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TESTS ON WHOLE A129 ENGINE BAY SIMULATING THE INERTIA AND AERODYNAMIC LOADS

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ABSTRACT

These experimental tests are conducted to verify the safety of engine bay of the A129 helicopter in the event of fire.

The importance of loads application during the tests are fundamental, beacuase they allow the integrity of engine bay and underlying frame to be checked under actual flight conditions during fire hazard.

The inertia loads simulation is carried out with hydraulic cylinders; while the aerodynamic loads are simulated with fans.

The engine inlet and outlet are simulated with air flow.

The tests are conducted with diffuse flame to verify the engine bay capability to contain the flame and with concentrate flame to verify the strength of installation parts under load.

These results permit us to warranty the safety of engine installation under all fire conditions and to optimize traditional and new materials.

INTRODUCTION

The A129 (Fig.1) is a light anti-tank helicopter, with two GEM 2 MK 1004 engines installed.

The purpose of our tests is to study the effective of fire on engine installation and to ensure the maximum safety of the helicopter in flight.

In order to overtake this objective we have stated the following criteria: laboratory tests will be realized in order to reproduce the most realistic in flight conditions.

They give us the following advantages:

a) Limited costs
b) Using sufficient equipment it is possible to reproduce any flight condition very closely.
c) Worthless risk factors or very limited
d) Extreme possibility tocontrol in an accurate and reproducible way either the ambient or the stress condition reaching and exceeding any limit condition without increasing testing risk factor.

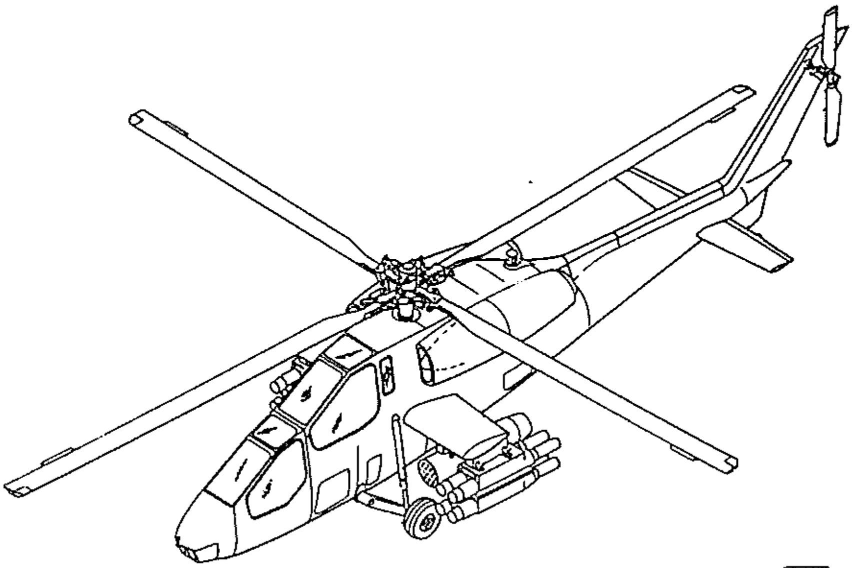

FIG. 1

ENGINE INSTALLATION

We would consider only the type of experiment deemed necessary to demonstrate the fire resistence of an engine bay. usually the civil and military (MIL-HDBK-221,AMCP) requirements divide the material to be used in engine compartment in classes.

The most important are: fire proof and fire resistant materials.

Such requirements give only general indication,without making distinctions between a helicopter installation and an airplane installation.

It become therefore extremely important to determine the installation type and the work in order to take into account the real construction conditions during design and experiment for the A129 helicopter (fig.2), The following criteria have been considered,in particular the isolation of the engine bay with other systems of the helicopter.

