Reference HAK/SG P 374

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24th, January 1962

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COMMONWEALTH AIRCRAFT CORPORATION PTY.LTD.
BOX 779 H P.O.
Elizabeth st.

MELBOURNE
Australia

Attention : The MANAGER.

Subject : Report on Processing details - ATAR 9C engine components.

Dear Sir,

This report is intended to give an overall picture of the processing requirements of the major components of the ATAR 9C engine. No detailed explanation of techniques involved will here be given, as these are covered either by separate report, S.N.E.C.M.A. instructions, and shop operation sheets.

Charts showing compositions of materials referred to in this report are appended for quick reference purposes.

(I) COMPRESSOR BLADES.

The following chart will serve to present in summary form, details of material, type of forging, and the number of blades per stage that go to make up the compressor.

Stage nº	Material	Type of forging	Nº off per engine
Rotor 1	Z 12 C 13	Forging	29
2	"	Precision forging	27
3	AU 2 N	Forging	37
4	"	Precision forging	39
5	"	"	53
6	"	"	53
7	Z 12 C 13	"	61
8	"	"	63
9	"	"	89
Stator 1	"	"	56
2	"	"	46

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Stator 3	AU 2 N	Precision forging	40
4	"	"	44
5	"	"	56
6	"	"	60
7	"	"	72
8	"	"	78

All blades are forged by Gennevilliers. The aluminium alloy blades are delivered in the fully heat treated and anodised condition. The steel blades are, with the exception of stage 1, delivered in the fully heat treated condition. Stage 1 is in the forged condition and is heat treated as an early shop operation prior to machining.

The practice adopted for holding the aluminium blades during machine shop operations does affect the intermediate processing operations employed at S.N.E.C.M.A.

(a) SNECMA machine shop practice.

-i- Rotor blades :

All stages, i.e. NO 1 to NO 9 blades, are set in cerrobend and machined. (as a result all the aluminium alloy blades receive an alodine 1200 protective treatment).

-ii- Stator blades :

Stage 1 and 2 blades are set in cerrobend and machined etc...
Stage 3,4,5,6,7 & 8 blades are machined in mechanical clamping fixtures. (as a result the aerofoil of stage 5,6,7 & 8 blades are protected with a sprayed plastic envelope treatment - no alodine 1200 treatment is used. Stage 3 & 4 blades are given an alodine 1200 treatment. This is only used because the geometry of these blades is such that if a plastic envelope is used there is a tendancy for it to be pulled off by the fixture).

(b) C.A.C. proposed machining practice :

Stator and Rotor blades :

All stages will be set in cerrobend and machined... Following the SNECMA practice, we would therefore : (i) not be using the sprayed plastic envelope technique at all and (ii) all aluminium alloy blades, with the exception of stage 3 which has a fully machined aerofoil, would be given an alodine 1200 treatment during production.

(c) Expected processing requirements at C.A.C. for aluminium alloy compressor blades.

-i- Alodine 1200 treatment.
for the protection of the aerofoil during production.

Total 495 blades per engine.

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-ii- Vapour blast - abrasive 90 grades.
This is used as a pre-treatment on the aerofoil of all blades after stripping the protective anodic film and just prior to the final sulphuric acid anodise on the finished machined blade.

Total 532 blades per engine.

-iii- Sulphuric acid anodise.
This is the final finish prior to painting of all aluminium alloy compressor blades. Total 532 blades per engine.

Total 532 blades per engine.

-iv- Spray painting.
The aerofoil of all aluminium alloy compressor blades are sprayed with a coat of phosphating primer followed by black high temperature ferrophenolic paint SC 45. This is the final surface finish prior to assembly into the engine.

N.B. : there is no electropolishing of aluminium alloy compressor blades carried out at any stage during production, or is there any brazing of the stator blades carried out either during production or assembly.

(d) Expected processing requirements at C.A.C. for steel compressor blades.

-i- Heat treatment :
A neutral salt bath harden - 950ºC air cool, and air circulating furnace temper at 575ºC is carried out on all stage 1 rotor blades

Total 29 blades per engine.

-ii- Electropolishing ;
All stages of steel compressor blades are electropolished as a final finishing operation, in a 80% phosphoric - 20% chromic acid bath, temp. 75-80ºC and for approximately 30 sec. at 100 amp. per square decimeter.

Total 371 blades per engine.

-iii- Brazing :
All stator blades of stage 1 and 2 are shrouded. They are brazed with silver solder using H-F brazing equipment and special fixtures after assembly into the compressor casing during engine build. This operation will be carried out in the assembly department at C.A.C.

