

PREVENTION AND RECOGNITION OF LOADING ERRORS ON F27 AND FOKKER 50 AIRCRAFT

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INTRODUCTION

Incidents have occurred of incorrect loading of F27 and Fokker 50 aircraft. Incorrect loading can lead to difficulties with the aircraft stability and controllability and can even lead to loss of an aircraft. This article describes the effects of improper loading on the aircraft Center of Gravity (CG), the aircraft stability and controllability. It informs you about the potential danger of incorrect loading and at the same time it refreshes your memory on some basics of CG calculation and loading.

CERTIFIED CG LIMITS

In the Limitations section of the Flight Manual (FM) or Aircraft Flight Manual (AFM) the certified CG limits for the F27 and Fokker 50 are given. These limits are determined in the design stage of the aircraft and are related to aircraft loads, longitudinal stability/ controllability of the aircraft, elevator capability, elevator trim capability and elevator

forces. These limits have been demonstrated to be safe and comply with the requirements.

The selected engine power, the flap position and the landing gear position affect the aircraft stability/ controllability, required elevator capability and elevator forces. Therefore for take-off and landing a narrower certified CG range is used compared to the aerodynamic clean in-flight configuration.

OPERATIONAL CG LIMITS

For practical purposes operators sometimes use their own methods of calculating the CG of the loaded aircraft. These methods are based on average moment arms for passengers and cargo holds, an even distribution around these arms and specific loading procedures. The use of these procedures always lead to some inaccuracy in the calculation of the loaded aircraft CG. To account for the inaccuracy and to allow movement of passengers in the cabin during flight, the operator has

to adjust the certified CG limits into an operational CG limit, such that the operational forward and aft CG limits will be more restrictive than the certified CG limits as published in the FM or AFM.

LOADING OF THE AIRCRAFT

In concurrence with the CG calculation method loading procedures are developed by the operator. Correct loading procedures ensure proper cabin and hold identification, passenger seat assignment, load hold assignment, load distribution and verification of the calculated loading with the actual loading.

IMPROPER LOADING

Differences between the actual loading and the predetermined loading of the aircraft may be caused by:

- Passenger seat assignment not in line with the CG calculation.
- Unequal distribution of cargo in the assigned holds.

F27



Fokker 50



- Holds not loaded according to load assignment.
- Cargo hold indication not clear or a difference between the hold indication in the aircraft and the cargo hold reference used during the CG calculations.

A combination of the above loading errors can result in exceedance of the forward or aft CG limit of the aircraft. Especially for an aircraft with half a passenger load in combination with only one cargo hold used, loading errors may result in a substantial difference between the calculated CG and the actual CG. For freight aircraft a typical critical condition to make a loading error is, with half a cargo load either in volume or in weight.

EFFECT OF CHANGES IN THE LOCATION OF THE CG ON THE AIRCRAFT STABILITY AND CONTROLLABILITY

For aircraft stability and control analysis purposes several theoretical points are defined located on the wing chord. Within the context of this article, the CG and the Neutral Point (NP) are important. The CG being the point where the weight force of the total aircraft is concentrated and the NP the point where

the lift force of wings, nacelles, fuselage and tailplane is concentrated.

The stability and controllability of the aircraft is determined by the position of the CG related to the NP. With the CG forward of the NP the aircraft is stable, with the CG at the NP the aircraft is neither stable nor unstable and finally with the CG aft of the NP the aircraft is unstable.

Within the certified CG range, the CG will always be forward of the NP and the aircraft will therefore always be stable. However, at the aft CG limit the aircraft is less stable than at the forward CG limit.

The level of stability is decisive for the controllability of the aircraft when considering the necessary amount of elevator deflection and thus also stickforces. As mentioned before the CG range is always in front of the NP. When assuming that the CG moves into the direction of the aft CG limit and eventually even beyond the aft CG limit the CG approaches the NP. As mentioned before the result of this is that the aircraft becomes less stable. The aircraft will require small pilot control inputs and control forces will be low. When the CG moves to an even further aft position and eventually into a position aft of the NP the aircraft will be unstable. Typical for an unstable aircraft is that it wants to enlarge the effects of a pilot control input, which forces the pilot to react

with an immediate opposite reaction, which may result in insufficient elevator capability for aircraft control. In a stable aircraft on the contrary the aircraft wants to reduce the effects of a pilot control input.

