The Engineering Society For Advancing Mobility Land Sea Air and Space

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AEROSPACE INFORMATION REPORT

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MILITARY SERVICE EXPERIENCE - AIRCRAFT WHEELS

1. PURPOSE: This Aerospace Information Report is intended to provide general background on aircraft wheel service lives on military aircraft, and, wheel laboratory test requirements as specified by military procurement agencies or aircraft manufacturers. This information is intended as a reference guide for those responsible for specifying O.E. wheel laboratory test requirements.

2. BACKGROUND: This study was precipitated by complaints from the military services (Air Force, Navy) of low wheel life on certain original equipment (O.E.) wheels on new aircraft. Low wheel life was cited as a chief concern by the Air Force Logistics Command (AFLC) with respect to supportability, and hence combat readiness of new aircraft. It should be noted, however, that low wheel life is not a problem on all new aircraft programs.

   From an overall perspective, low O.E. wheel life can in part be attributed to conflicting requirements and/or perceptions on "acceptable" wheel lives within military and industry communities.

   What is acceptable O.E. wheel life?

   One survey response, indicated in Fig. 1, suggests a spread of approximately four (4) years between wheel life goals of Performance and Logistics oriented communities. The result is best summarized by the following example:

   In the past, logistic procurement cycles within AFLC were based upon a 10-year minimum wheel life assumption. At the same time, wheels were being designed to specifications which were, in general, more compatible with performance (weight) objectives. Subsequently, wheel life was considered to be low by the Logistics community when wheel service lives did not meet the 10-year minimum life assumption. Passive procurement practices, coupled with long manufacturing leadtimes led to wheel shortages, hence supportability difficulties.

QUESTION

IN YOUR JUDGMENT WHAT FIELD SERVICE MAIN WHEEL LIFE DO YOU CONSIDER TO BE A DESIRABLE BALANCE BETWEEN WEIGHT SAVINGS (PERFORMANCE) AND MAINTENANCE/LOGISTICS?

A) FIGHTER/BOMBER AIRCRAFT

SERVICE LIFE (YRS.) ________

LANDING CYCLES ________

ROLL MILES ________

B) CARGO/TANKER AIRCRAFT

SERVICE LIFE (YRS.) ________

LANDING CYCLES ________

ROLL MILES ________

RESPONSE

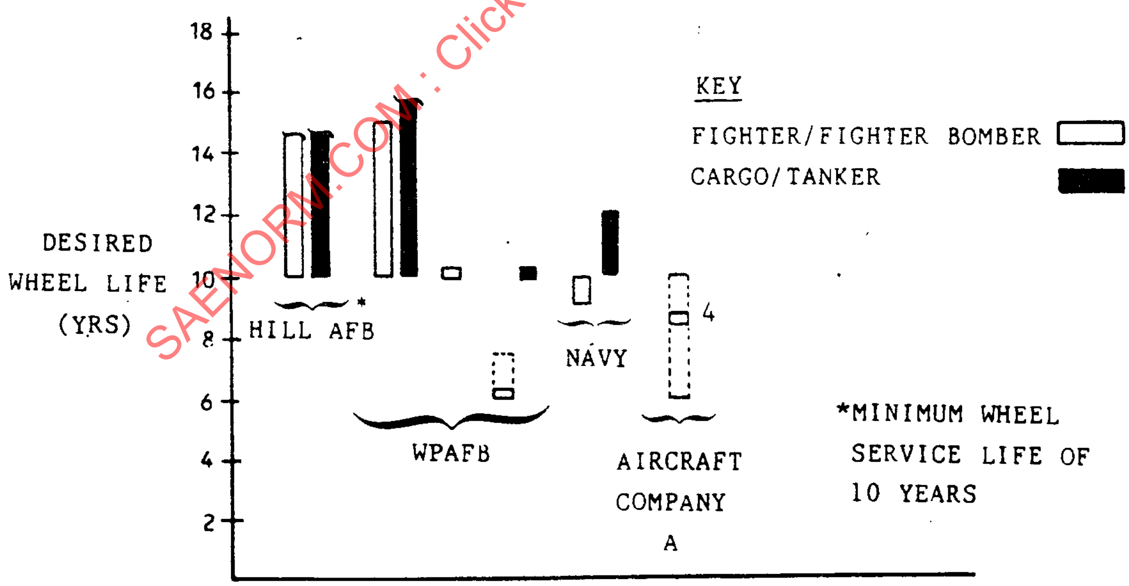

FIG. 1. PERCEPTIONS ON DESIRABLE WHEEL SERVICE LIVES (1983 SURVEY)

Examples of conflicting specification requirements and logistics expectations are noted in paragraph 3.1.

The foregoing highlights concensus and document issues to be resolved within the procuring agencies.

