

Sommaire ou Résumé

DOCUMENT INDEXED IN DRAWING FILE

TITRE

DOCUMENT APPLICABLE TO THE ADJUSTMENT  
OF MAIN ROTOR BLADES  
(332)

ON DYNAMIC BALANCING STAND.

Diffusion

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## INTRODUCTION

The purpose of this document is to describe the overall operations which must be performed to make main rotor blades interchangeable with one another, both from the dynamic and the aerodynamic standpoint.

This operation comes immediately after that for static balancing which guarantees equal centrifugal forces.

Specifically, the dynamic balancing operation consists in carrying out moment and tracking measurements with respect to a master blade.

Dynamic balancing is achieved by the chordwise displacement of balance weights located at the blade tip.

Aerodynamic balancing is achieved by cambering the tab.

A parameter called,  $\Delta I$ , is measured at end of balancing; it results of the effective twist of the blade and facilitates the trimming operations on aircraft by providing the best possible tracking right from the first rotation sequence.

## 1 - TEST CONDITIONS

### 1.1 - Atmospheric conditions

As a general rule, the requirements are as follows :

- . no rain nor fine drizzle
- . uniform wind, 25 knots (20 knots in average in case of buffeting gusts) or according to the quality of the measurements.

### 1.2 - Blade condition prior to balancing

- . The blades must have gone through a static balancing operation.
- . The tip caps must have gone through a weight adjustment operation.
- . Each blade must be balanced with its own tip cap installed with all the attaching screws.

WARNING - Never rotate without tip cap.

### 1.3 - Requirements to be met for guaranteeing the effectivity of the tests

- . All the dynamic balancing operations must be carried out with reference to a master blade.

As prescribed in Doc. GIR 3544, carry out the following checks :

- Daily :

$\Delta R/R$  and static zeroes (check twice daily in case of temperature variation exceeding 10°C).

- Weekly :

Calibration of recorders by dead weights and rotating zeroes as prescribed in Doc. GIR 3544.

- Monthly, or whenever a rotating component has been changed :  
Hub calibration check.

- Every 100 blades, or in case of high variation of accompanying blade :  
( > production tolerances).

Check the calibration of the secondary blade. In case of production rate exceeding 100 blades per month, this calibration shall be checked once a month.

IMPORTANT NOTE : Any blade having undergone modifications or repairs after dynamic balancing must be passed again through the balancing stand.

The personnel responsible for the balancing stand shall record any tendencies that they may have observed every day, as well as the results of the calibration checks, and report these to their direct hierarchy.

## 2 - TEST AND BALANCING EQUIPMENT

### 2.1 - Blade balancing system equipment and tools

#### a) Test equipment

- Moment measurements : 3 MECI Speedomax type graphic recorders (Leeds and Northrups license) are required (direct and differential measuring capabilities), accuracy :  $\pm 0.3\%$  F.I.R
- Tracking measurements : 1 cell-computer assembly Chicago Aerial model WMI/WMIA, measuring accuracy  $\pm 2$  mm.  
As an alternate, 2 graphic recorders (MECI 12.5 + 12.5 mV r.m.s. Lillipont) may be adapted to provide a better measuring accuracy

RADIUS for 332 : 28

or

1 cell-computer assembly

ALTILAS 2100 SORO with built-in graphic recorder,  
measuring accuracy :  $\pm 1$  mm, drag measurement capability,  
measuring accuracy :  $\pm 2/100$  of a degree.

#### b) Tools

- . 1 tab cambering tool
- . 1 11.804 kg weight (HES 607 940), for calibrating the MECI graphic recorders.

### 2.2 - Master blades

In order to ensure quality control over long periods of time, 3 primary master blades and 3 secondary master blades must mandatorily be available  
- See GIR No 3544.

These blades must be checked and adjusted on the static balancing stand once a year.

Provisions concerning approved and licensed balancing stands

The 3 primary master blades must mandatorily be sent in to Aerospatiale every 2 years for revalidation.

#### - Primary master blades

These serve only for checking  $\Delta I$  zero, calibrating the rotor head and recalibrating the secondary blades if need be. Whatever the circumstances, these blades must never be used when it is raining or when the atmosphere is dust-laden.

- Secondary master blades

These are used for balancing "production" blades and must be checked and touched-up if required with respect to primary master blade standards. Any differences which may possibly remain are counter-balanced by correcting operation (see GIR 3544).

