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Engineering Standard Practice

SELECTION OF METALLIC MATERIALS DHC-8 SERIES 400 PROGRAM

DOCUMENT: **ESP 80-1**

Issue **4**

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Engineering Standard Practice

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1.0 GENERAL

This document addresses materials currently used on the DHC-8 Programs and recommended on the Series 400 Program.

The use of materials and conditions not listed in this document should not be considered unless authorized by de Havilland Engineering department.

The design should utilize to the most practical and economical degree the materials listed in this document.

2.0 METALLIC MATERIALS

Selection of metallic materials shall be in accordance with the following paragraphs and tables. Please see also the following Engineering Standard Practices (ESP):

ESP 46-3	Drawing Call-Out Notes for Applicable Manufacturing and Quality Requirements
ESP 64-1	DHC-8 Series 400 Protective Treatment Specification
ESP 98	Preferred Metallic Raw Material Sizes.

2.1 ALUMINUM ALLOYS

The application of aluminum alloys is defined in the following section.

a. Materials and conditions/tempers that are susceptible to stress corrosion and/or exfoliation corrosion such as: 2024-T3XX, 7XXX-T6XXX, etc, shall not be used. Exceptions to the above rule may be obtained from de Havilland Engineering department only for wing skin and thin section extruded stringers with section thicknesses less than 0.50 inches.

b. Alloy 7150-T7751 plate for wing upper skin applications should be machined so that the wing outer surface is as near the original, as rolled plane as possible in order to maximize resistance to exfoliation corrosion.

c. Aluminum (7XXX Series) alloy components made from extruded and rolled bars, extruded shapes equal to or thicker than 0.5 inch, thick forgings, forged block or machined from thick plate or bar should utilize overaged tempers, ie T73XXX.

d. Machining distortion may be encountered with 7175 die forgings based on complexity of shape.

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TABLE 1 - Aluminum Alloy Usage

ALLOY / FORM	TEMPER AS-USED	SPECIFICATION	COMMENTS / REMARKS
SHEET AND PLATE			
2004 Sheet	-T6	Alclad AMS 4209	- Used for superplastic forming.
2024 Sheet	-T3, -T42	Alclad QQ-A-250/5	- For chem milling add note “Chem Mill Quality”. (1) used on fuselage skins and interior details
2024 Plate	-T351	QQ-A-250/4	*RESTRICTED USE* - Use only for wing lower skin, splice plate and fuel pump mount plate.
7075 Sheet	-T6, -T62	Alclad QQ-A-250/13	- Formed detail parts - For chem milling add note “Chem Mill Quality” (1) Used for fuselage skins and interior details
	-T6, - T62	Alclad one side QQ-A-250/18	- Use only for high strength metal-to-metal adhesive bonding
7075 Plate	-T7351	Bare QQ-A-250/12	- Machined structural parts such as frames, fittings, etc. Has improved resistance to S.C.C.

(1) This note means that the sheet shall be minimum residual stress (MRS) and possibly controlled fine grain structure if required to meet the surface roughness requirements stated for Type II of PPS 42.01.

TABLE 1 - Aluminum Alloy Usage

ALLOY / FORM	TEMPER AS-USED	SPECIFICATION	COMMENTS / REMARKS
7050 Plate	-T7451	AMS 4050	- Machined primary structural parts. Long parts may distort because of higher residual stresses than 7075- T7XXX. - General use is for thicknesses 4.00 inch - 6.00 inch. Where higher strength is required lower thicknesses may be used - When the design requires fracture toughness properties then state the following note on the drawing: Note: 7050-T7451 plate shall conform to AMS 4050, including the following requirement: - Fracture Toughness
7150 Plate	-T7751	AMS 4252	- Use T7751 where minor strength loss is acceptable in obtaining better resistance to exfoliation and stress corrosion cracking than the T6151 temper (2). - When the design requires longitudinal tensile or compressive yield strength and fracture toughness properties then state the following note on the drawing: NOTE: 7150-T7751 plate shall conform to AMS 4252, including the following requirements: - Longitudinal tensile - Compressive yield strength - Fracture toughness
7475 Plate	-T7351	AMS 4202	- To be used by Short Bros. in the nacelle structure in place of 7050-T7451 plate.
5052 Sheet	-H32, -H34	QQ-A-250/8	- Used for low strength, very high corrosion resistance applications. Is fusion weldable.

