APPROACHES TO ROTOR FRAGMENT PROTECTION

M. A. O'Connor, Jr.

Douglas Aircraft Company
McDonnell Douglas Corporation

In recent years there has been a substantial increase in regulatory attention in the area of rotor fragment protection. Concern appears to stem primarily from an apparent nearly constant per year occurrence of incidents involving uncontained fragments, large fan blade masses of the large high bypass ratio turbofans, and degree of secondary damage produced in some instances. Increase emphasis is evident from NASA and FAA activities including their sponsorship of some industry activities.

It is essential that the containment question be examined in the correct perspective. The commercial record is a fairly convincing argument that the requirements and practices in place today are reasonably effective. Since Douglas' entry into the jet transport field in 1956, two hulls have been lost and a single fatality incurred in a third incident involving rotor/blade failures. In none would additional "armor" isolation, or redundancy have affected the outcome. However, this is not to imply that there is no room for improvement. Some ideas that may provide insight include review of key controlling requirements, armor as a brute force approach, and an integrated airframe and engine solution.

As part of the approach to rotor/blade fragment protection, key airworthiness design criteria/considerations for fragment protection are reviewed. Various FAA requirements in FAR Parts 25 and 33, plus interpretive 8110 orders, deal with engine and installation requirements specifically aimed at minimizing this type of hazard. These requirements cover such features and design areas as engine isolation, containment of damage from rotor blade failures, containment of fire, and design of other features of the aircraft to permit continued flight and safe landing in the event of more serious engine failures.

Armor represents one end of the spectrum of protection approaches. An FAA sponsored study is in process at Douglas to evaluate the impact of providing aircraft armor in lieu of engine armor for typical 3 and 4 engine wide bodied transports. The initial area of discussion deals with protection within the length of the engine case. Protection from fragments exiting ahead of the engine inlet flange has some unique considerations and is therefore treated separately.

For protection within the length of the engine case, armor weight penalties, plus fuel burned and dollar cost of carrying the armor protection are defined. Immediately ahead of the inlet flange, direct tangential impacts are predominant, but further forward, rebound impacts predominate. Armor thickness requirements and fuel cost impact of protection are shown.

The right answer is a balanced or "system" approach involving both the aircraft and engine design. This approach whether formalized or not is basically responsible for the demonstrated success to date. Accomplishment involves nothing more than the systematic recognition of the problem during the basic design and development of both the aircraft and engine. Key steps in the aircraft design are delineated.

Design considerations relative to a tail engine installation are delineated. Limited armor is used for specific applications, i.e., tail engine fuel line protection, and tail engine inlet "flack jacket".

Results of demonstration testing and weight penalties are reviewed and areas of engine design which might be examined for optimum overall solutions are suggested.

This paper attempts to place the containment issue in better perspective and is felt to show that we are not faced with problems which would justify major regulatory and/or basic design concept changes. Based on Douglas' experience, however, areas where future effort could be directed productively are suggested.

DISCUSSION

J.H. Gerstle, Boeing

You showed the figure of eight million dollars a year as a fuel cost penality to carry the added containment weight on a quad-jet. Could you amplify on the assumptions that went into that figure?

M.A. O'Connor, Jr., McD-D

Basically, there were 971 aircraft in the estimate (635, 3 engine and 336, 4 engine wide bodied transports). We assumed a representative flight profile (based on an airline cross section) for the fleet and then merely calculated the fuel consumed to carry the armor weight. The total armor weights shown represent an upper bound (i.e., armor weights were not discounted for inherent and/or intentional containment capability of the engine cases. Each stage was assumed equally critical and armor weights were calculated and included for full protection).