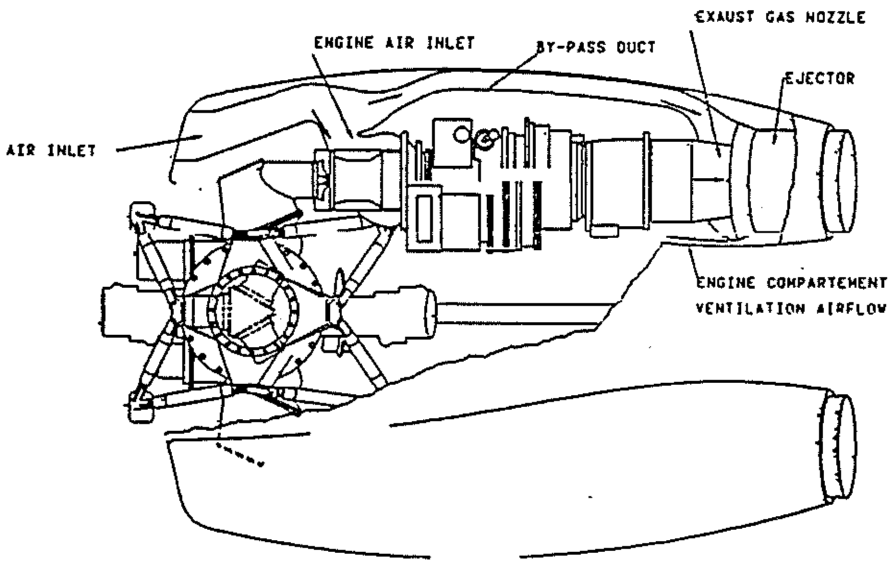

Fig.2

FIRE HAZARD

It should be noted that for a A129 helicopter, the probability of firing to the engine bay is related to a ballistic damage and accidental causes.

In fact, carrying out an analysis, it can be stated that the main causes are related to the fuel system or the engine oil system or both.

Fuel System

The system is of the sucking type, then, a failure to the depressurized lines can not result in a serious risk of firing.(see fig.3)

This risk, on the contrary, is present for the pressurized area of the system.

In this case, only the failure which can result in a leakage of fuel whitout engine shut-down is considered.

This can be connected to a partial rupture of a tubing allowing a leakage of fuel to the maximum flow rate of 1200 ppH.

Should this occur in the high pressure circuit, a kero sene nebulization with development of high local temperature would take place.

On the contrary, a leakage in the low pressure circuit would result in a diffuse flame.

The concentrate flame is considered as applicable to a limited number of areas, such as engine mount, engine fittings and bulkheads. (fig. 3)

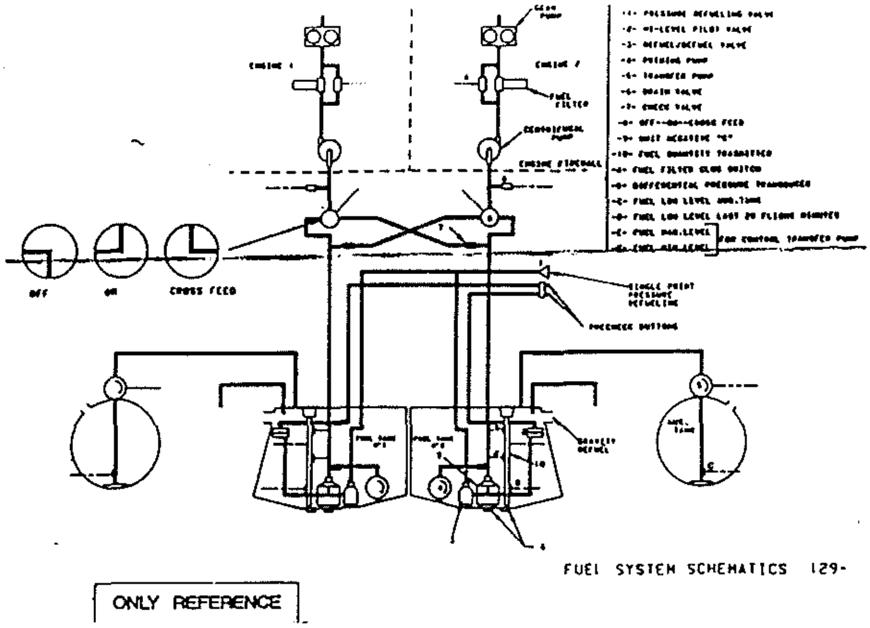

Fig.3

Lubricating Oil System

The risks related to the failure of parts of this sy stem are fully similar to the fuel system, but less criti tical for two aspects:

a) combustion temperature higher than the fuel (~550°C)

b) very limited amount of oil (7 l.), corresponding to flame of 2÷3 minutes.