(2) ALCOA takes exception to spec. fracture toughness values as follows: For Plate over 2.5 inches in thickness
L-T Dir. 19 ksi sq. root inch.
T-L Dir. 18 ksi sq. root inch.

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TABLE 1 - Aluminum Alloy Usage

ALLOY / FORM	TEMPER AS-USED	SPECIFICATION	COMMENTS / REMARKS
6061 Sheet	-T4, -T6, -T42, -T62	QQ-A-250/11	- For parts requiring fusion welding or brazing and good corrosion resistance
6061 Plate	-T651,-T42, -T62, T6		
EXTRUSION (SHAPES)			
2024	-T3511, -T3	QQ-A-200/3 CV Number	- Stringers, cleats, brackets etc. - use only when section thickness is less than 0.250 inch.
7075	-T6, -T6511, -T73, -T73511	QQ-A-200/11 CV Number	- Section thicknesses $\overline{>}$ 0.50 inches in the least dim. should be in the -T73XXX temper. - Stringers, cleats and brackets
7075	-T76511	QQ-A-200/15 CV Number	- Stringers, cleats and brackets with increased resistance to exfoliation and S.C.C.

TABLE 1 - Aluminum Alloy Usage

ALLOY / FORM	TEMPER AS-USED	SPECIFICATION	COMMENTS / REMARKS
7150	-T77511	AMS 4345 CV Number	- Intergranular corrosion from the mill processing may be present. - When the design requires long-transverse tensile compressive yield strength, stress-corrosion cracking and fracture toughness properties then state the following notes on the CV drawing: Note: 1) 7150-T77511 extrusion shall conform to AMS 4345, including the following requirements; - Long-transverse tensile - Compressive yield strength - Stress-corrosion cracking - Fracture toughness 2) Full section tensile test specimens shall be taken from the rear end of the extruded length. 3) Profile shown must not contain any intergranular corrosion. If required, 0.010" additional material may be added all around, to the basic extrusion and then machined or chem-milled to obtain the final dimensions shown.
6061	-O, -T4, -T6, -T4511, T6511	QQ-A-200/8 CV Number	- Interior trim
BAR, ROD AND WIRE (Rolled, Drawn or Cold Finished)			
7075	-T73, T7351	QQ-A-225/9	- Std material for machined structural and mechanical parts.

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TABLE 1 - Aluminum Alloy Usage

ALLOY / FORM	TEMPER AS-USED	SPECIFICATION	COMMENTS / REMARKS
6061	-T651, -T6	QQ-A-225/8	- Machined parts requiring brazing or fusion welding and good resistance to corrosion - 3% lighter than 7075. Consider 6061 if lower properties are acceptable.
FORGINGS			
7050 Hand Forging	-T74, T7452	AMS 4108	- Hand forgings or forged billets are used when lead time for thick plate is too long. - When the design requires fracture toughness properties, then state the following note on the drawing: Note: 7050-T7XXX forged billet shall conform to AMS 4108, including the following requirements: - Fracture toughness
7075 Die Forging	-T73	QQ-A-367	- Standard die forging.
7175 Die Forging	- T74	AMS 4149	- Higher strength die forgings with section thickness up to 6.0 inches. - When the design requires fracture toughness properties, then state the following note on the drawing: Note: 7175-T74 die forging shall conform to AMS 4149, including the following requirement: - Fracture toughness