N.B. There is no etching for inspection during production. Any material defects are evaluated by magnaflux inspection. The blades are not inspected after electropolishing - they go straight to store.

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(2) COMPRESSOR SHAFT.

The compressor shaft is built up from compressor wheels, inner spacers, outer spacers, a labyrinth seal, and a rear stub shaft.

9 compressor wheels 8 inner spacers 8 outer spacers 1 rear labyrinth seal 1 rear stub shaft	All produced as forgings machined and heat treated Z 12 C 13 material.

180 bolts and screws in 28 CDV 5.

(a) Heat treatment :

All compressor wheels, spacers, labyrinth seal, and rear stub shaft will require to be heat treated as follows :

-i - Harden 950ºC oil quench and temper 550ºC after a rough machining operation on the forging.

-ii- Stress relieve at 525ºC after detailed machining and before final machining.

Total 27 parts per engine.

(b) Silver plating :

There are approximately 180 bolts used in the build up of the compressor shaft and all are silver plated. These are, however, all being purchased as finished parts from SNECMA and therefore there will be no silver plating requirements from this section for C.A.C.

N.B. There is no etch inspection carried out on any wheel or spacer during production. All material defects are evaluated at magnaflux inspection.

(3) TURBINE SHAFT - H.P WHEEL and L.P WHEEL.

The turbine shaft and H.P wheel are forged as one part. This part and the L.P wheel are both forged at the SNECMA Gennevilliers plant.

- Turbine shaft and H.P wheel	Overall length 42" wheel diam. 19" weight. 120 kg. material 28 CDV 5
- L.P turbine wheel	Material 28 CDV 5.

The turbine shaft and H.P wheel (hard core item) will be supplied to C.A.C. after rough machining and the harden and temper operation. The L.P wheel will be supplied in the forged normalised and tempered condition.

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(a) Heat treatment :

The heat treatment to be carried out at C.A.C. will be as follows :

-i- Harden 1000ºC and oil quench. Temper 700ºC and air cool. This heat treatment is carried after a rough machining operation.
L.P turbine wheel only.

-ii- Stress relieve at 670ºC after detailed machining and before final machining.
Turbine shaft - H.P wheel and L.P wheel.

(b) Copper plating :

An aera on the turbine shaft is selectively copper plated.

(c) Vapour blasting :

All the L.P wheels are vapour blasted on both front and rear faces using grade 90 abrasive prior to phosphatisation. This vapour blast treatment is not carried out on the H.P wheel and shaft.

(d) Phosphating :

Both the turbine shaft - H.P wheel and the L.P wheel are phosphate treat (ed) all over by immersion in a parker D A2 bath.

(e) Plastic coating :

At SNECMA the inside bore of the turbine shaft is painted with plastimule using a long handled brush. This operation is carried out prior to the sulphur coating of the bore. It is reported that the plastic coating improves the adhesion of the sulphur and thus more effectively retains the sulphur around the area to be machined. The arrangements at C.A.C. for sulphur coating are covered by letters P 14 & M 16.

(f) Painting :

Both front and rear faces of the H.P and L.P wheels are spray painted with Ignicer S I 52 (a silicone based paint with 18% aluminium) after assembly of the turbine blades into each wheel. A mask is used to protect the blades during the spraying operation. Two coats of Ignicer S I 52 are applied (no primer) on the phosphated surface and baked for 2 hours at 300ºC.

(Sand blast (g) :

Sand blast using Corindon "G" grit is carried out on both parts after harden and temper and also after stress relieving.

(4) TURBINE BLADES - HIGH PRESSURE AND LOW PRESSURE.

These are at present being supplied by either IMPHY or AUBERT & DUVAL. SNECMA will, however, shortly be supplying these forgings from their Gennevilliers plant. All forgings are supplied in the "as forged" and solution heat treated condition.

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- H.P turbine blade — 73 off per engine Material NKCD20ATu. (little Udimet 500)

- H.P turbine blade — 50 off per engine Material NCK20TAv. (Nimonic 93).

(a) Heat treatment :

The following heat treatment will be required on these blades during production at C.A.C.

- For H.P turbine blades : 3 ageing treatments of 8 hrs each at 850ºC ex open furnace and air cool,
  1 ageing treatment of 16 hrs 760ºC ex open furnace and air cool.
- For L.P turbine blades : 2 ageing treatments of 8 hrs each at 700ºC ex open furnace air cool.

