BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 23.01

PRODUCTION PROCESS STANDARD

DESIGNATION OF ALUMINUM ALLOYS

Issue 11
- This standard supersedes PPS 23.01, Issue 10.
- Extensive changes and/or deletions have been made at this issue and, therefore, detail changes have not been noted.
- Direct PPS related questions to PPS.Group@aero.bombardier.com or (416) 375-7641.
- This PPS is effective as of the distribution date.

Prepared By:	(Christie Chung)	March 13, 2013
	PPS Group	
Approved By:	(L.K. John)	March 19, 2013
	Materials Technology	
	(B. DeVreede)	March 21, 2013
	Quality	

TABLE OF CONTENTS

Sections **Page**

Tables

1 SCOPE

1.1 This Production Process Standard (PPS) explains the alloy designations, temper designations and material specifications for aluminum alloys.

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 PPS 13.26 - General Subcontractor Provisions.

4 MATERIALS AND EQUIPMENT

4.1 Materials

4.1.1 Not applicable to this PPS.

4.2 Equipment

4.2.1 Not applicable to this PPS.

5 PROCEDURE

5.1 Definitions

5.1.1 *Alloy Designations* - Aluminum alloys are identified by a standard four digit number system as defined by the American National Standards Institute (ANSI).

5.1.1.1 *Wrought Products* - The first digit indicates the alloy group. The second digit indicates modifications of the original alloy or impurity limits. The last two digits indicate the aluminum purity or identify the aluminum alloy. Refer to Table I for a listing of the alloy groups.

5.1.1.2 *Cast Products* - The first digit indicates the alloy group. The second two digits indicate aluminum purity or identify the aluminum alloy. The fourth digit, separated from the others by a decimal point, indicates the product form (i.e., casting “0” or foundry ingot “1”). A modification of the original alloy or impurity limits is indicated by a letter “A” before the numerical designation. Refer to Table II for a listing of the alloy groups and a cross reference of superseded and current alloy numbers for various cast alloys.

5.1.2 *Temper Designations* - Immediately following the alloy number, and separated by a dash, is the temper designation, consisting of an alpha or alpha-numeric code. The temper designation indicates the treatment (thermal or mechanical) to which the alloy has been subjected in order to produce specific mechanical properties.

5.1.3 *Non-Heat Treatable Aluminum Alloys* - The “As Fabricated” and “Annealed” tempers are designated by an alpha code as shown in Table III. The various strain hardened tempers (see Table III) are designated by the alpha “H” followed by a number indicating the cold worked condition as follows:

- The first digit of the number indicates the specific combination of basic operations to which the alloy has been subjected.
- The second digit indicates the degree of hardness in the alloy.
- The third digit indicates that, for the temper designated by the first two digits of the number, normal fabricating practices have been varied to attain certain properties in the alloy, for specific applications.

5.1.4 *Heat Treatable Aluminum Alloys* - The “As Fabricated”, “Annealed” and “As Quenched” (after solution heat treatment) tempers are designated by an alpha code as shown in Table IV. Products which are thermally treated, with or without supplementary cold working, to produce a stable temper are designated by the alpha “T” followed by a number. The first digit of the number indicates specific sequences of the basic treatments to which the alloy has been subjected. This includes a high temperature treatment (i.e. solution heat treatment or a high temperature shaping process) and a low temperature or room temperature treatment (i.e. artificial age, natural age or stabilize). Treatments may or may not include a supplementary cold working treatment. Subsequent digits of the number indicate further thermal or cold work treatment applied to produce different characteristics.

5.1.5 *Material Specifications* - The following tables list the material specifications for the various aluminum alloys and product forms used at Bombardier Toronto.

EXTRUDED BAR, ROD, SHAPES, TUBE & WIRE	Table V
ROLLED, DRAWN OR COLD FINISHED BAR, ROD, WIRE AND SHAPES	Table VI
DRAWN SEAMLESS TUBE	Table VII
FORGINGS	Table VIII
ROLLED SHEET AND PLATE	Table IX
CASTINGS	Table X

5.1.6 Table XI lists superseded and current specification numbers for various forms of aluminum alloys.

5.1.7 *Minimum Residual Stress (MRS) Sheet* - Sheet material in which residual stresses have been reduced by stretching immediately after solution heat treatment. The purpose of this treatment is to reduce distortion in parts pocketed by chemical or machine milling.