TABLE 1 - Aluminum Alloy Usage

ALLOY / FORM	TEMPER AS-USED	SPECIFICATION	COMMENTS / REMARKS
7050 Die Forging	- T7452	AMS 4333	- Spar forgings - When the design requires fracture toughness properties, then state the following note on the drawing: Note: 7050-T7452 die forging shall conform to AMS 4333 including the following requirements: - Fracture toughness
CASTINGS - Standard Quality			
356.0 Investment	-T6	AMS 4260	- System and secondary structure low stress parts too difficult to machine from solid.
CASTINGS - Premium Quality (High Strength)			
A356.0	-T6	MIL-A-21180 Class 1 or Class 11	- Premium alloy casting same as alloy 356.0 except for part requiring higher strength than available from 356.0.
A357.0	-T6	MIL-A-21180 Class 1 or Class 11	- Premium alloy casting higher properties and price than A356.0.
TUBING			
6061 Structural and Systems	-T6, -T62, -T4	WW-T-700/6	- Moderate strength structural parts or systems piping requiring fusion welding, or internally swaged tube end fittings.
6061 Structural (Magneformed)	-T6	DHMS M2.21	- Special surface finish for magneformed control tubes.
6061 Systems	-T6, -T4	MIL-T-7081	- Systems with working pressure $\leq$ 3000 psi, single and double flared tube ends or internally swaged tube end fittings.
5052 Systems (Fuel Drain, etc)	- O	WW-T-700/4	- Systems with working pressures $\leq$ 1500 psi.

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2.2 FERROUS ALLOYS

The following criteria shall be used for the selection of ferrous alloys:

a. Only vacuum arc remelted low-alloy steels shall be used for structural fittings requiring strength levels of 200 ksi and above. These alloys are 4330V and 300M.

b. Alloy 15-5PH is the preferred corrosion resistant steel for structural fittings requiring strength levels of 150 to 170 ksi or 180 to 200 ksi.

c. CRES alloy PH 13-8Mo standard heat treatment (strength range) shall be 180-200 ksi.

d. CRES alloy 17-7PH should not be used except:

   1 For sheet applications up to 0.063 inch thickness in TH1050, 180 to 200 ksi and RH950, 200-240 ksi strength ranges.

   2 For spring applications, limited to CH 900 temper.

e. Due to the possibility of corrosion and/or brittle cracking, consult with Materials Technology regarding any potential application of 400 Series CRES steel.

f. For critical heat treat section sizes (i.e., through hardening depth, consult Materials Technology.

g. Characteristics of Some AISI 300 Series Stainless Steels (See next page).

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AISI	Characteristics
301	High work-hardening rate. Applications requiring good strength and ductility.
303	Free machining sulfur modification of Type 302.
304	General purpose austenitic grade for enhanced corrosion resistance.
316	Mo added to improve corrosion resistance in reducing environments. Improved creep resistance over Type 302.
316L	Low-carbon modification of Type 316 for welded construction.
321*	Titanium stabilized for service in 800-1600˚F range and to minimize carbide precipitation when welding for resistance to intergranular corrosion.
347*	Columbium stabilized for service in 800-1600˚F range and to minimize carbide precipitation when welding for resistance to intergranular corrosion

* No free machining grades allowed.

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TABLE 2 Ferrous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
1095	Rc 40-43 (180-200 ksi) R_c 43-46 (200-220 ksi)	Sheet and strip Sheet and strip	MIL-S-7947, Condition 3	- Flat springs, clips, etc.
1020 or 1025	Carburized see ESP 46-03 for drawing notes.	Sheet and strip	MIL-S-7952	- For small carburized parts
4130	Cond. D 90-120 ksi 125-145 ksi	Bar	MIL-S-6758	- For fusion welding use 90-120 ksi strength range for detail parts. Welded assemblies to be used in as welded condition or heat treated 125-145 ksi. - Machined and formed fittings - Machined structural and mechanical parts
4130	Cond. N (90-120) ksi 125 - 145 ksi 150 - 170 ksi	Sheet/Strip	MIL-S-18729	
		Structural Tubing	MIL-T-6736	
4330V	220-240 ksi	Bar/Forging	AMS 6411	- Primary structural parts requiring high strength, good ductility, high impact strength and transverse properties, i.e., wing to fuse attachment struts.
4340 (Air)	125-145 ksi 150-170 ksi	Bar/Forging	AMS 6409 (Formerly MIL-S-5000)	- Structural and mechanical parts requiring good impact and fatigue resistance.
4340 (Vac)	180-200 ksi	Bar/Forging	AMS 6414	- Same as air melted 4340 except where a cleaner material is required.

