of sags or runs.

Step 3. Allow each coat to air dry to a dull appearance between passes to prevent blistering of the coating during baking. A glossy appearance after air drying indicates improper stirring or mixing of the lubricant and is unacceptable. If necessary, remove Molykote 106 and Kal-Gard KG 200 coatings using solvents specified in PPS 31.17 before re-coating with a properly mixed lubricant.

5.5.3 Apply air drying coatings as follows:

- For Molykote D-321R lubricant, apply the coating by brush or aerosol spray to obtain a dry film thickness of 0.0002" to 0.0004".
- For MIL-L-23398 lubricant, apply the coating according to the applicable manufacturer's instructions to obtain a dry film thickness of 0.0002" to 0.0004".
- For Sandstrom 26A and Molykote 3402, apply the coating by aerosol spray to obtain a dry film thickness of 0.0003" to 0.0007".
- For Perma-Slik GLF lubricant, apply the coating by brush or aerosol spray to obtain a dry film thickness of 0.0002" to 0.0004". It is recommended that very thin coats be applied, allowing each to dry to the touch before applying the next coat.

5.6 Curing of Coatings

5.6.1 Cure coatings according to Table IV before further handling or working.

TABLE IV - DRY FILM LUBRICANT CURE SCHEDULES

TYPE OF COATING	MATERIAL	CURE SCHEDULE
Oven-cure coatings (Note 1)	Molykote 106	60 minutes at 300 ± 10°F
	Kal-Gard KG 200	60 minutes at 400 ± 25°F
Air dry Coatings	Molykote D-321R	Dry to touch - 5 minutes at 75 ± 2°F
		Full cure - 4 hours at 75 ± 2°F
	MIL-L-23398	Dry to touch - 20 minutes at 75 ± 2°F
		Full cure - 6 hours at 75 ± 2°F
	Molykote 3402	Dry to touch - 20 minutes at 75 ± 2°F
		Full cure - 4 hours at 75 ± 2°F
	Sandstrom 26A	Dry to touch - 30 minutes at 75 ± 2°F
		Full cure - 16 hours at 75 ± 2°F
	Perma-Slik GLF	Dry to touch - 5 minutes at 75 ± 2°F
		Full cure - 24 hours at 75 ± 2°F
Note 1. Remove masking materials before oven curing.		

5.7 Stripping, Re-Coating and Touch Up of Dry Film Lubricant Coatings

5.7.1 Strip dry film lubricant coating according to Table V.

TABLE V - METHODS FOR STRIPPING DRY FILM LUBRICANT COATINGS

DRY FILM LUBRICANT COATINGS	METHOD FOR STRIPPING COATINGS
Molykote D-321R	Solvent clean according to PPS 31.17
MIL-L-23398	
Perma-Slik GLF	
Molykote 106	Immerse parts in the stripping solution specified in Table VI or abrasive blast according to PPS 17.02 (Note 1)
Kal-Gard KG 200	Abrasive blast according to PPS 17.02 (Note 1)
Molykote 3402	Grit blast according to PPS 17.02 or sand the surface with 120 - 180 grit abrasive paper (Note 1)
Sandstrom 26A	
Note 1. Take care to prevent damage to parts when abrasive blast cleaning.	

TABLE VI - STRIPPING CURED MOLYKOTE 106 COATINGS

MATERIAL	STRIPPING SOLUTION	SOLUTION TEMPERATURE	IMMERSION TIME	RINSING AND DRYING
HARD ANODIZED ALUMINUM (NOTE 1)	10% Chromic Acid	170 to 180°F	45 to 60 seconds	Rinse immediately in clean hot water (180 to 190°F). Wash off any residue with an air-water blast. Air dry after final hot water rinse.
CORROSION RESISTANT STEEL			1 to 2 minutes	
COPPER AND COPPER ALLOY				
CARBON AND LOW ALLOY STEELS	20% Chromic Acid	170 to 180°F	1 minute	
PLATED STEEL (NOTE 2)				
CONVERSION COATED, CHROMIC AND SULPHURIC ACID ANODIZED				

Note 1. Inspect anodized parts for dimensional changes after stripping.
Note 2. Stripping will also result in the removal of conversion coatings, anodic coatings, phosphate coatings and metal plating. If it is necessary to avoid removal of metal plating, strip dry film lubricant by carefully controlled abrasive blast cleaning using glass bead size #BT12 according to PPS 17.02.

5.7.2 Re-coat stripped surfaces as follows:

Step 1. If metal plating has been removed or damaged during stripping of the dry film lubricant, re-plate parts according to the applicable plating PPS.

Step 2. Surface pre-treat parts according to Table II.

Step 3. Re-coat according to section 5.5.

Step 4. Cure according to section 5.6.

5.7.3 If touching up damaged oven cured coatings, solvent clean according to PPS 31.17 before touching up with the appropriate dry film lubricant.