6 REQUIREMENTS

6.1 Not applicable to this PPS.

7 SAFETY PRECAUTIONS

7.1 Not applicable to this PPS.

8 PERSONNEL REQUIREMENTS

8.1 Not applicable to this PPS.

TABLE I - DESIGNATION OF WROUGHT ALUMINUM ALLOYS

ALLOY GROUP	DESCRIPTION (MAJOR ALLOYING ELEMENT)
1XXX	Unalloyed - 99% minimum aluminum
2XXX	Copper
3XXX	Manganese
4XXX	Silicon
5XXX	Magnesium
6XXX	Magnesium and Silicon
7XXX	Zinc
8XXX	Other Element
9XXX	Unused Series

TABLE II - DESIGNATION OF CAST ALUMINUM ALLOYS

ALLOY GROUP	DESCRIPTION (MAJOR ALLOYING ELEMENT)
1XX.0	Unalloyed - 99% minimum aluminum
2XX.0	Copper
3XX.0	Silicon - with added copper and magnesium
4XX.0	Silicon
5XX.0	Magnesium
7XX.0	Zinc
8XX.0	Tin
9XX.0	Other Element

Superseded and current alloy numbers for aluminum castings:

OLD NUMBER	NEW NUMBER
195	295.0
220	520.0
356	356.0
A356	A356.0
A357	A357.0

TABLE III - TEMPER DESIGNATIONS OF NON-HEAT TREATABLE ALUMINUM ALLOYS

TEMPER DESIGNATION	DEFINITION
F	As fabricated condition resulting from normal shaping processes involved in mill fabrication of the material without special control over thermal treatment or degree of strain hardening
O	Annealed - softest temper, best formability
H12	Strain hardened to 1/4 hard temper
H14	Strain hardened to 1/2 hard temper
H16	Strain hardened to 3/4 hard temper
H18	Strain hardened to full hard temper
H22	Strain hardened and partially annealed to 1/4 hard temper
H24	Strain hardened and partially annealed to 1/2 hard temper
H26	Strain hardened and partially annealed to 3/4 hard temper
H28	Strain hardened and partially annealed to full hard temper
H32	Strain hardened to 1/4 hard temper and then stabilized
H34	Strain hardened to 1/2 hard temper and then stabilized
H36	Strain hardened to 3/4 hard temper and then stabilized
H38	Strain hardened to full hard temper and then stabilized
H112	As fabricated to specified special properties

TABLE IV - TEMPER DESIGNATIONS OF HEAT TREATABLE ALUMINUM ALLOYS

TEMPER DESIGNATION	DEFINITION
F	As fabricated condition resulting from normal shaping processes involved in mill fabrication of the material without special control over thermal treatment or degree of strain hardening
O	Annealed - softest temper, best formability
W	As quenched condition following solution heat treatment, used to facilitate severe forming operations. This condition is unstable and material will naturally age harden at room temperature. Refrigeration at 0°F or lower will maintain the condition for a maximum of 168 hours (7 days). If, at any time, the refrigeration temperature fluctuates into the range of 1 to 20°F, the W condition will be maintained for a maximum of 72 hours (3 days)
T3	Solution heat treated, cold worked by flattening or straightening by stretching and naturally aged
T31	Same as T3, but only applicable to 2219 alloy or 2024 rivets driven cold
T351	Solution heat treated, stress relieved by stretching and naturally aged. Applicable to 2024 plate and rolled or cold finished bar and rod
T3510	Same as T351, but only applicable to extruded material
T3511	Same as T3510, but minor straightening is permitted
T36	Solution heat treated, cold worked by a reduction in thickness of approximately 6% and naturally aged 2024 sheet and plate
T361	Same as T36 (2024 sheet and plate), but stress relieved by stretching before aging
T37	Same as T36 (2219 sheet and plate), but with 8% cold reduction
T4	2024 and 6061 alloy solution heat treated by the mill and naturally aged without cold working
T42	2024 and 6061 alloy solution heat treated by the user from the O, F or applicable T temper and naturally aged. Properties are lower than for -T4
T451	Solution heat treated, stress relieved by stretching and naturally aged. Applicable to 6061 alloy plate and rolled or cold finished bar and rod
T4510	Same T451, but applicable to extruded material
T4511	Same as T4510 (6061 alloy), but minor straightening is permitted
T5	Rapid cooled from an elevated temperature shaping process and artificially aged
T6	Solution heat treated and artificially aged
T62	Solution heat treated by the user and artificially aged OR artificially aged from the T42 temper
T651	Solution heat treated, stress relieved by stretching and artificially aged OR artificially aged from the T451 temper (2014, 6061). Applicable to plate and rolled or cold finished bar and rod. Similar to T6
T6510	Same as T651, but applicable to extruded material

NOTES:
1. The effect of cold work on 6061 material is not recognized and, consequently, this material does not exist in the T3 temper.
2. The strength of 7075 and 7079 alloys continues to rise at an appreciable rate after quenching. Such alloys are always precipitation hardened to at least the T6 temper before use.