TABLE 2 Ferrous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
300M	280-305 ksi	Bar/Forging	AMS 6419	- Primary structural parts requiring very high strength.
9310	150-190 ksi Core	Bar/Forging	AMS 6260	- Carburizing steel for parts requiring high wear case in areas with <400°F service temperature.
Nitralloy 135 M (7140)	Core 170-190 ksi	Rod/Bar	AMS 6470	- Nitriding steel for parts requiring high core/high case hardness.
9315	As purchased (annealed) Final Ht. Tr. (carburized and H.T.)	Bar/Forging/Tubing	AMS 6263	- To be used by Micro Technica for flap actuator worm gear and recirculation ballscrew shaft.
301 CRES	1/4 Hard (125 ksi min.) 1/2 Hard (150 ksi min.) 3/4 Hard (175 ksi min.) Full Hard (185 ksi min.)	Sheet/Strip	AMS 5517 AMS 5518 Formerly AMS 5902 MIL-S-5059 AMS 5519	- Formed parts requiring good strength and corrosion resistance for service < 700°F.
302 CRES	Spring Temper	Wire	AMS 5688 (Formerly QQ-A-423)	- Used for spring and hinge pins. Where higher strength is required, see 17-7PH, CH900 wire.
303 CRES	Annealed	Bar	DHMS M2.23 (Formerly QQ-S-764 Cond. A)	- Free machining stainless providing good surface finish on machined parts.
303F CRES	Cold Worked	Round Bar Only	AMS 5738 (Formerly QQ-S-764 Cond. B)	- For non-structural and non-fatigue critical parts. - Good machinability and surface finish.

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TABLE 2 Ferrous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
304 CRES	Annealed	Tubing	MIL-T-8504	- Can be used in high pressure (3000 psi) hydraulic and pneumatic systems and other systems in fire zones. Flared joints.
	1/8 Hard	Tubing	MIL-T-6845	- Hydraulic and other systems tubing
321	Annealed	Sheet/Plate/Strip	AMS 5510 (Formerly MIL-S-6721)	- For parts requiring fusion welding or brazing or high temperature applications <850°F. No free machining grades allowed.
	Annealed	Bar/Forging	QQ-S-763	
	Annealed	Tubing	MIL-T-8606	
347	Solution Heat Treated	Investment Casting	AMS 5362	- General purpose corrosion and heat resistant ($\bar{<}$ 850°F) casting alloy where low strength is acceptable.
21-6-9	Cold Worked	Tubing	BMS 7-185	- For high pressure (3000 psi) hydraulic systems tubing. Flared and non-flared tube joints.
17-7PH	TH1050 (180-200 ksi)	Sheet/Strip	MIL-S-25043, Condition A	- High strength CRES with good formability in Cond.A for part ≤ .063 inches. For parts >0 .063 inches, use 15-5 PH. - Used for flat springs
	RH 950 (200-240 ksi)	Strip	MIL-S-25043, Condition A	
17-7PH	CH900	Wire	AMS 5678	- Cold worked material suitable for coil springs where strength higher than 302 CRES is required.

