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HELICOPTER BIRD STRIKE RESISTANCE

by

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Abstract

The hazard created by bird encounters for helicopter occupants does not account for a large percentage of serious accidents. For example no fatal accident due to a bird strike has been recorded, to date, on the Aerospatiale fleet.

However, some cases of cockpit penetration and of engine ingestion have indeed occured. Furthermore the rotors, the sensible and vital part of the helicopter, must be proofed against bird strike effects.

The particularities of helicopter operation, as compared to its fixed-wing brothers, are essentially :

- usage of unprepared areas for take-off and landings
- necessity to provide for large transparent areas for pilot visibility
- low speed - low altitude operations
- no pressurization

The helicopter windscreens are tested to show compliance with the relevant BCAR regulations, and in some cases it has been necessary to improve the initial design.

The air intakes must be consistent with engine regulations regarding bird ingestion or protection. Tests are carried out to develop suitable protection and show compliance with engine regulations.

Rotor blades are not subjected to any regulation, but Aerospatiale has assessed, through similar testing and strain measurements, that bird strikes have only minor effects on blade integrity.

A movie is presended to illustrate typical tests conducted on these three sensitive areas of the helicopter.

I - GENERAL

Helicopter, like fixed wing aircraft sometimes meet birds in flight and therefore are at risk to sustain some damage, possibly endangering flight safety. So, like airplanes this type of encounter is taken into account when designing exposed areas of helicopters.

1.1 - In-Service experience

First if we look at the accident history of Aerospatiale helicopter fleet, bird impacts are not an important cause of accidents, and in particular no fatality has been recorded to date for this reason (cables, for example, are by far a much greater jeopardy for helicopters). The reasons may be attributed to specific features of helicopters and their type of operations.

1.2 - Helicopter operation particularities

As compared to fixed wing operations, those of helicopters feature positive and negatives aspects :

- operations from and to unprepared areas where specific action against bird presence cannot be contemplated

- large transparent surfaces needed for crew visibility in specific aerial work missions very close to ground

- but low speeds generally used at low altitudes, and for current models no pressurization of the cockpit and cabin.

It is possible that some degree of protection owing to the main rotor in forward flight, and specific devices avoiding engine ingestions may help minimize birds hazards.

1.3 - Regulations

But the risk must not be ignored, and to start dealing with it some regulatory requirements must be met to obtain type certification.

- For airframe, only UK regulations (BCAR G-4-1-10) require specific resistance of rotorcraft to bird impacts.

- For engines, US (FAR 33-77) UK (BCAR C-4-6 parag.19) and European (JAR E) regulations consistently require a specific engine response. Compliance with these requirements could be obtained by engine design by itself but the present practice is to provide protection through engine intakes design.

Although no regulation at all applies to rotor resistance to bird impacts, Aerospatiale has carried out some tests to make sure that no problems could arise with this essentially vital part of the helicopter.

1.4 - Helicopter exposed areas

So we shall deal successively with these three groups of exposed areas of the helicopter: wind screens, engine intakes, rotor blades.

1.5 - Test installations

Full scale testing being generally necessary to assess structural resistance to object impacts, Aerospatiale makes use of specific installations named "bird guns" which have been built at two different Government Tests Laboratories in France :

- Saclay (near Paris) Powerplant Test Centre (CEPr) for engines intakes

- Toulouse Aeronautical Test Centre (CEAT) for windscreens and rotor blades.

Both installations allow full strain instrumentation recording and high speed movie cameras.

2 - WINDSCREENS BIRD IMPACT RESISTANCE

2.1 - Windscreen bird strike tests

Bird strike tests are carried out to show compliance with BCAR G-4-1-10. The impact must be demonstrated at maximum forward speed. The bird size to be tested is dependent upon the helicopter maximum gross weight (up to 4 lbs for large helicopters). The specification retained by Aerospatiale is that the bird must not penetrate the cockpit. Permanent deformations are acceptable if they do not affect airframe structural integrity.

2.2 - Windscreen impact research

Beyond strict compliance with existing regulations, research and development actions are in progress to optimize, as regard to cost and weight, material and attachments of windscreens, and to develop analytical methods to predict impact behaviour. Most promising are multi-layer panels with energy absorption capabilities, but research is only at an early stage and no conclusive results have been obtained so far.

3 - ENGINES BIRD INGESTION

3.1 - Engine regulations

The above mentioned regulations stipulate that in case of engine bird ingestion:

- no hazardous conditions are created by a 4 lb-bird impact at max speed. (in fact, no risk of engine uncontained breakdown)

- the power loss, after small and medium birds ingestions at V climb, is limited to 25%.

