(1)

FIRE PROTECTION PROPOSAL

ENGINE COMPARTMENT

VERTOL MODEL 42

VERTOL AIRCRAFT CORPORATION

MORTON, PENNSYLVANIA

PREPARED BY: P. Lynahan		REPORT NO.: 42-P-02	NO. OF PAGES:
CHECKED BY:		MODEL: VERTOL 42	
APPROVED BY: J. Diamond		CONTRACT NO.:	ITEM NO:
APPROVED BY: W. Fleming		DATE: January 22, 1957	

REVISIONS

REV.	DATE	PAGES AFFECTED	REMARKS
A	2-27-57	i,1,2,4,5,6,7,8,(Removed App. I & App. II.) New App. I was App. III	

Form No. 0576 (1-56)

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REFERENCES

(a) Aircraft Fire Protection Handbook (NAVAER 00-105E-501) as Revised 1 September 1955

(b) VERTOL Report TMR-293, Fire Test of Materials Components Required for CAA Certification - VERTOL Model 42

(c) VERTOL Report MIR-61910 - Albi 99 Fire Retardant Paint - Evaluation

(d) Design Manual on Aircraft Fire Protection for Reciprocating and Gas Turbine Engine Installation - AIA Publication - Revised 15 April 1954

(e) MIL-E-5352A - Extinguishing System, Fire, Aircraft, Installation of

(f) 42-P-01 - Substantiation of Power Plant Installation VERTOL Model 42 Helicopter

(g) MIR-61869 - Fire Proof Characteristics of Self Sealing Oil Tanks - CAA-VERTOL Model H-42

(h) MIR 571-7 - Fire Testing of Firewall Curtain Material and Fasteners

(i) Technical Development Report #260 - Preliminary Report on High Rate Discharge Fire Extinguishing Systems for Aircraft Power Plants.

(j) VERTOL Report 42-S-60 - Structural Substantiation for Engine Compartment Fire VERTOL 42 Helicopter

(k) 42-T-111 - Fire Extinguisher System Test

(l) VERTOL Report TMR-327 - Fire Test of Model 42 Transmission Oil Cooler for CAA Certification

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REFERENCES (Cont'd)

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VERTOL Drawings

83P0001	Installation Fire Protection Provisions, Engine Compartment
83P8002	Installation Fire Proof Curtain, Sta. 562
83P8003	Installation Fire Proof Curtain, Sta. 464½
83P8004	Installation Fire Proof Panels - Upper Deck Engine Compartment Fwd.
83P8005	Fire Protection - Fwd Keel Fitting - Sta. 521
83P8006	Fire Protection Provisions, Oil Tank
83P8007	Fume Proof Cover - Fuel Line
83P8008	Fire Protection - Aft Keel Fitting - Sta. 521
83P8010	Installation Fire Proof Panels Upper Deck Engine Compartment Aft
83E8001	Installation Fire Extinguisher System

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1. INTRODUCTION

The current military helicopter, VERTOL Model H-21, is being certified to CAA requirements as the VERTOL Model 42. In order to meet the fire protection requirements of the CAR Part 6, and Amendment 6.4, certain changes to the military configuration are considered necessary.

This report presents those proposed changes, the premise under which the changes were established, and a summary of the substantiating tests results.

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2. PREMISE

2.1 Possible Sources of Fire

2.1,1 The possible sources of fire in the engine compartment are considered to be:

(a) Transmission Oil Cooler Core Failure

(b) Engine Oil Cooler Core Failure

(c) Engine Intake Pipe Leak

(d) Fuel Line Fitting Loose or Broken

(e) Engine Oil Line Fittings Loose or Broken

(f) Carburetor Leak - Crack in Body - Gasket Failure

(g) Breather Fitting Loose or Broken

(h) Engine Exhaust Collector Leak

(i) Fuel Line Fitting Loose or Broken Forward of Engine Fan Fire Curtain (This source will be eliminated by proposed change 4.1.1c)

(j) Structural Failure of Engine

2.2 Temperature and Flame Pattern

2.2.1 Several of the above sources of fire will be localized. In the event, however, of a fuel or oil system failure, a major fire in the engine compartment could occur and is considered as the worst possible condition and blankets all others. It is further conservatively assumed that:

(a) The fire extinguisher is inoperative.

(b) The elapsed time between the start of the fire and engine stoppage and also stoppage of flow of flammable fluids is one full minute.

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2. PREMISE (Cont'd)

2.2.2 During the first minute of fire, the engine fan is operating and discharging approximately 26 pounds of air per second. During this one minute, ample oxygen is available for fuel or oil combustion with the hottest portion of the flame directed toward the air exit opening. It is expected that a peak temperature of 2000°F can be reached in this area in approximately 15 seconds and continue at that temperature until the engine fan is shut down.

2.2.3 After fan shut down, the amount and flow of combustion air is considerably reduced. Autorotation flights with engine off have shown that the flow of air thru the engine compartment actually reverses direction. Under these conditions, the flow of air thru the fan and stator openings was measured as only 4 miles per hour, peak velocity. With the rapid reduction of quantity and flow of air in the compartment, it is expected that the maximum flame temperature will decrease and approach the free burning temperature of gasoline or oil. Thru actual tests, reference (c), it was found that in a slow to moderate wind the freeburning temperature of a 100 octane gasoline fire was 1575°F. For a 50% mix of gasoline and engine oil, the free burning temperature was 1450°F. Because of possible spurts, this temperature is conservatively assumed to be 1700°F. It is assumed that this temperature exists in the major portion of the engine compartment forward of the air exits.