Loads Application

The following assumptions of loading are formulated:

a) aerodynamic loads

b) engine loads (weight, torque)

c) inertial and gyroscopic loads and factor "g"

These are applied to provide the real flight conditions.

- TEST METHOD

After defining the requirements and selecting the appropriate materials, experimenting their application, a method for testing all the bay is now established.

Tests can be divided in two different conditions: concentrate flame tests and diffuse flame tests.

Concentrate flame tests are considered as development of fire in a limited area of the installation, with a tempe rature of about 2000°F (1100°C).

This type of flame is simulated via a Lennox burner, capable of meeting the required conditions.

The diffuse flame is obtained by simulation of rupture or disconnection, to pour in the bay a specific amount of fuel, enriched with fresh air.

The set of proposed tests are to analyse and check all the possible fire conditions.

A full engine installation has been manufactured and the area of fuselage which this configuration lies on, repre sents exactly, for both the shape and the material, that of the A129 helicopter (Fig.4).

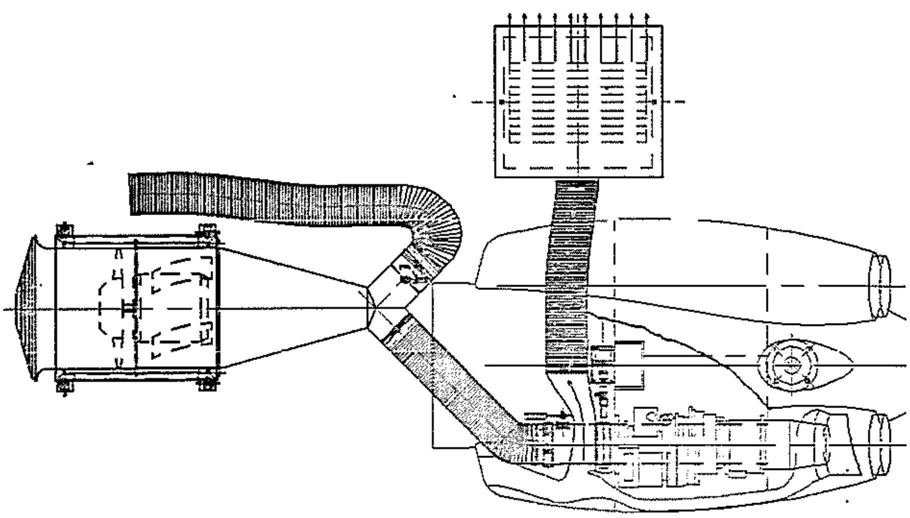

Fig.4

A steel mock-up has been used in place of the engine.

Exhaust, by- pass intake flows and aerodynamic loads have been simulated through fans.

A series of preliminary tests have been conducted to assess the aerodynamic effect due to flow and engine transients, such as acceleration, deceleration, ignition, shut-down, and the tail wind effect., in order to study the worst bay loading and ventilation conditions.

In addition, among the different flight and/or inertial loads, the most critical and significant ones have been analysed.

Finally the cause and the way in which a fire may develop have been considered.

This analysis consists in assembling the possible amounts of fuel/oil involved and the way of filling the bay versus attitudes and drain capability.

The possibility of leakages due to ballistic damages and failure, in conjunction with the possibility of having fuel jets at low and high pressure, has been studied, and also the possibility of fire to the different areas.

Starting from that, the first set of concentrate flame tests with Lennox burner, as per fig.5, 6 through fans and hydraulic cylinders, can be set.