The master blades must be stored in special premises sheltered against any contamination (grease, oil etc.) ; they must be carried on special trolleys on short paths and in containers corresponding to the relevant type of blade for travelling a long way.

They must be scrupulously clean and, if need be, washed with a water + Teepol solution or any MIL C 25179 A equivalent product. Next, rinse them with running water and wipe dry.

This operation must be performed immediately after removing the blades and prior to storing. Thus, it will be simply necessary to wipe them with a clean and dry rag before installing them for a new operation.

2.3 - Balancing stand blades

It is recommended to have available a set of blades for the balancing stand ; this set can be used for any test risking to put in question the balancing properties of the master blades (regulation adjustment, excessive rises in pitch, etc.)

The dynamic balancing qualities of these blades are the same as those imposed for the "production" blades.

### 3 - PREPARATION OF BLADES AND BALANCING STAND

#### 3.1 - Preparing the balancing stand

- . Designate a responsible for inspecting the balancing stand in accordance with instructions.
- . Check wind speed and direction (see test conditions), orient cyclic pitch  $1^\circ$  windward.
- . Check that rotation direction corresponds to type of blades to be installed.
- . Inspect the balancing stand area and remove any items liable to cause damage (rags, lockwire, etc.).

#### 3.2 - Calibrate the recorders - Doc. GIR No 3544

According to case, refer to appropriate maintenance schedule (1.3).  
Adjust static zero, proceeding as follows :

Bare head with adapters = N 250 RPM -  $\theta = 1^\circ$  dial, cyclic  $1^\circ$  FWD.

Adjust the recorders on direct and differential zero.

Stop the rotor, disconnect the rods and record the values obtained on each recorder (static zeroes).

#### 3.3 - Install the blades

- ##### 3.3.1 - Install the secondary master blade on the yellow sleeve (check serial number) and preset the $\Delta I$ value corresponding to this blade indicated on the results sheet.

Check the blade for cleanliness : if just rotated for a previous balancing operation, clean with a wet sponge and wipe dry.

(A soiled blade can cause an error in  $\Delta M\theta$  value reaching the tolerance limits).

- ##### 3.3.2 - Install the blade to be balanced on the blue sleeve ; set the $\Delta I$ to 0. Inspect the blade.

Check that the blade dash-number corresponds to that of a blade capable of being balanced with the installed secondary master blade.

Check for cleanliness.

Make sure that all the tip cap attaching screws are fitted.

Check the blade for overall condition (L.E, T.E, Tab, tip cap alignment, etc).

3.3.3 - Install the accompanying blade on the red sleeve (this serves for checking the stability of the adjustments).

Same cleanliness requirements as for the secondary blade.

4 - BLADES BALANCING PROCEDURE

4.1 - Adjusting the tab

4.1.1 - Run the rotor at 250 RPM nominal rating, at 1° collective pitch.

4.1.2 - Data recording

Cancel the track deviation for blue and red with respect to the yellow master, by operating the corresponding actuator.

CAUTION - Never touch the master blade yellow actuator when balancing production blades.

Record the moment values : direct measurement on yellow and differential measurement on blue and red. If the value of the blade to be balanced exceeds the differential measurement capability (instrument at full scale), change-over to the direct mode, multiply by three and reconvert the difference into algebraic value with respect to the master blade.

WARNING - For all measurements, the correction values must be taken into account while attempting to obtain the specified values (secondary sleeves and master blades).

4.1.3 - Tab corrections to be made

If the value shows a deviation exceeding 10mM, correct by cambering the tab.

. Positive differential value

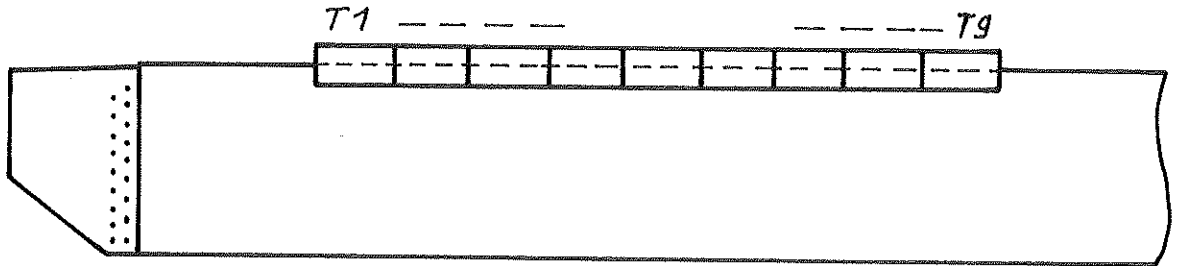
Camber tab downward

. Negative differential value

Camber tab upward

#### 4.1.4 - Procedure

The tab is divided into 9 segments :



N.B. - The segments T8-9 must be set to zero and must not be cambered ; these are reserved for in flight adjustment.