(b) Turco 4008 treatment :

This three bath treatment, Turco 4008 at 132ºC for 60 to 20 mns plus potassium permanganate plus nitric acid, is carried out on the H.P blades after the final ageing treatment and prior to vapour blast and shot blast operations.

Total 73 blades per engine.

(c) Electrolytic etching :

This is carried out by etching anodically in a sulphuric acid bath, the finished,machined and hand polished aerofoil of both L.P and H.P blades to reveal material defects.

Total 123 blades per engine.

(d) Vapour blasting :

During the production of both H.P and L.P turbine blades, only one vapour blast operation is called up. This is a final finish on the aerofoil surface. Grade 325 grit is used.

Total 123 blades per engine.

(e) Shot peening :

The fir tree root of all H.P and L.P turbine blades are shot peened using grade 30 round shot.

Total 123 blades per engine.

N.B. There is no skin annealing or electropolishing carried out on any turbine blades.

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(5) CAST MAGNESIUM ALLOY CASINGS.

These parts are all cast at the Gennevilliers foundry ; the following being representative in regard to size and material.

Intake casing	Material	ZREI	Overall dimension 34" diam. x 12½" wide.
Centre casing	"	ZTI	Overall dimension 36" diam. x 16" wide.
Half compressor casing	"	ZTI	Overall dimension 37" long. x 33½ wide x 17" deep.
Accessory support casing	"	ZREI	Overall dimension 23" long. x 9" wide x 9" deep.
Air collector	"	ZTI	Overall dimension 22½" diam. x 6 1/4" wide.
Interior cover	"	GA 9	Overall dimension 3" diam. x 1" wide.

With the exception of the air collector and interior cover, all the other parts listed above are "Hard core" items and will be supplied to C.A.C. as semi-finished parts, however, in each case final machining, processing, and fitting will be carried out at C.A.C.

(a) Potassium dichromate treatment :

All magnesium alloy castings are given this treatment, some of which are treated several times during machine shop operations and before final assembly. C.A.C. will be carrying out this operation on all the hard core magnesium alloy castings being purchased as well as those being produced locally. This treatment consists of an electrolytic degrease (recommended but not obligatory) in a 5% caustic soda bath at 90ºC, pummice clean, chemical clean in a 5% ammonium bifluoride bath, and then potassium bichromate treat for 30 mins. immersion in a bath consisting of 40 gm/l. potassium bichromate plus 60 gm/l. of magnesium sulphate, at boiling point.

(b) Autoclave sealing :

This operation, where required, will be carried out in the Light Alloy Foundry section at C.A.C. Refer letter P 354 for details. It will either have been carried out, or it is not a requirement, on the listed hard core magnesium alloy castings in this report.
The equipment at present installed at C.A.C. should be adequate to cover the requirements for the non hard core items.

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(c) Heat treatment :

A heat treatment at C.A.C. of 300ºC for 1 hour and air cool before final machining operations will be required. This will also apply to the hard core items.

(d) Painting :

Painting will be required to be carried out at C.A.C. on all magnesium alloy castings, including all hard core items, as a final surface finish. This operation consists of a spray application of one coat of Bollicone primer, bake for 2 hours at 230ºC, spray application of one coat of finish Bollicone and bake for 5 hours at 300ºC.

(6) ACCESSORY DRIVE SHAFTS AND GEARS.

The following is a representative list of accessory drive shafts.

Part nº	Name	Material	Forging nº	Section group nº
501.254.001	Shaft	30 CD 12	Bar stock	5
501.252.034	Shaft coupling	"	501.252.034.9	5
501.320.059	Shaft driving	30 NCD 16	Bar stock	7
501.304.003	Shaft speed detector drive	35 NC 6	"	6
501.320.046	Shaft oil distributor drive	20 CD 4	"	7
501.322.013	Shaft int. gear	25 CD 4	"	7
501.320.065	Shaft worm wheel assy.	20 CD 4	"	7
501.354.002	Shaft	25 CD 4	"	33
501.303.020	Shaft tachodrive	XC 38 f	501.303.020.9	6
501.303.006	Shaft hyd. pump drive	10 NCD 12	501.303.006.9	6
501.320.027	Shaft driving	10 NC 12	Bar stock	7
501.324.014	Shaft stationary	10 NC 12	"	7

The materials used for the production of gears will either be a carburising grade or nitriding grade of steel, and will be one of the following compositions :

- for carburised gears : 10 NC 12, 16 NC 6, 10 NCD 12, 16 NCD 13.
- for nitrided gears : 30 CD 12, 30 CADG 12.