6 REQUIREMENTS

6.1 Sampling

6.1.1 Select samples randomly from each lot according to the sampling plan specified in Table VII. Inspect the samples for appearance according to section 6.2, adhesion according to section 6.3 and coating thickness according to section 6.4. Consider items of a sample that fail to meet any of the requirements as non-conforming. If the number of non-conforming items exceeds the acceptance number for the sample specified in Table VII, inspect every part of the lot. Strip and re-coat all unacceptable parts according to section 5.7 and inspect for appearance, adhesion and coating thickness as specified herein. Also select one part from each lot at random for cure testing according to section 6.5.

TABLE VII - SAMPLING SCHEDULE

NUMBER OF ITEMS IN LOT	REQUIRED NUMBER OF ITEMS IN RANDOM SAMPLE	ACCEPTANCE NUMBER (Note 1)
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. Any defective items within the permitted number of defectives shall not be accepted with the lot but stripped and re-inspected as specified herein.		

6.2 Appearance

6.2.1 Molykote D-321R, Molykote 106, Molykote 3402 and Sandstrom 26A coatings shall have a dull grey-black smooth even finish. Slight variations in colour are acceptable. Glossy, lacquer-like coatings or coatings that appear brown, yellow or green are not acceptable.

6.2.2 MIL-L-23398, Kal-Gard KG 200 and Perma-Slik GLF coatings shall have a dull grey-black smooth even finish.

6.2.3 Any type of dry film lubricant coated part with a rough pebbly surface finish is not acceptable.

6.3 Adhesion

6.3.1 The coating shall show no evidence of flaking or peeling after removing (with one abrupt stripping motion) a strip of masking tape that has been pressed firmly onto a selected non-critical area of the part.

6.4 Coating Thickness

6.4.1 The coating thickness shall meet the requirements specified in Table VIII. Avoid compressing the coating too heavily when measuring with a micrometer.

TABLE VIII - COATING THICKNESS REQUIREMENTS

DRY FILM LUBRICANT	COATING THICKNESS
Molykote D-321R	0.0002" to 0.0004"
Kal-Gard KG 200	
MIL-L-23398	
Perma-Slik GLF	
Molykote 106	
Molykote 3402	0.0002" to 0.0004"
Sandstrom 26A	

6.5 Cure Test for Oven-Cured Coatings

6.5.1 Determine if the oven-cures coatings are acceptable by firmly rubbing the surface of the oven cured coating several times with a pair of clean white cloths dampened with the solvents specified in PPS 31.17. If both the cloths show approximately the same degree of darkening, the cure is acceptable. Re-bake the parts according to Table IX and re-test. If a sample fails the cure test after additional baking, strip and re-coat according to section 5.7 before re-inspecting according to section 6.

TABLE IX - ADDITIONAL BAKING CURE

DRY FILM LUBRICANT COATING	TEMPERATURE	CURE TIME
Molykote 106	300 ± 10°F	30 minutes
Kal-Gard KG 200	400 ± 25°F	30 minutes

6.6 Wear Life Testing

6.6.1 For Molykote 106, Kal-Gard KG 200 and MIL-L-23398 dry film lubricants, wear life testing is required before commencing production and at least once every 3 months thereafter. If no application of dry film lubricant has been performed within the last 3 months, it is acceptable to omit wear life testing as specified herein; however, before resuming application of dry film lubricants, perform wear life testing as specified herein. Wear life testing is **not** required for Molykote D-321R, Molykote 3402, Sandstrom 26A or Perma-Slik GLF dry film lubricants.

6.6.2 For wear life testing for Molykote 106 dry film lubricants, prepare and wear life test one Timken #T54148 or Falex #S25 test cup as follows:

Step 1. Abrasive blast clean the test cup using 180 grit (or finer) aluminum oxide according to PPS 17.02.

Step 2. If possible, treat the test cup with manganese phosphate according to PPS 32.06.

Step 3. Coat the outer diameter of the test cup with the applicable dry film lubricant according to the procedure specified herein.

Step 4. Submit the test cup to an approved laboratory as specified in paragraph 4.3.3.2 for wear life testing on the MacMillan tester according to DHLPM Procedure No. 6053. The minimum acceptable time to wear test failure of manganese phosphated cups is 70 hours and the minimum acceptable time to wear test failure of non-phosphated abrasive blast cleaned cups is 36 hours.

Alternatively, it is acceptable to test Molykote 106 according to ASTM D2625. When tested according to ASTM D2625, the endurance (wear) life shall be 120 minutes minimum at 1000 lbf load and the load-carrying capacity shall be 2500 lbf minimum.

If the test cup or specimens fail to meet wear life requirements, suspend the coating process. Determine and correct the cause of failure before coating any further parts. Maintain test results on file.

6.6.3 For Kal-Gard KG 200 and MIL-L-23398 dry film lubricants, use the Falex method of wear life testing as follows:

Step 1. Prepare 3 standard Falex test specimens each containing 2 V-blocks, one #8 test pin and one shear pin.