3.2 - General remarks

The philosophy at Aerospatiale is to prevent bird ingestion, protection of the engines being necessary for several other reasons like F.O.D., compressor erosion (sand or dust), snow-water-ice ingestion.

3.3 - Air intake protective design

So, the design of air intakes must take these effects into account and appropriate arrangements are used to this effect :

- static air intakes (SA 365C, AS 350)

- front or lateral dynamic air intakes (AS 332, SA 365N, AS 355) with protective grids

- optional protective devices : "snow-shields", sand filters, multi-purpose air intakes.

3.4 - Air intakes design objectives

For dynamic air- intakes, most often utilized because of better performance, the design objectives are to retain small and medium birds with the grid and if possible to retain also large birds. If not, it is necessay to demonstrate large bird ingestion into running engine.

3.5 - Bird strike tests

Bird strike tests are carried out on actual complete structure(grid, stiffness, attachments, stubframe, forward air duct) each component participating, through its deflection, to bird retention. The bird retention up to 4 lbs, is in fact obtained by controlled deformation of all the components.

4 - ROTOR BLADES BIRD IMPACTS

4.1 - General remarks

Bird impact tests on rotor blade sections have been carried out, in the absence of specific regulation, but presented to Certification Authorities during the type certification process.

The objectives were to evaluate direct impact damage on blade section, to analyze possible detrimental effect on rotor transmission systems, and to validate theoretical analysis capable of transferring the results to other types of blades and aircraft.

4.2 - Test program

The test program objectives were to checkbird impact effect on three typical blade stations. These stations differ because of angle of attack, centrifugal tension and resultant speed variation with blade radius.
The test conditions are intended to simulate VNE plus local velocity due to rotor rotation, actual angle of attack and centrifugal tension, and to test a 4 lb-bird impact.
The validation of mathematical analysis model, to be used for determining the effects on transmission and for application to other designs, necessitates to carefully identify the blade section vibratory modes, and to record a time-history of stress levels.
This is done by means of a comprehensive strain gauge equipment and measurement circuits.

4.3 - Bird strike test results

The bird strike tests as described above, have given very satisfactory results on AS 332 blade sections. Local damage is limited to minor dents showing neither separation nor degradation requiring blade shop repair.
The effect on transmission system is not significant as compared to normal service loads.
The mathematical analysis model has been validated and is now available for other types.

5 - CONCLUSIONS

Bird strike hazard, although accounting for a small percentage of all accidents, exists for helicopters, as it does for airplanes.
It is consequently necessary to minimize such hazards and windscreens, air intakes and rotor blades will have to be specifically designed and tested to withstand bird impacts.
Some changes to the initial design may have been necessary to comply with existing regulations, but the final certified definition amply meets, and exceeds in some cases, the applicable requirements.

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HELICOPTER BIRD STRIKE RESISTANCE

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HELICOPTER BIRD STRIKE RESISTANCE

1. GENERAL

1.1. IN SERVICE EXPERIENCE

FOR AEROSPATIALE HELICOPTER FLEET, TOTALLING TO DATE 18000000 FLIGHT HOURS,

- NO FATAL ACCIDENT
- 4 NON FATAL OCCURRENCES (INCLUDING ONE ACCIDENT FOLLOWING AN AVOIDING MANOEUVER)

HELICOPTER BIRD STRIKE RESISTANCE

1. GENERAL

1.2. HELICOPTER OPERATION PARTICULARITIES

- UNPREPARED AREAS FOR TAKE-OFF & LANDING
- LARGE TRANSPARENT SURFACES NECESSARY FOR CREW VISIBILITY
- LOW SPEED, LOW ALTITUDE FLIGHTS
- NO PRESSURIZATION

HELICOPTER BIRD STRIKE RESISTANCE

1. GENERAL

1.3. REGULATIONS

– AIRFRAME	: BCAR G 4.1.10 NO FAR REQUIREMENT
– ENGINES	: FAR 33.77 BCAR C 4-6 PARA. 19 JAR E

1. GENERAL

1.4. HELICOPTER EXPOSED AREAS

- WINDSCREENS
- ENGINES AIR INTAKES
- ROTOR BLADES

HELICOPTER BIRD STRIKE RESISTANCE

1. GENERAL

1.5. TEST INSTALLATIONS

- «BIRD GUN» WITH SIZE AND SPEED VARIATION
- HIGH SPEED MOVIE CAMERAS
- POSSIBILITY OF STRAIN MEASUREMENTS AND RECORDINGS

2. WINDSCREENS

2.1. WINDSCREEN BIRD STRIKE TESTS

- AIMED AT SHOWING COMPLIANCE WITH BCAR G 4.1.10
- AIRSPEED SIMULATED : MAX FORWARD SPEED
- BIRD SIZE : AS PER REGULATIONS (2 TO 4 LBS)
- SPECIFICATION : NO PENETRATION INTO COCKPIT