2.2.4 The estimated temperature patterns for the engine on and engine off conditions are shown on Figure 2.2 and Figure 2.2a. The actual air flow pattern thru the engine compartment in autorotation, engine off condition will be determined from current flight tests.

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3.1 Summary of Test Results

3.1.1 Detail fire tests at 2000°F of several of the questionable components existing or porposed in the engine compartment have been completed, reference (b). A summary of these tests on the acceptable configurations is shown in Table 3.1, together with a summary of other testing intended to verify the assumptions of this proposal.

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4.1 Power Plant Section Changes Related to CAR-6 and Amendment 6-4. (Refer to Fig. 4.1 - SK-4922 Rev. B)

4.1.1 CAR 6.384 - Fire Protection of Structure, Controls, and Other Parts.

The power plant fire zone will be confined between the engine fan curtain, the frame at Station 562, and the upper deck. This section will be protected from the foreseeable power plant fire conditions for at least 5 minutes by the following additions or changes:

(a) The present engine fan curtain will be replaced with a wire reinforced, neoprene coated asbestos cloth.

(b) The attaching angle for the fan curtain will be replaced by a similar angle of stainless steel. The attaching hardware, which has been proven fire proof (Table 3.1), will remain the same.

(c) The fuel line between the engine fan curtain and the fire wall at Station 407.83 will be enclosed. The enclosure will be vented to the outside.

(d) A fire curtain of the same material as the revised engine fan curtain will be added at Station 562.

(e) A local barrier will be added at the intersection of the keel and the engine fan curtain to prevent any possible liquid flow forward of the curtain.

(f) A stainless steel fire guard will be installed over the keel fitting at Station 521.3.

(g) The internal fuselage structure between the engine fan curtain and Station 562 will be coated with 18 mils of Albi 99 fire resistant paint. The exception in this area is the removable keel which is presently protected by a stainless steel shield. The structural justification of this section of the fuselage under fire conditions is presented in reference (j).

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4.1.1 (Cont'd)

A (h) The Upper Deck, Part No. 42S7044, will be protected by means of a stainless steel fire wall .009 inches thick located 1½ inches below the upper deck skin. The gap between the deck web and the stainless steel will be filled with 4 layers of glass wool insulation. This deck configuration has been fire tested, reference (c), under 2000°F with no air flow on the cold side.

(i) The drive shaft and upper controls will be protected from the fire zone by means of the insulated deck. In addition, a fire guard will be added below the drive shaft in the area of the transmission oil cooler and the carburetor air intake.

A (j) The transmission oil cooler has been successfully fire tested under the assumed temperature conditions with a representative quantity of system oil flowing thru the cooler, Table 3.1.

4.1.2 CAR 6.481 Ventilation

The power plant section is adequately ventilated thru the cooling air exits between Stations 521.3 and 562. Drain holes are provided in the keel section.

4.1.3 CAR 6.482 Shut Off Means

An electrically operated fuel shut off valve is located out of the engine compartment and forward of the fire wall, Station 407.83.

An electrically operated oil shut off valve is located on the oil tank assembly which is in the fire zone. The operation of the valve under fire conditions has been successfully demonstrated. This valve must be coated with Albi 99 paint (Table 1), the present wiring replaced with fire resistant wire, and the present cannon plugs replaced with fire resistant plugs.

4.1.4 CAR 6.483 Fire Wall

A stainless steel fire wall, .012 thick, is located at Station 407.83. In addition, the present engine fan curtain will be replaced with a fire proof curtain.

Protection of structure, controls, etc. in the power plant section is discussed under requirement 6.384 above.

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4.1.5 CAR 6.485 Lines and Fittings

Justification of lines and fittings is presented in VERTOL Report 42-P-01, reference (e).

4.1.6 CAR 6.486 Flammable Fluids

The fuel cell is located out of the engine compartment and forward of the stainless steel fire wall at Station 407.83.

A The oil cell is located in the engine compartment in the fire zone. The cell has been demonstrated as fire proof thru fire tests on the complete assembly and thru detail fire testing of the cell material. A neoprene coating is added to the cell exterior to suppress burning of the 2 outer layers of tire chord. The fire tests were conducted on the later model nylon tire chord cell. Fire proof justification is considered applicable to the rayon tire chord type also since the fiberglas build up in each is identical. A comparison of the material is shown A on Appendix I.

4.1.7 CAR 6.487 Fire Detector System

Three circuits make up the present fire detection system, reference Drawing 22E8002. The detector circuit is a permanently closed circuit consisting of 18 cage-type thermocouples, Edison Model 108-11, located throughout the engine compartment. The relay panel mounted on the forward side of the firewall, Station 407, consists of a sensitive relay, slave relay and thermal test unit. The test switch and the warning light are located in the cockpit.

The proposed system will be identical except that the transmission oil cooler detector unit will be relocated downstream of the cooler in the cooling air duct. One additional detector will be located inside the carburetor intake duct.

4.1.8 CAR 6.488 Fire Extinguisher System

A fire extinguisher system will be installed for the engine compartment. The quantity of agent used will be based on the volume of the compartment and the estimated flow of air thru the compartment in accordance with reference (d) and (f). Current fire control procedure in other aircraft, reference (a), is to shut down the engine before releasing the extinguisher. The estimated flow of air, therefore, is based on the engine off condition. The proposed system is a high rate discharge type wherein the agent is released in from .5 to .9 seconds. To be conservative, the quantity of agent is doubled over that required by present formulae.

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