TABLE IV - TEMPER DESIGNATIONS OF HEAT TREATABLE ALUMINUM ALLOYS

TEMPER DESIGNATION	DEFINITION
T6511	Same as T6510, but minor straightening is permitted
T73	Solution heat treated and overaged OR artificially overaged from the T6/T62 temper. Provides increased resistance to stress corrosion cracking and exfoliation corrosion
T7351	Solution heat treated, stress relieved by stretching and overaged OR artificially overaged from the T651 temper. Provides increased resistance to stress corrosion cracking and immune to exfoliation corrosion. Applicable to 7079 alloy plate and rolled or cold finished bar and rod
T73510	Same as T7351, but overaging is from the T6510 temper. Applicable to extruded material
T73511	Same as T73510, but minor straightening is permitted
T736	Solution heat treated and overaged. Applicable to die and hand forgings
T73652	Solution heat treated, stress relieved by compression and overaged. Applicable to 7175 and 7050 alloy hand forging material
T7451 (formerly T73651)	Solution heat treated, stress relieved by stretching and overaged. Applicable to 7050 alloy plate material
T76	Solution heat treated and overaged OR artificially overaged from the T6/T62 tempers. Provides increased resistance to stress corrosion cracking and exfoliation corrosion
T7651	Solution heat treated, stress relieved by stretching and overaged OR artificially overaged from the T651 temper. Provides increased resistance to stress corrosion cracking and exfoliation corrosion. Applicable to 7050 and 7075 plate and rolled or cold finished bar and rod
T76510	Same as T7651, but overaging is from the T6510 temper. Applicable to extruded material
T76511	Same as T76510, but minor straightening is permitted
T7751	Solution heat treated, stress relieved by stretching, overaged
T77511	Same as T7751, but minor straightening is permitted
T81	Solution heat treated, cold worked by flattening and artificially aged OR artificially aged from the T3 temper
T851	Solution heat treated, stress relieved by stretching and artificially aged OR artificially aged from the T351 temper. Applicable to plate and rolled or cold finished bar and rod
T8510	Same as T851, but overaging is from the T3510 temper. Applicable to extruded material
T8511	Same as T8510, but minor straightening is permitted
T861	Solution heat treated, cold worked by a reduction in thickness of approximately 6% and artificially aged OR artificially aged from the T361 temper
T87	Solution heat treated, cold worked by a reduction in thickness of approximately 7% and artificially aged OR artificially aged from the T37 temper

NOTES:
1. The effect of cold work on 6061 material is not recognized and, consequently, this material does not exist in the T3 temper.
2. The strength of 7075 and 7079 alloys continues to rise at an appreciable rate after quenching. Such alloys are always precipitation hardened to at least the T6 temper before use.

TABLE V - EXTRUDED BAR, ROD, SHAPES, TUBE & WIRE ALLOY NUMBER/MATERIAL SPECIFICATION CROSS REFERENCE

ALLOY NUMBER	MATERIAL SPECIFICATION
2014	QQ-A-200/2
2024	QQ-A-200/3
6061	QQ-A-200/8
7075	QQ-A-200/11
7075 (-T76, -T76510 or -T76511)	QQ-A-200/15
7150-T77511	AMS 4345

TABLE VI - ROLLED, DRAWN OR COLD FINISHED BAR, ROD AND WIRE ALLOY NUMBER/MATERIAL SPECIFICATION CROSS REFERENCE

ALLOY NUMBER	MATERIAL SPECIFICATION
2014	QQ-A-225/4
2017	QQ-A-255/5
2024	QQ-A-225/6
5052	ASTM B 211
6061 Temper O	AMS 4115
6061 (-T4 or -T42)	AMS 4116
6061 (-T451)	AMS 4128
6061 (-T6, -T62 or T651)	AMS 4117
6061 Temper F	AMS's 4115/4116/4117
7075	QQ-A-225/9

TABLE VII - DRAWN SEAMLESS TUBE ALLOY NUMBER/MATERIAL SPECIFICATION CROSS REFERENCE

ALLOY NUMBER	MATERIAL SPECIFICATION
2024	WW-T-700/3
5052	WW-T-700/4
6061	WW-T-700/6 or AMS 4081 (-T4) & AMS 4083 (-T6)

TABLE VIII - FORGINGS ALLOY NUMBER/MATERIAL SPECIFICATION CROSS REFERENCE

ALLOY NUMBER	DESCRIPTION	MATERIAL SPECIFICATION
2014	Die and hand forgings	QQ-A-367 or AMS-A-22771
6061		
7075		
7050-T7452	Hand forgings	AMS 4108
7175-T74	Die forgings	AMS 4149