From the wheel vendors point of view, wheel service life is dependent upon a large number of variables such as tire characteristics, wheel static load requirements, roll spectrums, vendor design and test procedures, actual airplane operational loads and environments, wheel corrosion protection and handling practices. There is evidence on some models that aircraft manufacturer wheel laboratory test procedures and vendor design practices, have combined to yield acceptable O.E. service lives.

3. WHEEL LABORATORY TEST REQUIREMENTS:

3.1 Procurement Documents:

U.S. Air Force

- MIL-L-87139 (USAF)

- Aircraft Manufacturer Wheel/Brake Procurement Specification

The current Air Force approach of addressing wheel service life is outlined in MIL-L-87139 (USAF). Overall responsibility on the definition of wheel laboratory test requirements is relegated to the aircraft manufacturer. Based upon analyses and/or prior experiences, the aircraft manufacturer estimates wheel laboratory test requirements to yield the desired service life objective: The following excerpt from MIL-L-87139 (USAF) is provided for reference:

> "The conditions must account for maximum gross weight usage (taxi and takeoff), design mission takeoff, landing, and taxi. A spectrum should be generated to simulate the anticipated load distribution to give the required life. The environment developed by the wheel-brake-tire combination must be accounted for in the design conditions of the wheels."

In comparison to earlier procurement specifications (MIL-W-5013) this approach offers flexibility in specifying wheel design criteria which focuses on intended missions and life cycle cost objectives. Variability in aircraft manufacturer wheel laboratory test requirements and philosophies may contribute to continued variability in O.E. wheel service lives. Since this approach is relatively new, experience on newer and future aircraft must be accrued to determine if specific instances of low O.E. wheel life have been substantially reduced or eliminated.

Examples of incompatibilities between procurement documents and wheel life expectations, are noted below to highlight typical changes needed in the procurement area.

a) MIL-L-87139 (USAF), paragraph 3.2.3.2-b requires that "average" field service life should be specified." AFLC life expectations are expressed in terms of minimum wheel life. Given the statistical distribution of failures, the average requirement of MIL-L-87139 (USAF) is recommended.

b) MIL-L-87139 (USAF) intent is that average wheel service life be determined by the "function of the type of air vehicle on which it will be installed and the overall logistic plan." Regarding wheel life typical goals, it is stated: "10,000 service miles for cargo air vehicle is consistent with airline criteria. 2,000 service miles for high performance air vehicle wheels seems to reflect the primary concept of design."

It is recommended that these sentences be modified or deleted since the goals can be incompatible with life objectives in Fig. 1 of this document:

Examples:

1) Fighter Aircraft Scenario

- Peacetime
- 100 percent spares
- 200 to 250 missions/year
- 4 to 5 roll miles/mission

At 2,000 service miles, average life = 3.2 to 5 years

2) Airline Service Miles - typical service mile requirements range from 25,000 to 50,000 miles for more recent commercial aircraft.

U.S. Navy

- MIL-W-5013K

The Navy approach to improving wheel service life has been to accept or modify earlier versions of MIL-W-5013. Table I summarizes the increased intensity of wheel laboratory test requirements from MIL-W-5013G to MIL-W-5013K versions. Service experience is currently insufficient to assess wheel service life improvements provided by MIL-W-5013K versus MIL-W-5013H wheels.