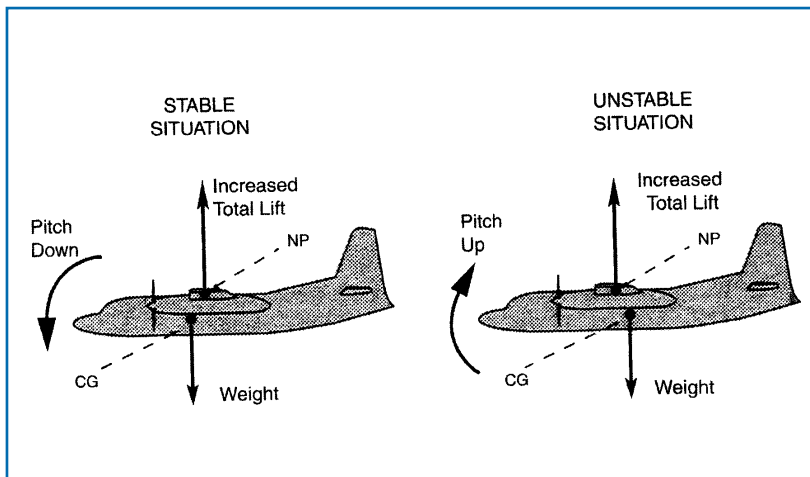
At the other hand when the CG moves into the forward direction and eventually beyond the forward CG limit a too stable aircraft will be the result. The aircraft will require large pilot inputs and control forces are high. In all cases applies that whenever the CG is beyond the certified limits the certified controllability of the aircraft is no longer assured.

FACTORS AFFECTING THE POSITION OF THE NP

Above the relation between the CG and NP has been explained. During flight the CG position will only move marginally. However the NP will move substantially. Factors affecting the in flight NP position are (in order of importance):

- Propeller thrust/Engine power
- Aircraft speed
- Flap position

Engine power increase will cause the NP to move forward significantly. A decrease of speed will also result in a more forward NP, and finally flap down selection will cause the NP to move forward. This implies that when during the approach flap 35 (max flap setting for the Fokker 50) or flap 40 (max flap setting for the F27)) is selected, the NP position will be closer to the aft CG certified limit position than with lesser flap-settings. Within the certified CG range the NP will always be aft of the certified aft CG limit and the aircraft will therefore be stable. When due to incorrect loading the actual CG position is aft of the certified limit, the aircraft may be (just) stable



during take off and cruise, but during landing the aircraft may become unstable.

FLIGHT CREW RECOGNITION AND FLIGHT HANDLING OF CRITICAL LOADING ERRORS

ON GROUND:

On the ground, before take off, the Flight Crew may already get an impression of the aircraft's loading by judging the amount of nose gear deflection during the walk around inspection. Especially a very extended nose gear strut may indicate that the CG will be at or close to its aft limit for take off. If the nose gear deflection looks very unfamiliar, make sure the load and the loaded index is verified before the load-sheet is signed.

DURING TAKE OFF:

As explained before, if the aircraft CG is aft the aircraft will require small pilot control inputs and control forces will be low. These effects will be even more pronounced during

the subsequent take off as engine power/propeller thrust will be high and airspeed relatively low, especially in combination with take off flaps selected. If the aircraft shows a tendency to lift the nose 'by itself' before V_r is reached, a slight forward pressure on the control column may even be required until V_r is reached. The flight crew in command of an aircraft having an aft CG must be careful not to over-rotate.

If on the contrary the aircraft CG is forward, as mentioned before, the aircraft will require large pilot control inputs and control forces will be high. For the same pilot input the aircraft may have a slow rotation and therefore the pilots may have to pull somewhat harder to the control column to enable the normal rotation.

DURING APPROACH:

Although flap position is one of the parameters that have impact on the NP, it's role is not significant enough to warrant a landing with less than full flaps if required, assuming the CG is not outside the certified limit for landing. The most significant factor affecting NP position is definitely engine power/propeller

thrust. Therefore the most delicate part of the approach is an eventual go-around, where engine power is increased rather suddenly from near idle to maximum power, shifting the NP significantly forward in just a few seconds.

SPECIAL CONSIDERATIONS:

If despite of all precautions in calculation and actual loading, the flight crew notices the aircraft to be obviously out of aft CG range during the take off roll, abortion of the take off must be considered. If the problem becomes obvious after V_1 it is strongly recommended to return to the departure airport. In such a case the passengers must be reseated to a more forward position in the cabin and a normal approach must be performed. No full flaps must be used during the landing and a go-around must be avoided at all cost by informing ATC about the aircraft controllability problem.

SUMMARIZING

As you can see from the above, proper loading of an aircraft is very important. Also verification of proper loading is very important. Errors made during the loading could lead to controllability problems during flight. Although this should be old news to people involved in loading or Flight Operations, incidents and accidents due to loading errors continue to occur throughout the industry. With this article Fokker Services hopes to have refreshed your knowledge about this subject in relation to the Fokker 50 and F27. STORY Fokker