TABLE IX - ROLLED SHEET AND PLATE ALLOY NUMBER/MATERIAL SPECIFICATION CROSS REFERENCE

ALLOY NUMBER	DESCRIPTION	MATERIAL SPECIFICATION
1100	Bare	QQ-A-250/1
2004	Bare	AMS 4208
	Clad both sides	AMS 4209
2014	Clad both sides	QQ-A-250/3
2024	Bare	QQ-A-250/4
	Clad both sides	QQ-A-250/5
2219	Bare	QQ-A-250/30
5052	Bare	QQ-A-250/8
6061 Temper O	Bare	AMS 4025
6061 (-T4, -T42 or -T451)		AMS 4026
6061 (-T6, -T62 or T651)		AMS 4027
6061 Temper F		AMS's 4025/4026/4027
7075	Bare	QQ-A-250/12
	Clad both sides Temper O & F	AMS 4048
	Clad both sides T6/T651	AMS 4049
	7011 Clad both sides	ASTM B 209
	Clad one side	QQ-A-250/18
7075 (-T76 or -T7651)	Clad both sides	AMS 4316
7050-T7451	Bare	AMS 4050
7150-T7751	Bare	AMS 4252
7475-T7351	Bare	AMS 4202

TABLE X - CASTINGS ALLOY NUMBER/MATERIAL SPECIFICATION CROSS REFERENCE

ALLOY NUMBER	DESCRIPTION	MATERIAL SPECIFICATION
A356.0	Permanent mould and investment castings	AMS-A-21180
	Sand castings	ASTM B26/B26M
A357.0	Permanent mould and investment castings	AMS-A-21180
356.0-T6	Permanent mould and investment castings	AMS 4260
	Sand castings	ASTM B26/B26M

TABLE XI - SUPERSEDED AND CURRENT MATERIAL SPECIFICATIONS

OLD SPECIFICATION	CURRENT SPECIFICATION
QQ-A-225	QQ-A-250/3
QQ-A-250/25	AMS 4316
QQ-A-250/26	ASTM B 209
QQ-A-261	QQ-A-200/2
QQ-A-266	QQ-A-225/4
QQ-A-267	QQ-A-200/3
QQ-A-268	QQ-A-225/6
QQ-A-270	QQ-A-200/8
QQ-A-277	QQ-A-200/11
QQ-A-282	QQ-A-225/9
QQ-A-283	QQ-A-250/12
QQ-A-287 & QQ-A-250/13	AMS 4048; AMS 4049
QQ-A-315 & QQ-A-225/7	ASTM B 211
QQ-A-318	QQ-A-250/8
QQ-A-325 & QQ-A-225/8	AMS 4115; AMS 4116; AMS 4117; AMS 4128
QQ-A-327 & QQ-A-250/11	AMS 4025; AMS 4026; AMS 4027
QQ-A-351	QQ-A-225/5
QQ-A-355	QQ-A-250/4
QQ-A-356	QQ-A-225/2
QQ-A-357	QQ-A-200/1
QQ-A-362	QQ-A-250/5
QQ-A-365	QQ-A-225/3
QQ-A-411	QQ-A-225/1
QQ-A-561 & QQ-A-250/1	ASTM B 209
QQ-A-601	ASTM B26/B26M

OLD SPECIFICATION	CURRENT SPECIFICATION
WW-T-783	WW-T-700/1
WW-T-785	WW-T-700/3
WW-T-787	WW-T-700/4
WW-T-789	WW-T-700/6
MIL-T-7081 & AMS-T-7081	AMS 4081 & AMS 4083
MIL-A-8825	QQ-A-200/12
MIL-A-8877	QQ-A-250/17
MIL-A-8902	QQ-A-250/18
MIL-A-8920	QQ-A-250/3
MIL-A-9180	QQ-A-250/14
MIL-A-9183	QQ-A-250/15
MIL-A-9186	QQ-A-200/13
MIL-A-17358	QQ-A-250/6
MIL-A-19005	QQ-A-200/4
MIL-A-19070	QQ-A-250/7
MIL-A-19842	QQ-A-250/9
MIL-A-21170	QQ-A-200/7
MIL-A-21180	AMS-21180
MIL-A-21579	QQ-A-200/5
MIL-A-21598	QQ-A-250/10
MIL-A-21599	QQ-A-200/6
MIL-A-22771	AMS-A-22771
MIL-A-25493	QQ-A-200/10
MIL-A-21494	WW-T-700/5