AVIATION OCCURRENCE REPORT

COMPONENT FAILURE / LANDING GEAR TORQUE LINK

CANADIAN REGIONAL AIRLINES
FOKKER F28-MK1000 C-FCRK
CALGARY INTERNATIONAL AIRPORT, ALBERTA
01 NOVEMBER 1995

REPORT NUMBER A95W0202

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

The left main landing gear of the Fokker F28-Mk1000 began to shimmy immediately after touchdown when landing at Calgary. Brakes were applied to slow the aircraft in an attempt to control the shimmy, but the oscillations continued until both left main wheels and brake assemblies separated from the axles.

After the aircraft came to a stop, the passengers and crew were evacuated without incident through the forward main cabin door.

Site examination revealed that the upper torque link failed within the first 200 feet of the landing roll, and the wheels separated about 1,450 feet from touchdown. There was substantial damage to the oleo lower sliding member, wheels, tires, brakes, and left inboard and outboard flaps.

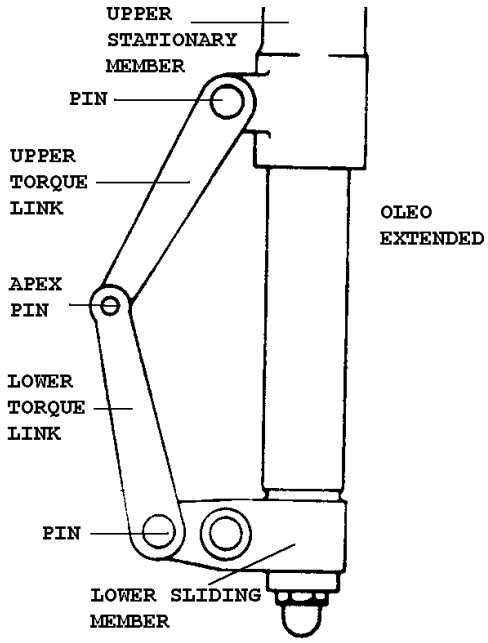
The crew reported that the lift dumpers (spoilers) had been armed on the approach. They were found to be deployed when the aircraft came to a stop, but the crew was uncertain as to when they had deployed.

Ce rapport est également disponible en français.

Other Factual Information

The aircraft had recently been out of service because of a shimmy problem. The problem had been isolated to the right main gear and was rectified by the replacement of an out-of-balance inboard wheel and tire. A successful flight test and positioning flight had preceded the occurrence flight when the left main gear developed a shimmy.

In normal operation, any torsional loads on the lower oleo sliding member from the wheel assemblies on the dual axles are transferred through the torque links (T/Ls) to the stationary upper oleo member. The T/Ls prevent rotation about the vertical axis to maintain wheel alignment in the fore-and-aft direction throughout the vertical range of oleo travel. In maintaining proper wheel alignment, the T/Ls stabilize any torsional oscillations (shimmy). By their design, T/Ls have their maximum mechanical advantage and control when the oleo is compressed, and minimum advantage when the oleo is fully extended.



Both left and right oleo assemblies were disassembled and examined in the operator's overhaul (O/H) shop. Dimensions were generally found to be within service limits, with the exception of the fit of the T/L pins to the main oleo lug bushings and the sliding member lug bushings. The clearances in the main bushings were from 0.0012 inches to 0.0034 inches, and in the sliding member bushings were from 0.0021 inches to 0.0154 inches. The manufacturer's O/H Manual specifies an interference fit, whereby the pin is pressed into the bushings without any clearance. This interference fit is necessary to minimize free play and ensure stability of the moving parts of the landing gear -- that is, to prevent shimmy. The pins are locked in position in the bushing, and wear in service is minimal. The increased clearances on the occurrence aircraft, beyond overhaul manual limits, would have reduced stability. It was reported that a former operator had used a non-factory-approved O/H procedure for a period of about two years, in which the bushings were reamed for a loose fit on the pins.

Both upper and lower torque links (T/L)s and pins were examined at the TSB Engineering Branch, and all materials and dimensions met the manufacturer's specifications. It was determined that the upper link failed in overload, with no evidence of pre-existing damage. The dimensions of both pins were equal to new parts limits, with no wear evident. The Engineering Branch report further states: "There

appears little doubt that the problem relates to the overall landing gear design and an inability to tolerate looseness or slack in the component build-up."

The left oleo pressure and fluid had been discharged following the accident. The nitrogen pressure in the right oleo was 278 pounds per square inch (psi), and the fluid quantity was 10.5 litres (L). Servicing of both main oleos had taken place four days prior to the accident, and it was reported that the two oleo extensions had been equal prior to the flight. Specified nitrogen pressure in the oleos is 195/215 psi, and fluid quantity should be 13.1 L.