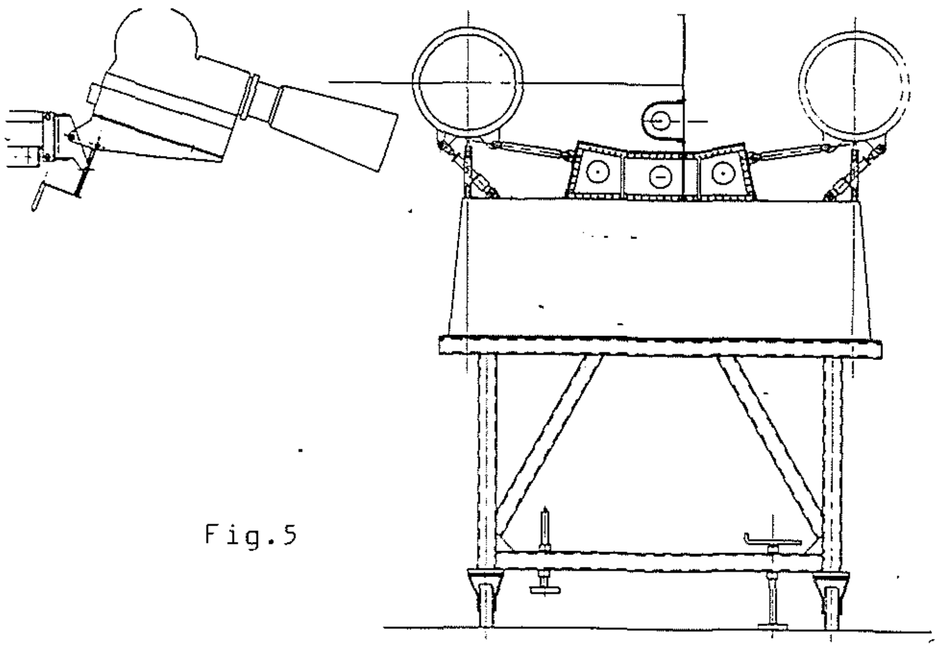

Fig.5

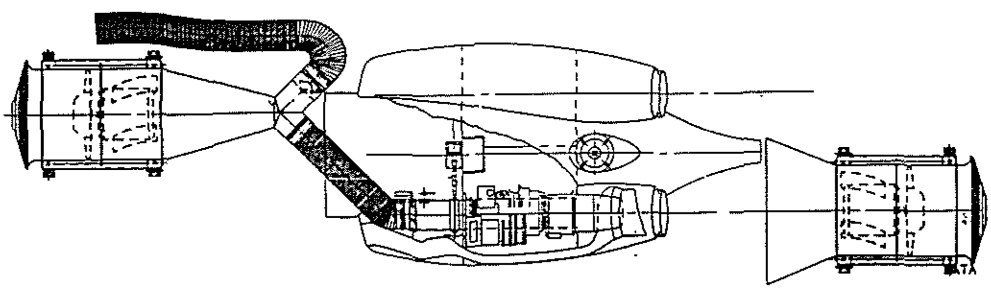

Fig.6

The aerodynamic and engine loads will be simulated, applying then the concentrate flame to the various critical parts (engine mount, supports bulkheads, joints, floor bulkheads, hinges) no part shall collapse or, if so it shall not damage the helicopter.

This test is conducting for 15 minutes, with the simulation of the rupture of a pressurized tube, which remains active during that period, in the event of a failure to the fire warning system.

This assumption is precautionary and remote enough to occur but it ensures, if met, the full safety of these parts.

The diffuse flame tests have required a deeper preliminary study.

First, the flow of the temperature with or without ventilation, in mock-ups with equivalent volume, has been experimented in other tests.(Fig.7).