The adjustment possibility is of  $\pm 5^\circ$  with respect to the original 0 setting.

The use of tool No 703.A.94.1130.00 is mandatory.

The value corresponding to the adjustment must be entered on the blade equipment log card (FME).

Rule : When making the adjustments, attempt to camber the segments by the same value ; if this is not possible, camber segment T1 by  $1^\circ$  less, then T<sub>2</sub>, etc.

#### EFFECTIVENESS

$1^\circ$  on tab = 2 mN

#### 4.2 - Adjusting the weights

Rotation or nominal rating corresponding to type of blade to be balanced and blade pitch variation.

4.2.1 - Run the rotor at low pitch nominal rating.

4.2.2 - Recording the data

Cancel the tracking deviation at low pitch, then record the moments by direct measurement on Y and by differential measurement on B and R.

Increase the pitch by  $2^\circ$  at a time up to high pitch value corresponding to the type of blades being balanced ; record moment and tracking values at each step.

Determine the M $\theta$  and T $\theta$  difference between high pitch and low pitch for each blade.

This difference will be called slope ( $\Delta M\theta$  and  $\Delta T\theta$ ).

#### 4.2.3 - Corrections to be made

$\Delta M\theta$  and  $\Delta T\theta$  positive : move the weights forward towards the leading edge.

$\Delta M\theta$  and  $\Delta T\theta$  negative : move the weights back towards the trailing edge.

#### 4.2.4 - Procedure

On blades coming from the static balancing stand, the dynamic weights are contractually distributed :

<u>FNT stud</u>	3 weights 332A 11 1560.20	} 261.5 g
	3 weights 332A 11 1561.20	
<u>RR stud</u>	7 weights 332A 11 1560.20	} 542.5 g
	3 weights 332A 11 1561.20	
TOTAL		805 g

#### Weights effectiveness

70 g displacement =  $\Delta M\theta$  variation = 5 mN  
 $\Delta T\theta$  variation = 3.5 mm.

(see table, page 20).

#### 4.3 - Tolerance limits

Mt at all pitch values	*	$\Delta M\theta$ mN	*	$\Delta T\theta$ mm	*	INCIDENCE DEVIATION · $\Delta I$	TAB CAMB. (per unit) + $\lambda$	*
$\pm 4$	0.5	$\pm 6$	0.5	$\pm 8$	1.5	$\pm 20$	$+ 6^\circ$ $- 6^\circ$	1

\* Permissible overshoot in absolute value for 1 single parameter from measurement standpoint.

#### 4.4 - Resolving the $\Delta M\theta$ and $\Delta T\theta$ compromise

As the  $\Delta M\theta$  and  $\Delta T\theta$  parameters are associated with a same action (weights), it may be sometimes necessary to bring the  $\Delta M\theta$  to a maximum value so that the  $\Delta T\theta$  will fall within tolerance limits.

4.5 - Resolving the TAB-WEIGHTS compromise : for complying with moment tolerance limits at all pitch values.

For example :

The tolerance limits impose a  $\Delta M\theta$  value of  $\pm 6$  mN and of  $\pm 4$  mN at all pitch values.

This means that, for a  $\Delta M\theta$  of + 6, it will be necessary to have a negative low pitch moment of at least - 2 mN in order to fall within tolerance limits at high pitch.

$$LP = - 2 \quad HP = + 4$$

4.6 - Final acceptance readings and determination of  $\Delta I$  value

4.6.1 - Once the previous operations have been performed, a minimum number of 2 readings will have to be made for estimating the qualities of the blade based on an average (increase the number of readings in case of high variations).

Proceed as follows :

- . Cancel the tracking at low pitch,
- . record the  $H\theta$  and  $T\theta$  for each pitch value,
- . revert to low pitch and resume a new series of readings,
- . having completed these readings, do not stop the rotor and pass on to the  $\Delta I$  determining step.

