TOWING FROM NOSE UNDERCARRIAGE

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LOG/105/3 January 1955.

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CF-105

TOWING FROM NOSE UNDERCARRIAGE

Report No. LOG/105/3

January 1955

AVRO AIRCRAFT LTD., MALTON, ONT.

INTRODUCTION

This report has been prepared in order to state and discuss the towing problem of the CF-105 with the object of arriving at a solution which is acceptable to the R.C.A.F. and the Company.

THE PROBLEM

Due to the configuration of the airplane, the towing loads as specified by ARDCM80-1, when applied to the lowest, i.e. the castoring part of the nose undercarriage leg, cause stresses in this leg and related parts which exceed those caused by landing, take-off and taxiing conditions. In order to cater to these towing loads, it would be necessary to add 57 lb. of extra structural weight to the airplane (refer Appendix A of this report).

DISCUSSION

Since it is obviously undesirable to carry this amount of dead weight in the airplane simply to cater to ground-handling, the Company has investigated the two methods available which would not incur this weight penalty. The methods are:

(1) Reduce the specified towing loads.
(2) Raise the tow bar attachment on the leg to a point where the resulting stresses due to towing do not exceed those caused by other design conditions.

With regard to method 1, it has been calculated that our specified towing load of 12,000 lb. would have to be reduced to 8000 lb. in order not to cause any weight penalty. It behoves us therefore to take a closer look at the methods of various procuring agencies for specifying towing loads.

R.C.A.F. specification AIR-7-4 calls up U.S.A.F. spec ARDCM80-1 which in turn calls up Bulletin ANC-2 for the determination of ground loads. ANC-2 relates the limit towing load to the maximum take-off weight of the airplane as follows:

For take-off weights below 30,000 lb., $F_{tow} = 0.3\ W_{to}$.

For take-off weights between 30,000 lb. and 100,000 lb., $F_{tow} = 6429 + \frac{6}{70} W_{to}$.

For take-off weights over 100,000 lb., $F_{tow} = 0.15\ W_{to}$.

The altimate load factor is 1.5

For our maximum design take-off weight of 65,000 lb. the above formula gives a towing load of 6429 + 5571 = 12,000 lb. limit. ANC-2 further states that the limit towing load may be halved when applied at an angle of 45° to the airplane's fore and aft axis.

The British Military requirement is called up in AP970 chapter 310 para. 9. It states in effect that the overload release of the tow bar need not be greater than 0.3 $W_{t.o.}$ and shall not be less than 0.15 $W_{t.o.}$ to prevent too frequent operation of the release mechanism, making the tow bar useless in practice. Strength-wise this requirement is more severe than the U.S. requirement because an ultimate load factor of 2 is specified when pulling along the fore and aft axis and a factor of 1.5 when pulling at an angle of 45° to this axis.

The American Civil requirement is that of ANC-2. In reply to a request by the Company, Trans-Canada Airlines have supplied us with relevant information (refer Appendix B of this report). They design their tow bar shear pin to fail at a load of 0.5 $W_{t.o.}$ for all values of take-off weight. This would give an additional safety factor on the strength of the nose leg for airplanes weighing less than 100,000 lb. (if shear-pin failure were reliable).

From the above it appears that the specified limit towing load of 12,000 lb. for our airplane gives an ultimate load for stressing of the airplane of 1.5 x 12,000 = 18,000 lb.; the British minimum allowable ultimate load would be 2 x .15 x 65,000 = 19,500 lb., which gives a pretty close agreement.

Hence, the absolute minimum towing load which could be considered for the CF-105 would be that corresponding to .15 x 65,000 = 10,000 lb. (say), with an ultimate factor of 1.5. This would require a deviation from the existing specification. The shear-pin should then be set to fail at a load not lower than 9,750 lb. and not greater than 10,500 lb.

With regard to method 2, the Company had proposed a scheme whereby the towing attachment on the nose leg was raised to a point about 3.5 feet above the ground. By doing so, there would be no weight penalty for the airplane. There are however several disadvantages:

(a) The tow bar requires additional structure to pick up the castoring lower part of the leg for purpose of steering the nose wheels. The tow bar therefore becomes heavier and difficult to lift and attach to the leg.

(b) The tow bar definitely becomes non-standard. No standard tow bar exists yet, although efforts towards this are being made. From the logistics aspect there are obvious advantages in standard tow-bars for certain categories of airplanes.

(c) Design difficulties are foreseen when this type of tow-bar has to clear the nosewheel steering mechanism and the landing light. According to AIR-7-4 the latter must be fitted to the castoring part of the nose leg.