HELICOPTER BIRD STRIKE RESISTANCE

2. WINDSCREENS

2.2. WINDSCREEN IMPACT RESEARCH

TESTS IN PROGRESS WITH OBJECTIVES :

- VALIDATION OF MATHEMATICAL IMPACT MODEL
- OPTIMISATION OF WINDSCREEN MATERIAL (MULTI-LAYER PANELS)
- EFFECT OF BOUNDARY ATTACHMENT

HELICOPTER BIRD STRIKE RESISTANCE

3. ENGINES

3.1. ENGINES REGULATIONS

- FAR 33.77, JARE, BCAR C 4-6 PAR. 19
- NO HAZARDOUS CONDITION AFTER IMPACT OF LARGE BIRD (4 LBS) AT V MAX
- LESS THAN 25 % LOSS OF POWER AFTER SMALL AND MEDIUM BIRDS IMPACTS AT V CLIMB

HELICOPTER BIRD STRIKE RESISTANCE

3. ENGINES

3.2. GENERAL REMARKS

AIR INTAKE DESIGN MUST PROVIDE PROTECTION AGAINST

- F.O.D.
- BIRDS
- COMPRESSOR EROSION (SAND, DUST)
- SNOW, WATER OR ICE INGESTION

HELICOPTER BIRD STRIKE RESISTANCE

3. ENGINES

3.3. AIR INTAKE PROTECTIVE DESIGNS

- STATIC INTAKES (SA 365 C, AS 350)
- RAM AIR INTAKES WITH GRIDS (AS 332, SA 365 N, AS 355)
- OPTIONAL PROTECTIONS :
  - SNOW SHIELDS
  - SAND FILTERS
  - MULTI-PURPOSE AIR INTAKES

HELICOPTER BIRD STRIKE RESISTANCE

3. ENGINES

3.4. RAM AIR INTAKES : DESIGN OBJECTIVES

- THE GRID SHALL RETAIN SMALL AND MEDIUM BIRDS
- FOR LARGE BIRDS :
  - THE GRID RETAINS THE BIRD OR
  - COMPLETE DEMONSTRATION OF BIRD INGESTION INTO RUNNING ENGINE

HELICOPTER BIRD STRIKE RESISTANCE

3. ENGINES

3.5. BIRD STRIKE TESTS

- ACTUAL COMPLETE STRUCTURE UNDERGOES TESTING
- DEVELOPMENT TEST MAY LEAD TO GRID MODIFICATION
- BIRD RETENTION OBTAINED BY CONTROLLED DEFORMATION OF GRID, STIFFENERS AND ATTACHMENTS

HELICOPTER BIRD STRIKE RESISTANCE

4. ROTOR BLADES

4.1. GENERAL REMARKS

- NO SPECIFIC REGULATORY REQUIREMENT
- TEST OBJECTIVES :
  - EVALUATION OF DIRECT IMPACT DAMAGE ON ACTUAL BLADE SECTION
  - ANALYSIS OF EFFECT ON TRANSMISSION SYSTEMS
  - VALIDATION OF MATHEMATICAL MODEL

HELICOPTER BIRD STRIKE RESISTANCE

4. ROTOR BLADES

4.2. TEST PROGRAM

- DYNAMIC IDENTIFICATION OF BLADE SECTION *
- BIRD SIZE : 4 LBS
- AIR SPEED : VNE + ROTATIONAL VELOCITY
- 3 BLADE STATIONS (EFFECT OF CENTRIFUGAL TENSION AND ANGLE OF ATTACK)
- STRESS TIME-HISTORY ANALYSIS *

* REQUIRES COMPREHENSIVE STRESS MEASUREMENTS

HELICOPTER BIRD STRIKE RESISTANCE

4. ROTOR BLADES

4.3. BIRD STRIKE TEST RESULTS

- MINOR LOCAL DAMAGE (DENTS)
- NO IMPORTANT DEGRADATION (REQUIRING SHOP REPAIR)
- NO EFFECT ON TRANSMISSION SYSTEM
- MATHEMATICAL MODEL VALIDATED

HELICOPTER BIRD STRIKE RESISTANCE

5. CONCLUSIONS

- HAZARDS DUE TO BIRD IMPACT EXIST FOR HELICOPTERS
- IT IS THUS NECESSARY TO CHECK BEHAVIOUR OF :
  - WINDSCREENS
  - AIR INTAKES
  - ROTOR BLADES
- WITH SOME PRECAUTIONS, APPLICABLE REGULATIONS ARE SATISFIED, AND BEYOND