This accident is the 29th occurrence of this type recorded in the aircraft manufacturer's data base. Numerous investigations and considerable research have been conducted over the previous 20 years and 28 occurrences, with the causes of landing gear shimmy emerging as a combination of any or all of the factors listed below (with comparison to this occurrence):

SHIMMY INITIATION FACTORS	CONDITIONS PRESENT IN THIS OCCURRENCE
F28-Mk1000 gear on F28-Mk4000 aircraft	Not applicable
Boeing 707 nosewheel tires on F28 main gear	Not applicable
Non-approved maintenance practices such as introducing clearances between lugs and link pins at overhaul	Additional clearances introduced at previous overhaul
Excessive wear or play on all T/L connect points	Clearances at or within limits, (except as above)
Tires - pressures/balance/ profile, different makes on 2 axles of the same oleo	Tires normal, pressures not available, approx. 50% wear, same make & model
High nitrogen pressure, and high or low fluid quantity	Nitrogen pressure above specs., fluid quantity below
Brakes - uneven drag on one wheel or the other	Unknown
Soft landing, possibly with a crosswind	Soft landing, no crosswind
Low gross weight, around or below 50,000 lb	Landing weight 46,800 lb
Flaps set to max. lift (42°)	Flaps set 42°

Higher than normal touchdown speeds	Touchdown speed normal; 109 kts (V ref)
Lift dumpers not armed, or not deployed (squat switch not activated)	Lift dumpers were armed, but may not have deployed until aircraft almost stopped

The aircraft had been in operation with the regional airline for about 11 months, and had previously been operated in the United States. Since O/H in 1987 by the former operator, the landing gear had accumulated about 7,157 cycles. The operator's mid-life inspection of the gear was due at 8,000 cycles, with O/H required at 12,000 cycles. The T/L Apex Joint End Float inspection had been completed three days prior to the accident, and the clearance reset to specifications.

The aircraft manufacturer had previously decided that the installation of a Torque Link Apex Damper (TLAD) would be the most effective means of eliminating or controlling the shimmy. Dutch Airworthiness Authorities (RLD) had proposed to require the installation of the TLAD kit on all Dutch-registered F28-Mk1000 and -Mk2000 series aircraft before 31 December 1993 by means of an Airworthiness Directive (AD) based on Fokker Service Bulletin (SB) F28/32-151. SB F28/32-151 was based on the original Dowty SB 32-169R. Because of problems with the TLAD development program, SB F28/32-151 was not issued, resulting in the compliance date of the proposed AD being postponed indefinitely.

The aircraft manufacturer had previously taken the position that the probability of a T/L failure was relatively low, and the consequences minimal. However, because of the continuing failures of torque links and the recent incidences of substantial secondary damage to the aircraft involved, finding a solution to the shimmy problem has received higher priority.

The regulatory authorities of Canada, the United States, and the Netherlands are monitoring further developments.

Analysis

The original excitation of the oscillations which resulted in the shimmy could not be determined, but it would appear that two factors allowed the oscillations to continue and amplify:

1. The additional clearances in the T/L pins and bushings which reduced the dampening capability of the T/Ls; and

2. The excessive nitrogen pressure in the oleo, which prevented the oleo from compressing immediately at touchdown.

With the T/Ls extended in a position of minimum mechanical leverage, considerable unchecked torsional movement of the sliding member had occurred, and the severity of the shimmy overloaded the T/L to failure.

The current operator was unaware of the non-approved fit of the T/L pins and bushings. The aircraft had not been in service for a sufficient length of time to require this operator's mid-life inspection on the gear, which would have revealed the excessive clearances.

The conditions listed as being shimmy initiation factors appear to be normal landing conditions for this class of aircraft; therefore, it would appear that the problem relates to the overall landing gear design. Changes in tolerances, whether from wear, overhaul, servicing, etc., compromise the margin of shimmy control, which can lead to torque link failure.

The following TSB Engineering Branch reports were completed:

LP 157/95 - FDR/CVR Analysis; and
LP 171/95 - Torque Link Analysis.

Findings

1. The left main gear began to shimmy immediately after touchdown, resulting in failure of the upper torque link and eventual separation of the wheels from the axles.

2. The aircraft landing configuration and other landing conditions were conducive to the initiation of landing gear shimmy.

3. The loose fit of the torque link bushings and pins from the previous overhaul prevented the torque links from controlling and eliminating the shimmy.

4. The nitrogen pressure in the oleo exceeded the pressure specified in the maintenance manual, and contributed to the oleo's stiffness.

5. The landing gear design is intolerant of looseness or slack in the component build-up.

Causes and Contributing Factors

The left landing gear torque link failure and wheel separation was caused by a shimmy, which developed when the shimmy dampening capability of the torque links was degraded by a combination of non-standard clearances in the torque link pins and bushings, and a delay in oleo compression. The oleo did not compress on initial touchdown because of excessive nitrogen pressure, a 42-degree flap angle, low descent velocity, and low aircraft landing weight.

Safety Action

Immediately following this occurrence, three changes were implemented by the operator's maintenance department on all aircraft in their fleet:

1. All landing gear will have had the nitrogen pressures rechecked and serviced in strict accordance with the maintenance manual within 21 days, to reduce the possibility of increased stiffness from over-serviced oleos.

2. All undercarriages for which the status of the T/Ls cannot be confirmed as having been overhauled to "new" limits will have the mid-life inspection performed as soon as possible.

3. All future additions to the fleet will have the mid-life inspection incorporated as part of the initial inspection.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, Benoît Bouchard, and members Maurice Harquail and W.A. Tadros, authorized the release of this report on 27 August 1996.