AVRO drawing 7-4427-3 shows the general arrangement of such a tow bar.

CONCLUSION

There are three solutions to the problem confronting us and the time has now arrived to make a decision in favour of one of these. The three solutions are:

(1) Design to 12,000 lb. limit towing load with orthodox tow bar, and accept the weight penalty of 57 lb. on the airplane.

(2) Design to 12,000 lb. limit towing load with a complicated and difficult to handle tow bar, thus keeping the airplane weight to a minimum.

(3) Compromise on an orthodox tow bar arrangement but with a design limit towing load of 0.15 $W_{t.o.}$, i.e. 10,000 lb., requiring a deviation from the present specification. The weight penalty for the airplane will then be reduced to about half of 57 lb., that is 29 lb.

The compromise solution is recommended in the light of the following considerations:

(a) It conforms to T.C.A. practice in designing the shear-pin of their tow bars.

(b) It conforms to the minimum allowable overload release load in British airforce practice for the design of tow bars.

(c) A towing bridle attached to the main legs will be available to tow the CF-105 through deep snow and mud, when the required maximum towing effort will exceed 10,000 lb.

(d) The CF-100 tow bar release load is set at 5,000 lb. which corresponds to only 0.12 of the overload take-off weight of 42,000 lb. or only 0.133 of the normal take-off weight of 37,500 lb.

If this recommendation is adopted, the tow bar shear pin should be designed to fail at a load not lower than .15 x 65,000 = 9,750 lb. and not greater than 10,500 lb.

APPENDIX 'A'

COPY

Ref: S272/48/J
Date 7th January, 1955
To Mr. J.P. Booth - Logistics Engineer
From E.W.H. Thompson
Subject C-105 A/C - TOWING FROM NOSE UNDERCARRIAGE
(A/C ALL UP WEIGHT INCREASE CONSEQUENT ON
TOWING FROM NOSEWHEEL INSTEAD OF AT MID LEG)

(a) It is an objective in the design of the C-105 Nose Undercarriage that the towing lug shall be located so that the towing cases shall not be critical for the nose undercarriage and fuselage structure.

(b) The present arrangement meets these requirements in that the required towing load (per ANC-5) of 12,000 lbs. for an all-up weight of 65,000 lbs., does not design the nose gear when the towing lug is located at approximately 47" below the nose undercarriage pickup.

(c) If towingwere by attachment to the nose wheel, the towing load will have to be reduced to 8,000 lbs. in order that the towing case should not be a design case of the nose undercarriage.

(d) If a fore and aft jury strut were introduced, this would be effective only for fore and aft components of the towing load, and the undercarriage leg would still require strengthening for side components. It would appear that the increase in weight required to carry fuselage strengthening for the jury strut pick-up would offset the weight saving arising out of the relief to the drag strut and the undercarriage leg.

(e) It is estimated thatthe following weight penalty would arise if the required 12,000 lbs. towing load were taken at the nose wheel:-

	Increase
Drag Stay Pickup	1 lb.
Local Stiffening of Longeron	5 lb.
Pivot pickups	15 lb.
Drag Stay	12 lb.
Undercarriage Leg	24 lb.
Total Increase	57 lbs.

E.W.H. Thompson
Chief Structures Engineer.

cc: F.N. Lindley
G. Hake
F.P. Mitchell
T.B. Rutherfoord

EWHT:dmh

APPENDIX 'B'

COPY

TRANS-CANADA AIR LINES

Montreal Airport
Dorval, Quebec
January 11th, 1955

File: 3022-3

A.V. Roe Canada Ltd.
Aircraft Division
Box 430, Terminal "A"
Toronto, Ontario

Attention: Mr. J.P. Booth, Logistics Engineer

Dear Sirs: Subject: Shear Pins for Aircraft Tow Bars

With reference to your leeter 8170/09/J, dated January 4th, 1955, on the above subject, we advise you that unless other information is forwarded by the aircraft manufacturer, we design the shear pins to shear at a push or pull load of 15% of the maximum aircraft take-off weight. By doing this, our maximum towing loads are smaller (for aircraft up to 100,000 lbs.) or equal (for aircraft over 100,000 lbs.) than the design towing loads specified in ANC2, October 1952, Ground Loads.

In addition to a shear pin for push and pull loads, we incorporate a second shear pin. This pin will protect the torque-link and steering mechanisms of the oleo leg when the wheel is turned inadvertently by the tow bar, while the above mechanisms are still engaged.

We hope this will answer your question, but if it does not, please do not hesitate to write us again.

Yours very truly

Signed by: J.C. Curtis

for

A.E. Ades
Asst. Director of Engrg.

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