TABLE 2 Ferrous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
17-4 PH	H1150 (125-155 ksi) H1025 (155-175 ksi)	Bar/Forging	AMS 5643	- Machined parts requiring high strength, corrosion and oxidation resistance to 600°F - For fusion welded parts consult welding specialist to ensure design is suitable for fusion welding.
17-4PH	H1100 (130-160 ksi)	Investment Casting	AMS 5342	- Standard ferrous casting material - For parts requiring improved transverse ductility and toughness use PH 13-8 Mo or 15-5 PH, depending on required strength
Custom 455	H1050 (180-200 ksi) H1000 (205-225 ksi) H950 ≤4.00” (225-245 ksi) 4.01” -6.00” (220-240 ksi)	Bar/Forgings	AMS 5617	- For CRES parts requiring corrosion and oxidation resistance and high strength at temp. up to 800°F. - Material can be fusion welded, but shall be solution heat treated after welding. Welding specialist shall be consulted to ensure design is suitable for welding - For parts requiring improved transverse ductility and toughness use PH 13-8 Mo or 15-5 PH, depending on required strength.
15-5 PH	H1025 (155-175 ksi)	Bar/Forging	AMS 5659	- CRES parts requiring improved transverse ductility and toughness over 17-4 PH of same strength level.
		Sheet, Strip, Plate	AMS 5862	

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TABLE 2 Ferrous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
PH13-8 Mo	H1050 (180-200 ksi) H1000 (205-225 ksi)	Bar/Forging	AMS 5629	- CRES parts requiring improved transverse ductility and toughness compared to 17-4 PH and Custom 455 of the same strength levels. - Material can be fusion welded.
Greek Ascoloy	As purchased (annealed) Final HT (H.T.)	Bar/Rod	AMS 5616	- To be used by Micro Technica for shafts in flap actuator and power unit.
Cronidur 30	As purchased (annealed) Final HT (H.T.)	Bar/Forging	AMS 5898	- To be used by Micro Technica for flap actuator recirculating ballscrew shaft.
440C CRES	As purchased (annealed) Final HT (H.T.)	Bar/Forging	AMS 5618	- To be used by Micro Technica for flap actuator recirculating ball screw balls.

2.3 HEAT-RESISTANT ALLOYS

The recommended heat-resistant alloys are covered in Table III.

TABLE 3 Heat-Resistant Alloy Usage

USE/ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS AND COMMENTS
Inconel 625	Annealed	Sheet/Plate/Strip	AMS 5599	- For high temperature application, where parts require corrosion and oxidation resistance to 2000^{o}F e.g., jet pipe, etc.
		Bar/Forging	AMS 5666	
Inconel 718	Solution Treated 140-160 ksi	Sheet/Plate/Strip	AMS 5596	- High temp. applications requiring high strength with good fatigue, creep and stress rupture strength, to 1300^{o}F and for oxidation resistance to 1800^{o}F.
	Aged: 180-200 ksi			
	Aged: 180-200 ksi	Bar/Forging	AMS 5663	
	Aged: 180-200 ksi	Bar/Forging	AMS 5662*	* Used when aging after machining is more advantageous.

2.4 TITANIUM ALLOYS

The following criteria shall be used for the selection of titanium alloys:

a. The following practices are prohibited:

1. Cadmium or silver plating of titanium or titanium alloy components, including fasteners and nuts.

2. Cadmium-plated components in contact with titanium or titanium alloy components. Use of cadmium plated alloy steel tube fittings in titanium systems shall be limited to applications of proven durability.

b. The use of titanium and its alloys is restricted in areas subject to elevated temperatures and exposure to phosphate ester hydraulic fluid to prevent damage to the titanium component, as specified below:

c. Titanium and titanium alloy components, including ducts, shall not be used if exposure to temperatures above 270˚F is anticipated and surfaces are wetted with phosphate ester hydraulic fluid (Skydrol) by dripping or spraying. The design should consider accidental failure of hydraulic systems and hot (270˚F) duct systems when selecting titanium components.

d. High formability titanium alloy Ti-15-3-3-3 should be considered as an alternative to Ti-6-4 in applications involving forming, which is more complex than straight line bends.

e. See Table 4 for titanium alloy selection.