4.6.2 - Determining the  $\Delta I$  value

Running at low pitch, cancel the tracking, rise in pitch several times and check that the tracking remains at zero at low pitch.

4.6.3 - Stop the rotor

Read the  $\Delta I$  value on the blue and red actuators.

If the  $\Delta I$  value correct :

Determine the mean value 2 readings and apply sleeve corrections (from values to be obtained).

Record following in the corresponding boxes of the test sheet :

- a
- .  $\Delta I$  value, \*
  - . tab camber, \*
  - . weights location,
  - . (L.E. - T.E.)  $\Delta$  (in remarks box),  
weight at L.E - weight at T.E

. operating time (for balancing)

. number of starts.

If the  $\Delta I$  value is out of tolerance : overshoot of less than four minutes, pass-on to  $\Delta M\theta - \Delta T\theta - \Delta I$  compromise

a | \* N.B. - These values must also be entered on the blade equipment log card (FME).

Carry over the values of the accompanying blade onto the graph for  $M\theta 1^\circ - \Delta M\theta - \Delta T\theta$ .

Inform the relevant engineer in case of excessive variations.

4.7 - Resolving the  $\Delta M\theta$ ,  $\Delta T\theta$  and  $\Delta I$  compromise (in event of  $\Delta I$  out of tolerance limits only).

If  $\Delta I$  negative  $\longrightarrow$  camber tab downward

If  $\Delta I$  positive  $\longrightarrow$  camber tab upward.

Effectiveness

$1^\circ$  on tab  $\approx$  2 minutes on  $\Delta I$  value

Example (general)

$\Delta I = - 22'$  (therefore 2' out of tolerance for tolerance)

$M\theta 1^\circ = 0$

$M\theta 7^\circ = + 1.5$

$\Delta M\theta = + 1.5 \Delta T\theta = 0$

$1^\circ$  tab camber downward on 1 segment

$\Delta I = - 20'$

$M\theta 1^\circ = - 2$

$M\theta 7^\circ = - 0.5$

$\Delta M\theta = + 1.5 \Delta T\theta = 0$

In some instances, the  $M\theta$  value at a certain pitch will not allow any compromise via tab adjustment ; in this case, resume adjustment of the weights (within tolerance limits) in the direction enabling tab trimming to become effective.

This procedure can also be used when tab trimming only is not sufficient for correcting the  $\Delta I$  out-of-tolerance.

When these requirements are met, resume the steps described in paragraph 4.6.

After these operations, the blade shall be considered as balanced.

The responsible shall check and sign the test sheet, and report the activities of the day on the daily sheet.

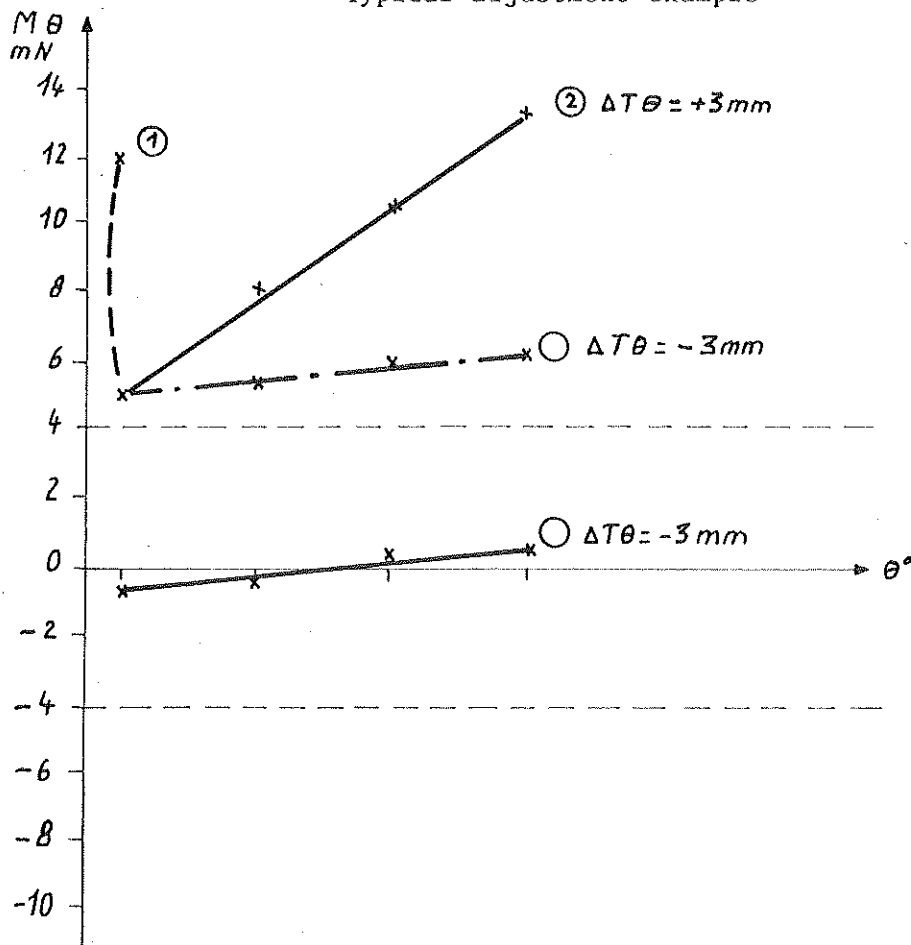
Before removing the blade, the operator shall mark it with a stamp : OK stand, or OT (out of tolerance).