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(a) SNECMA shop practice for production of carburised shafts and gears :

SNECMA adopt the practice of carrying out the maximum amount of machining prior to carburising, and copper plate the areas where a carburised case is not required.
The basic shop operations are as follows :

Forge

H.T for machinability by 850ºC
oil quench and 500-550ºC temper
for hardness 248-285 BHN.

Machine etc...

Vapour blast using grade 90 abrasive.

Protective varnish areas where case is required.

Copper plate areas where case is not required.

Pack carburise at 900ºC for case depth. 1.0 to 2.0 mm, generally 1.0 - 1.2 mm.

Temper at 670ºC for machinability.

Machine

Harden 800-820ºC ex salt, into salt
at 180ºC for prescribed time on operation sheet

Temper 160ºC

Finish machine

Vapour blast using grade 90 abrasive.

Silver plate where required (this is used on splines etc.. where galling in service is likely to occur)

Phosphate coat where required in Parker DA 2 bath.

(b) SNECMA shop practice for production of nitrided shafts and gears.

The SNECMA shop practice for the production of these gears is briefly as follows :

Forge or cut bar stock.

Harden and temper.

Rough machine.

Stabilize.

Finish machine

Vapour blast using grade 90 abrasive.

Varnish where nitrided case is required.

Copper plate where nitrided case is not required.

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Gas nitride 495ºC, 20 to 30 hrs, 8 to 12% dissociation to give a case depth 0.10 to 0.15 mm (i.e. .004" to .006") and hardness 800 HV.

Vapour blast using grade 90 abrasive.

Silver plate where called for (this is used on all splines where galling in service is likely to occur).

Phosphate treat in a Parker D A 2 bath.

(7) NUTS, SCREWS, and BOLTS.

Nuts, screws and bolts scheduled for production at C.A.C. from bar stock will require either zinc, cadmium or silver plating. No attempt has here been made to carry out a detailed survey of the exact sizes and quantities involved. It will however be sufficient to say that no part size under this heading will be over 12" in length. The quantities in each case can be considerable, particularly where silver plating is required.

The following is tabulated data extracted from the Canal List of Parts and standard List of Parts.

Ex Canal List of Parts :

Part nº	Material	Made from	Nº off per engine	Canal group nº
557.606.012	Z10CNW17	Hex bar	20	1
561.497.055	"	"	30	2
502.705.125	"	"	36	3
557.605.010	"	"	18	1
557.305.015	28 CDV 5	"	14	1
557.405.012	"	"	28	2

N.B. all above parts are silver plated.

Ex standard Parts List :

Part nº	Material	Plating finish
7 part numbers	XC 38 f	Zinc plated
44 "	35 NC 6 25 CD 4 30 NC 11	Cadmium plated
29 "	28 CDV 5	Silver plated.

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Finish plating requirements at C.A.C. on nuts, screws and bolts.

- i - Zinc plating :

On plain carbon and low alloy steels:-Electrolytic degrease.
-Electrolytic sulphuric acid etch.
-Zinc plate in cyanide bath.

-ii - Cadmium plating :

On plain carbon and low alloy steels :Electrolytic degrease.
-Electrolytic sulphuric acid etch.
-Cadmium plate in alkaline bath of cadmium cyanide + sodium cyanide.

-iii- Silver plating :

On plain carbon and low alloy steels:-Electrolytic degrease.
-Electrolytic sulphuric acid etch.
-Nickel strike-thickness 4 microns $\pm$ 1
in a bath Ni SO4 - 250g/l
Na cl - 20g/l
H3BO3 - 30g/l
Temper 45 to 50ºC, current density 1-2 A/dm2 in a still bath or 2-5 A/dm2 in an agitated bath.
-Depassivate by anodic and cathodic immersion in KCN + K2CO3 bath.
-Silver strike in a bath rich in CN^- and poor in Ag^+ having a base
Silver cyanide
Potassium cyanide
Potassium carbonate.
-Silver plate in alkaline bath having a base
Silver cyanide
Potassium cyanide
Potassium carbonate.

- iv- Silver plating :

On stainless type steels : - Electrolytic degrease.
- Electrolytic sulphuric acid etch.
- Nickel strike in a bath having a base
Nickel chloride
Dydrochloric acid
Temp 20ºC $\pm$ 5ºC

- Depassivate by anodic and cathodic immersion in KCN + K2CO3 bath.
- Silver strike in bath rich in CN^- and poor in Ag^+
  Silver cyanide
  Potassium cyanide
  Potassium carbonate.
- Silver plate in alkaline bath having a base
  Silver cyanide
  Potassium cyanide
  Potassium carbonate.