STATIC TESTS	MIL-W-5013 VERSION			
	G	H	J	K
YIELD RADIAL LOAD TEST (Ground Based and Carrier Based Aircraft)				
Apply 1.15 times maximum limit load at 0°, 90°, 180°, 270°, 0°, 0° with rated tire pressure	X	X	X	X
ULTIMATE RADIAL LOAD TEST (Ground Based and Carrier Based Aircraft)				
Apply 1.50 times maximum limit load at 0° with rated tire pressure and hold at least 10 seconds.	X	X	X	X
Reapply radial load until wheel fails.			X	X
DESIGN LANDING RADIAL LOAD TEST				
(A) Ground Based Aircraft				
Apply maximum design landing load with maximum operating tire pressure and hold for 10 seconds.	X	X	X	X
(B) Carrier Based Aircraft				
Apply maximum design landing load, with maximum operating tire pressure, through a 1-3/8 inch cable and hold for 10 seconds.	X	X		
Apply maximum design landing load, with maximum operating tire pressure, through a 1-1/2 inch cable and hold for 10 seconds.			X	X
YIELD COMBINED LOAD TEST (Ground Based and Carrier Based Aircraft)				
Apply 1.15 times the maximum limit combined load components to the wheel supported at 0°, 90°, 180°, 270°, 0°, 0° with rated tire pressure and hold for 10 seconds. Test must be performed on inboard and outboard of same wheel.	X	X	X	X
ULTIMATE COMBINED LOAD TEST				
(A) Ground Based Aircraft				
Apply 1.50 times the maximum limit combined load components to the wheel supported at 0° with rated tire pressure.	X	X	X	X
Holding side load constant or allowed to proportionally increase with vertical load the vertical load should be increased to wheel failure.			X	X
(B) Carrier Based Aircraft				
Apply 1.50 times the maximum limit combined load components to the wheel supported at 0° with rated tire pressure. The radial component may be in excess of the maximum limit radial load.	X	X	X	X
Holding side load constant or allowed to proporationally increase with vertical load, the vertical load should be increased to wheel failure.			X	X
BURST TEST				
(A) Non-Carrier Aircraft				
Using hydrostatic pressure in the tire, test the wheel to a burst pressure of 3.5 times the rated tire pressure, at the rated static load of the wheel or to the burst strength of the tire, whichever is least.	X	X	X	X
(B) Carrier Aircraft				
Using hydrostatic pressure in the tire, test the wheel to a burst pressure of 4.5 times the rated tire pressure, at the rated static load of the wheel or to the burst strength of the tire, whichever is least.	X	X	X	X
ROLL TESTS				
THERMAL CONDITIONING (Ground Based and Carrier Based Aircraft)				
Prior to roll testing, wheels shall have been subjected to thermal conditioning equivalent to the cumulative temperature-time history resulting from brake heat dissipation experienced during dynamic torque tests except for the rejected takeoff condition.		X	X	X
STRAIGHT ROLL				
(A) Ground Based Aircraft				
1,500 miles with an applied load equivalent to maximum taxi gross weight and rated tire inflation pressure.	X	X		
2,700 miles with the rated static load applied and rated tire inflation pressure.(1)			X	X
(B) Carrier Based Aircraft				
1,770 miles with the rated static load applied and rated tire pressure inflation.			X	X
900 miles with the rated static load applied and high pressure tire inflation.			X	X
YAW ROLL (Ground Based and Carrier Based Aircraft)				
75 miles each inboard and outboard yaw with combined radial and side loads corresponding to a 0.25g turn at maximum design gross weight using rated tire pressure.		X		
150 miles each inboard and outboard yaw with combined radial and side loads corresponding to a 0.25g turn at maximum design gross weight using rated tire pressure.			X	X
CATAPULT ROLL (Carrier Based Aircraft)				
Conditions determined by aircraft manufacturer.	X	X		
30 miles with high pressure tire inflation at loads determined by the aircraft manufacturer.			X	X
3,000-MILE INSPECTION (Ground Based and Carrier Based Aircraft)				
Inspection by zyglo and eddy current methods.			X	X

(1) 25 miles may be done at 90 percent of the maximum recommended tie bolt torque on the design drawing.

TABLE I. COMPARISON OF WHEEL STATIC AND ROLL TEST REQUIREMENTS

3.2 Reference Documents:

- Aerospace Recommended Practice ARP 1493, Wheel and Brake Design and Test Requirements for Military Aircraft: The stated purpose of ARP 1493 is as follows:

  "This ARP provides recommended practices for the design and testing of wheels and brakes for new design military aircraft. It is intended for use by airframe and military personnel in formulating detail design and performance specifications. It is not intended to be used as a procurement document in replacement of MIL-W-5013."

It is beyond the scope of this document to provide a comparison of similarities and differences between ARP 1493 and current military procurement documents.

- AIR-811 Disposition of Overheated Wheels

4. FIELD SERVICE EXPERIENCE: Fig. 2 and 3 illustrate responses to two survey questions regarding field service experience on wheels with bias ply tires. Figure 2 response indicates that wheel corrosion was ranked as the number one cause for retirement of wheels from service. AFLC and Navy report that the wheel condemnation rate for "general corrosion" increases as the average wheel life on a given model increases. In these cases, diligent attention to wheel corrosion protection practices (anodic treatment, paint systems, etc.) and more generous corrosion cleanup allowances are more important than increasing wheel structural design criteria (roll spectrums, etc.). The importance of maintaining wheels in accordance with wheel vendor recommendations is clear if maximum service life is to be attained. Corrosion protection of wheels in storage must also be practiced.

Wheel softness condemnation rates are also relatively independent of wheel structural design criteria. Wheel softness may result from initial design temperature control provisions and/or field service conditions in excess of specification thermal design requirements.

Condemnation of wheels due to fatigue (emanating from corrosion pits, stress risers, etc.) in general increases percentagewise as the average wheel service life of a particular model decreases. In this regard, improvements in wheel laboratory test requirements of Section 3 can be effective in avoiding low O.E. wheel service lives.

Fig. 3 illustrates approximate current wheel service life ranges on eight (8) military aircraft. Hill AFB reported O.E. wheel service life to be inadequate on seven (7) models which included trainer, fighter and cargo aircraft. Current wheel service life on three (3) of the seven (7) models is included in Fig. 3.

The bar charts suggest that most wheels are now achieving adequate service lives. In some cases, wheel design iterations were necessary to accommodate low O.E. service life, increases in aircraft gross weights, and/or changes in field service operations.