5 - BALANCING STAND PARAMETERS

Adapter	Actuator position	Rotor N RPM	Pitch range used (dial)	Blade shank I at zero° on dial
87.05.330.11.0000 00 + 561 B 1000	Pitch lever yoke upper hole	250	0.5-2.5-4.5-6.5	6°12

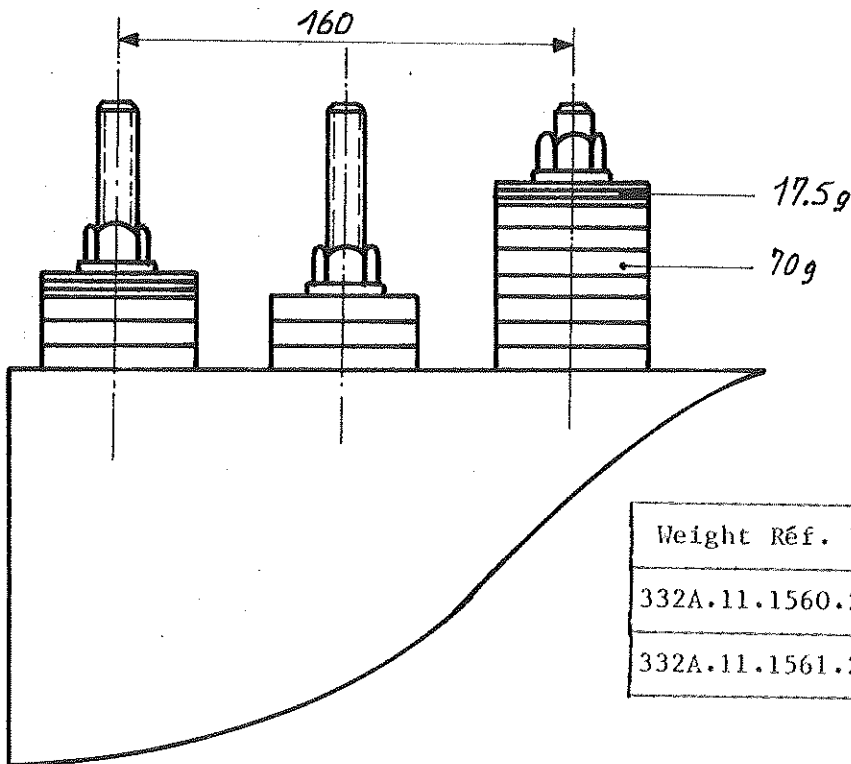
6 - CHARTS AND TABLES

Typical adjustment example



Rotation sequence	Result analysis	Action
1	0.5° Mθ deviates by more than 10 mN	Camber tab downward to return 0.5 Mθ towards zero
2	ΔMθ and ΔTθ positive ΔMθ out of tolerance	Displacement of weights towards leading edge
3	ΔMθ and ΔTθ correct ± 4 mN at all pitch values not respected	Decrease of 0.5 Mθ by cambering tab downward
4	Results correct ΔMθ ± 6 ΔTθ ± 8 Mθ ± 4 at all pitch values	ΔI, correct
Remove blade for finishing steps		

DISPLACEMENT OF DYNAMIC WEIGHTS  
ON 332 BLADES



N.B. Basic dynamic value : 805 g  $\pm$  32  
Center stud reserved for static  
balance adjustment ; do not  
displace the weights