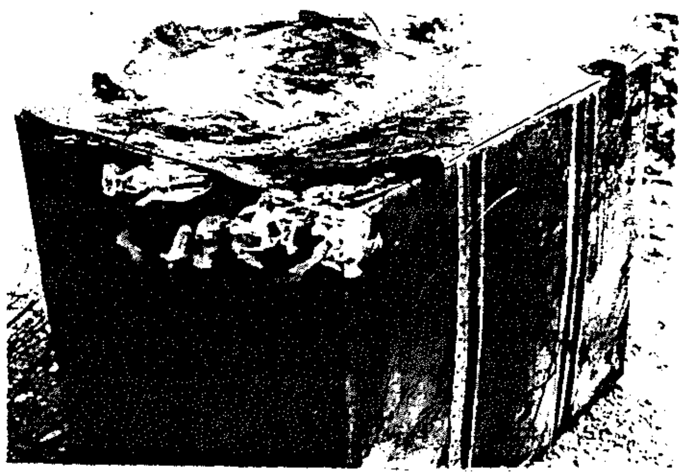

Fig.7

Then other tests have been carried out to search mate rials and their manufacture to contain the flame.(see figg.8, 9).

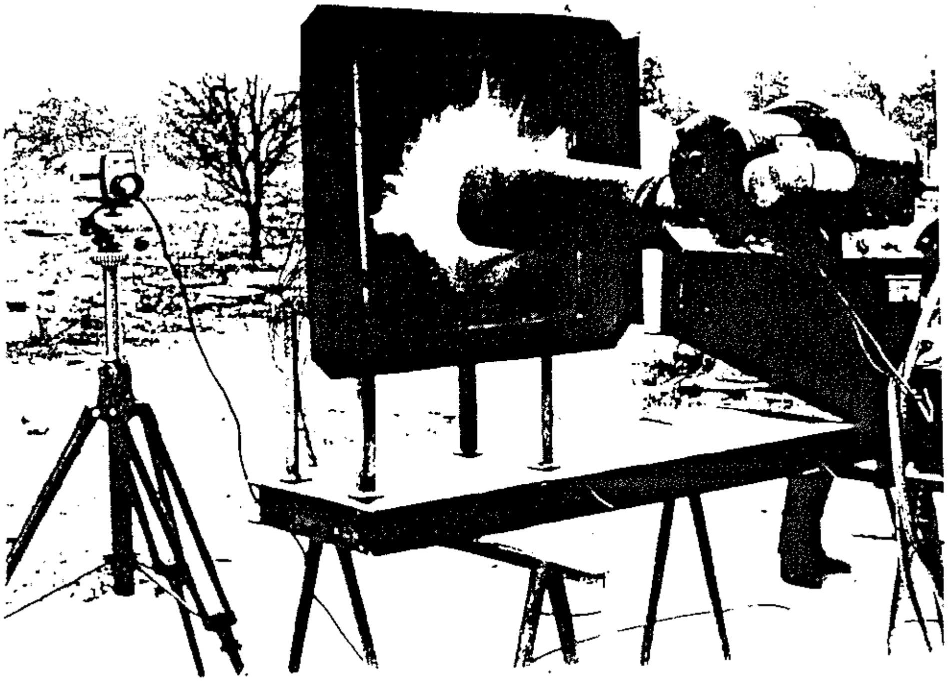

Fig.8

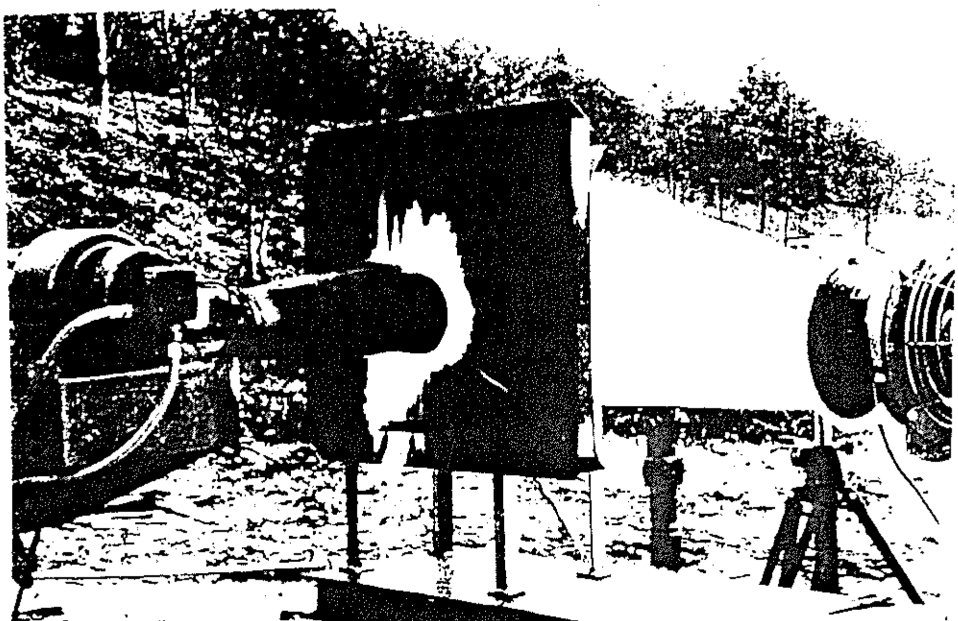

Fig.9

Once the configuration has been defined, a method for the final test has been established, so that it represents the most significant and critical condition in all flight conditions.

This simulation developed on the previously described mock-up will be conducted as follows:the bay will be filled with the maximum amount of fuel the system is capable of providing, with helicopter attitude where the possibility of draining is minimum.

The flight loads will be applied via the cylinder,the respective flows via the fans.(fig.10).

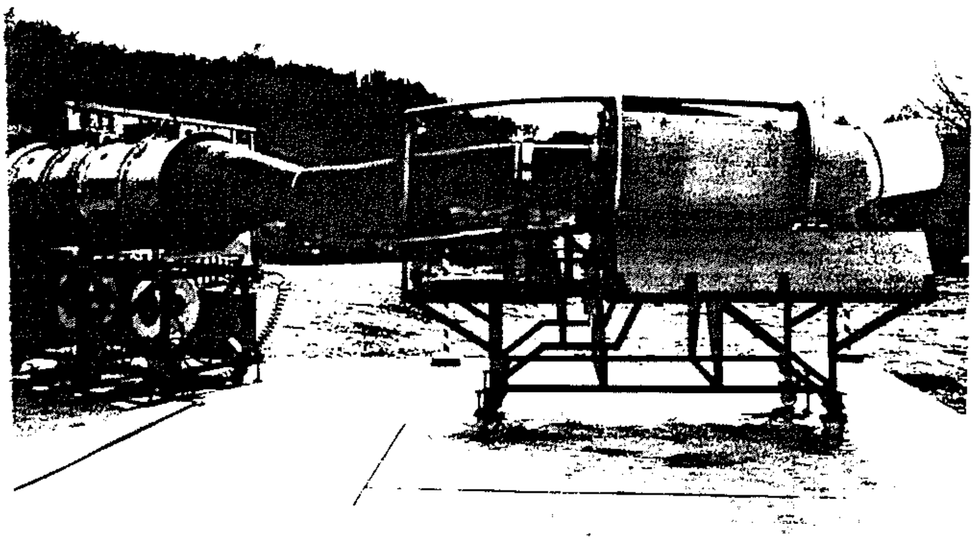

Fig.10

The maximum amount of fuel will be poured and, then, under these conditions, the fire will be developed.

The test will be conducted for 15 minutes, reducing the air flows and the engine loads to the inertial.

The global integrity of the bay and the close areas (floor bulkeads, intake, by-pass and ejector) will be so checked.

CONCLUSION

All the preliminary tests have been done, only the final complete test has not been carried out yet; but these preliminary tests permitted us to freeze the configuration and give all the information about installation.

The final test will be done to verify the compliance of the choices, and within short time.

In this paper we do not want to highlight the testing resolution for an individual installation, but a methodology considered as suitable to prove the capability of safety and survival of the engine installation under all firing conditions.

These tests allow the critical areas of an installation to be found, intervening and stiffening just these areas.

This exceeds the rules which, being too precautionary, tend to generalize in some areas and to be not well defined as regards the ballistic damage.

Reference

A.ABBA' - A129 Helicopter Laboratory and Testing Methods for: Flight Control System, Fuel System, Engine Compartments, Paper presented at Ninth European Rotorcraft Forun, Stresa, Italy, 1983.