TABLE 4 - Titanium Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
Ti-CP-40	Annealed	Sheet	MIL-T-9046, Class CP-3	- Parts requiring good long time oxidation resistance up to 600°F and good short time oxidation resistance up to 800°F. - Formed parts requiring double curvature forming. Room temperature straight line bend radius=3t - Fire zone parts
Ti-CP-70 Ti-CP-70	Annealed	Sheet	MIL-T-9046-Class CP-1 AMS 4901*	- Fire Zone Parts requiring only single curvature forming and higher mechanical properties. R.T. straight line bend radius.=4t * To be used by Short Bros. for nacelle parts.
	Annealed	Bar	MIL-T-9047	- Machined parts and fittings used in fire zones to reduce weight.
Ti-6Al-4V	Annealed	Sheet/Plate	MIL-T-9046 Class AB-1	- Parts requiring to withstand prolonged exposures to temperatures up to 750°F without loss of ductility. - Flat rolled products are usually formed and used in the annealed condition.
		Bar	MIL-T-9047	

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TABLE 4 - Titanium Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
Ti-6Al-4V (con't)				- This alloy has R.T. and elevated temperature mechanical properties higher than C.P. titanium and Ti-5Al-2.5Sn.
	Annealed (135-155 ksi for t ≤ 2.00 inch; 130-150 ksi for t=2.001-6.000 inch)	Die Forgings	AMS 4928	- Standard die forging material where titanium is required. - Use Ti-10V-2Fe-3Al where higher mechanical properities are required.
Ti-3Al-8V-6Cr-4Mo-4Zr	Solution Heat Treated	Bar/Rod	AMS 4958	- To be used by Micro Technica for torsion bars in flap drive line.
Ti-5Al-2.5Sn	Annealed	Sheet	MIL-T-9046 Cl. A-1	- This Ti alloy has good oxidation resistance up to 900^{o}F. - This alloy has higher room temperature and elevated temperature mechanical properties than C.P. Ti. - Room temperature straight line bend rad = 4.5t.
Ti-3Al-2.5V	CWSR (cold worked stress relieved)	Tubing	AMS 4945	- Hydraulic systems tubing.

2.5 MISCELLANEOUS ALLOYS

TABLE 5 - Miscellaneous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
Copper Pure	(060) Soft Annealed or (061) Annealed	Sheet Strip Plate & Bar	DHMS M2.22	- Bus Bars
C 17200 Beryllium Copper	*TB00 or TF00 TD01 or TH01 TD02 or TH02 TD04 or TH04	Strip	ASTM-B194 (Formerly QQ-C-533)	- Flat springs, spring type electrical contacts
	TB00 or TF00 TD04 or TH04	Rod & Bar	AMS 4533, AMS 4534 (Formerly QQ-C-530)	- Highly loaded static or dynamic bearings and bushings, spline shafts
	TF00	Rod & Bar	AMS 4533 (Formerly QQ-C-530)	- To be used by Short Bros. for above stated applications.
	TB00	Rod, Bar Shapes & Forgings	AMS 4650 (Formerly QQ-A-530)	
C 63000 Aluminum Bronze	Annealed	Rod & Bar	ASTM-B150-Alloy 630 or AMS 4640	- Light to medium loaded static or dynamic bearings and bushings.
Aluminum Comp. 1	Type I or Type II	Shim Stock	MIL-S-22499	- Aluminum shim stock for aluminum structures
Brass Comp. 2	Type I or Type II	Shim Stock	MIL-S-22499	- Brass shim stock for monel, titanium components and structures

TABLE 5 - Miscellaneous Alloy Usage

ALLOY	USE CONDITION	FORM	SPECIFICATION	REMARKS & COMMENTS
Stainless Steel Comp. 3	Type I or Type II	Shim Stock	MIL-S-22499	- Stainless steel (CRES) shim stock for stainless components and structures.
Carbon Steel	Type 1, Comp.A. Tin over zinc coating	Wire Rope (Cable)	MIL-W-83420	- Control cables
Stainless Steel	Type 1, Comp.B (Non-coated)	Wire Rope (Cable)	Mil-W-83420	- Other cable applications requiring improved corrosion resistance.

* TB00(1) or TF00(2)
(1). As purchased (solution heat treated or solution heat treated and cold worked).
(2). After precipition heat treatment.

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