Step 2. Submit the Falex test specimens to an approved laboratory as specified in paragraph 4.3.3.2 for wear life testing on the Falex test machine at room temperature. The minimum acceptable time to wear test failure of Kal-Gard KG 200 is 25 minutes. The minimum acceptable time to wear test failure of MIL-L-23398 coatings is 50 minutes. If specimens fail to meet wear life requirements, suspend the coating process. Determine and correct the cause of failure. Maintain test results on file.

Step 3. Determine and correct the cause of failure. Maintain test results on file.

7 SAFETY PRECAUTIONS

7.1 Safety precautions applicable to the materials and procedures specified herein shall be defined by the subcontractor performing the work for Bombardier Toronto.

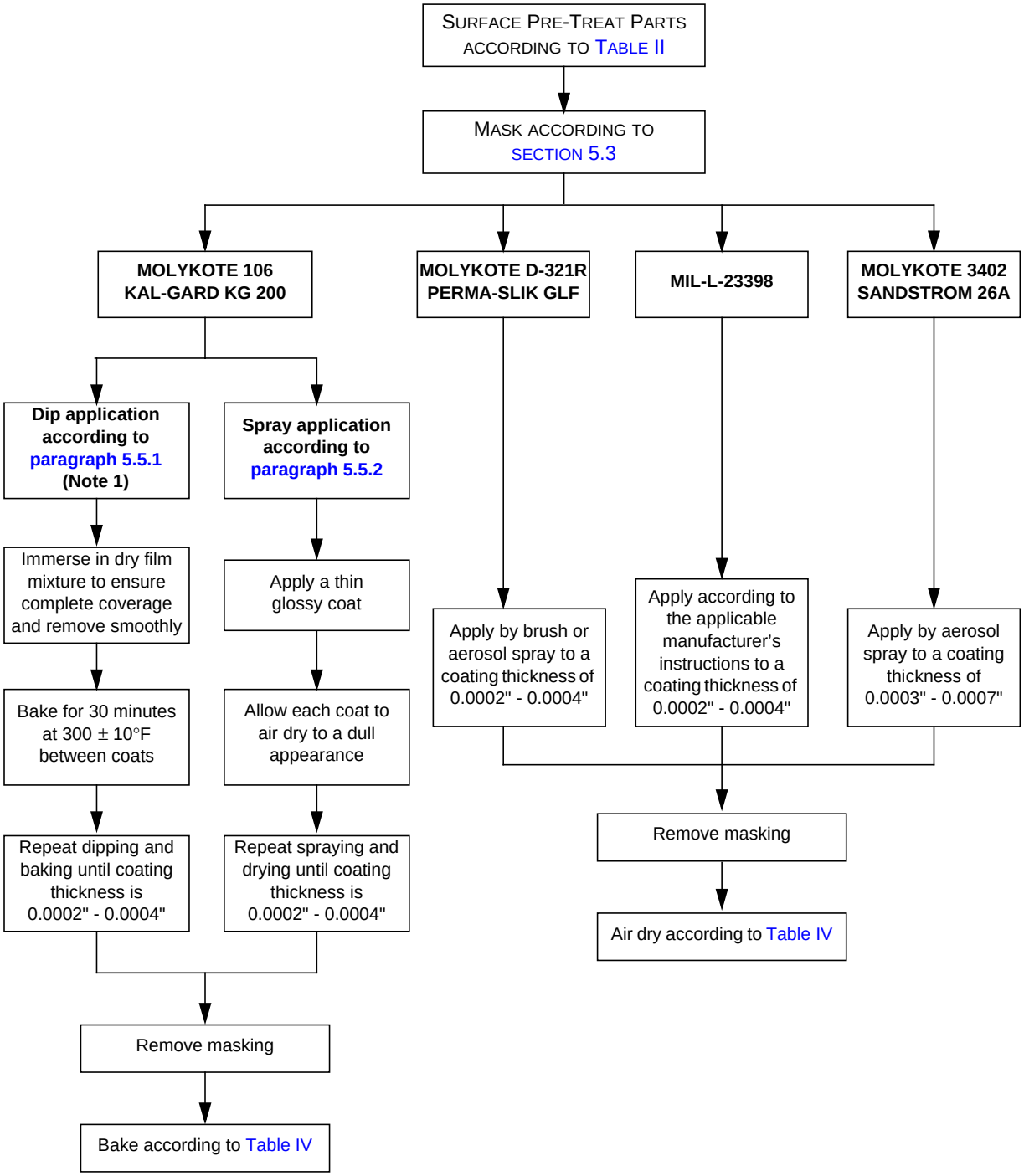
8 PERSONNEL REQUIREMENTS

8.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39. Refer to PPS 13.39 for personnel requirements.

9 STORAGE LIFE OF DRY FILM LUBRICANT

9.1 Refer to PPS 13.28 for the storage life of the dry film lubricants referenced herein.

FLOW CHART 1 - APPLICATION OF DRY FILM LUBRICANT COATING



Note 1. Only dip parts that are not suitable for spraying (e.g., small parts and parts with internal bores or pockets).