(8) ASSEMBLED COMPRESSOR SHAFT AND COMPRESSOR BLADE UNIT.

The blade tips and shaft journals of this unit are machined after assembly. In the event of the journal finishing up undersize, it is salvaged by a chrome plating operation which has to be carried out on the assembled unit. This has happened on a few occasions at SNECMA although not during the last three months.

- Overall dimensions of the compressor shaft and blades as assembled = 48" long x 32" diam.
- Wt. of compressor shaft and blades as assembled = 130 kg.

The chrome plating operation is carried out as follows. Only stage 1 and 2 blades can be easily removed however it is also possible to remove stage 3 if required.

- Mask off with wax.
- Completely seal off all holes into the compressor shaft.
- Chrome plate.
  bath CrO_3 - 250 g/l
  H_2SO_4- 2.5 g/l.
  temper 50-55ºC.
  current density 35 amp/dm2.
- Strip wax masking.
- Degrease in thrichlorethylene vapour spraying with thrichlorethylene liquid both inside as well as outside.

This report represents information obtained to date. Additional sections will be added should it be necessary, however in regard to essential detail and the main items for processing, it is considered complete.

A further report covering a résumé of the processes required for ATAR 9C engine is being prepared and will be forwarded when complete.

Yours faithfully,

G.H. FOSTER

HAK/SG 26th, January 1962

MATERIALS FORGINGS ATAR 9C

Material designation	Composition					
	C	Ni	Cr	Mo	Ti	V
Z 12 C 13	.10	.	12			
	.15	.	14			
16 NC 6	.12	1.2	0.9			
	.18	1.6	1.25			
35 NC 6	.30	1.2	0.75			
	.38	1.6	1.10			
20 CD 4	.18	.	0.80	0.15		
	.25	.	1.20	0.30		
10 NCD 12	0.08	2.8	0.60	0.20		
	0.13	3.2	0.90	0.50		
30 CD 12	0.27	.	2.50	0.30		
	0.35	.	3.50	0.50		
10 NC 12	0.08	2.80	0.60	.		
	0.13	3.20	0.90	.		
Z 10 CNT 18		9	17	.	0.3	
	0.12	13	20	.	0.7	
28 CDV 5	0.25	.	0.9	0.50	.	0.20
	0.30	.	1.6	0.80	.	0.35

LOW ALLOY STEELS ATAR 9C FORGINGS.

Material designation	Composition					Remarks
	C	Ni	Cr	Mo	V	
20 CD 4	0.18	.	0.80	0.15	.	
	0.25	.	1.20	0.30	.	
30 CD 12	0.27	.	2.50	0.30	.	
	0.35	.	3.50	0.50	.	
30 CDN 16	.26-.33	3.3-4.3	1.2-1.5	.3-.6	.	
35 NC6	0.30	1.2	0.75	.	.	
	0.38	1.6	1.10	.	.	
28 CDV 5	0.25	.	0.90	0.50	0.20	
	0.30	.	1.60	0.80	0.35	

Plain carbon sheels. Material designation : A 37 c Composition : C = 0.10 %
XC 38 f C = 0.38 %
XC 18 f C = 0.18 %

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CARBURIZING GRADE STEELS ATAR 9C FORGINGS.

Material designation	Composition			
	C	Ni	Cr	Mo
16 NC 6	.12	1.2	0.9	.
	.18	1.6	1.25	.
10 NC 12	0.08	2.80	0.60	.
	0.13	3.20	0.90	.
10 NCD 12	0.08	2.80	0.60	0.20
	0.13	3.20	0.90	0.50
16NCD 13	0.12	3.0	0.85	0.15
	0.17	3.5	1.15	0.3

HIGH ALLOY STEELS ATAR 9C FORGINGS.

Material designation	Composition						Remarks
	C	Ni	Cr	Mo	Ti	V	
Z 12 C 13	.10	.	12				
	.15	.	14				
Z 10 CN T 18	.	9	17	.	0.3		
	0.12	13	20	.	0.7		
Z 10 CN W 17	.10	13	17	.	0.6	.	W = 3

NITRIDING GRADE STEELS ATAR 9C ENGINE.

Material designation	C	Mn	Si	Cr	M	V	Al
30 CD 12	0.27	0.4	0.4	2.5	0.3	.	.
	0.35	0.8		3.5	0.5		
30 CAD 6-12	0.27	0.4	0.4	1.5	0.2	.	0.8
	0.35	0.8		1.75	0.45	.	1.3

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