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LANDING GEAR BRAKES TESTING

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Abstract: *Utva Aviation Industry is in the process of certifying airplane Sova according to CS-23 regulations. Using different means of compliance, we are showing that our airplane is designed and manufactured to comply with all requirements.*

Along with numerous flight tests, we performed a flight test to show compliance of landing gear brakes with specific requirements. During the landing, we proved that brakes are able to prevent the wheels from rolling on a paved runway under specified conditions. Also, the pressure specified by the brake manufacturer was not exceeded while landing in previously determined landing distance.

Keywords: *Brakes, flight testing, landing distance, pressure.*

1. INTRODUCTION

UTVA Aviation Industry is finalizing the certification process of prototype Sova in normal and utility category.

Analysis and flight tests were performed in order to show compliance with CS 23requirements.

In this paperwork, compliance and tests for CS 23 Subpart D (Design and Construction) will be demonstrated.

2. CERTIFICATION

CS 23.735 Brakes requirements:

a) The landing brake kinetic energy capacity rating of each main wheel brake assembly must not be less than the kinetic energy absorption requirements determined from the following formula:

KE = ½MV2/N

KE = kinetic energy per wheel (J)
M = mass at design landing weight (kg)
V = aeroplane speed (m/s)
N = number of main wheels with brakes

b) Brakes must be able to prevent the wheels from rolling on a paved runway with take-off power in the critical engine, but need not prevent movement of the aeroplane with wheels locked.

c) During the landing distance determination required by CS 23.75, the pressure in the wheel braking system must not exceed the pressure specified by the brake manufacturer.

3. ANALYSIS

a) The kinetic energy the brake should absorb when slowing the plane to a stop is given by the formula

KE = ½MV2/N

In chapter 5 of the document "Analysis of increase in the maximum landing mass of the main leg and nose leg of the UTVA 75A aircraft" the value of kinetic energy was determined to be 198.15 kJ.

In paragraph 23.735(a)(2) is defined that kinetic energy can be calculated with the formula:

$$KE = \frac{mV_{s0}{}^2}{2N} = \frac{1200 \cdot 25{,}7^2}{2 \cdot 2} = 198{,}15\ kJ$$

$m = 1200\ kg$ take off max mass
$V_{s0} = 50\ kts = 25{,}7\ ^m/_s$ lift loss speed
$N = 2$ number os wheels with brakes

b) When taking off from Vršac Airport (flight No. 122), the minimum take-off and landing length was determined by holding the brakes at maximum power, in order to achieve the shortest take-off length. The diagram shows that the aircraft was idling at full power and maximum rpm and then went into the take-off phase

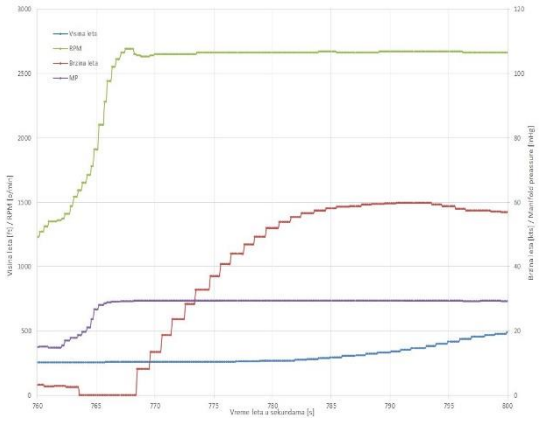

Figure 1. Flight parameters during flight No.122

From the condition that all absorbed kinetic energy is converted into thermal energy, i.e. KE=Q and by knowing the formula for thermal energy :

$$Q = m_d c_p \Delta T$$

we may evaluate mass of braking disc:

$$m_d = \frac{Q}{c_p \Delta T} = \frac{198{,}15}{0{,}49 \cdot 773{,}15} = 0{,}52\ kg$$

Braking cylinder is made of steel, like hollow cylinder, with outer diameter $d_s = 190\ mm$ and internal diameter $d_u = 133\ mm$. Knowing density of steel is $\rho = 7850\ {}^{kg}/_{m^3}$, braking disc thickness can be evaluated as :

$$h = \frac{4m_d}{\rho\pi(d_s^2 - d_u^2)} =$$

$$= \frac{4 \cdot 0{,}52}{7850 \cdot \pi(0{,}19^2 - 0{,}13^2)} = 4{,}58 \cdot 10^{-3}\ m = 4{,}58\ mm$$

Previous value corresponds to condition when wheels do not roll, at maximum gas and pressed brakes. Disc thickness on "SOVA'' aircraft is 5mm, so braking disc complies to requirements.

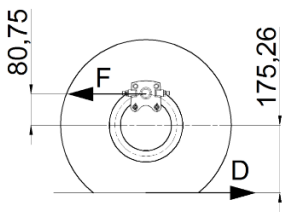

Figure 2. Brake dimensioning

Reduction of disc thickness of 2mm is expected as a result of exploitation for 400 braking cycles. Taking into account the need for a reserve, a value of 7 mm is adopted for the thickness of the brake disc.

c) According to the test plan, on 04/23/2020. three flights were performed, during which the landing was made on the concrete runway in Vršac. The aim of this test was to measure the pressure in the brake system during braking on a track length of 245.77 m previously determined in paragraph CS 23.75. The pressure in the brakes measured during braking must not exceed 30 bar.

The brake temperature measured after braking should be around 500 °C.

Before starting the test, it was necessary to perform the following activities:

- on the right landing gear wheel, instead of standard connector, place an adapter, so that the thread for the pressure gauge ½ NPT is positioned in the plane's flight direction
- position the manometer into the adapter in the plane's flight direction (figure 2)
- take transparent tape and wrap it around the landing gear wheel in several circles so that the hose, tube, adapter and pressure gauge are fixed
- place the camera on the landing gear right wheel so that the lens is directed towards the pressure gauge and secure it with transparent tape.

Figure 3a. Pressure gauge installation

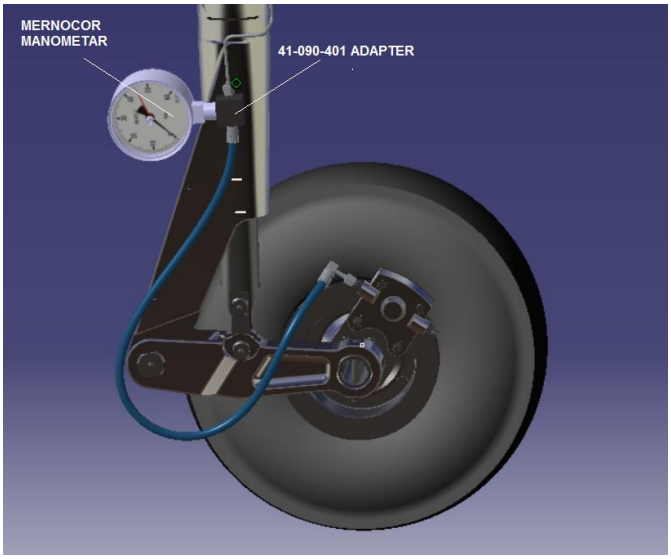

Figure 3b. Pressure gauge installation

The instruments for testing the brake system of the Sova aircraft consists of the following devices:

- MVP-50P
- GT-50
- G500
- pressure gauge MERNOKOR E1805771161
- laser thermometer DT8011H
- camera.

Test procedure:

- Front centering, with maximum mass, i.e. 1200 kg.
- Pour the ful into both tanks up to the filler cap, i.e. a total of 150 l
- Maximum oil quantity (8 Qts).
- 115 kg of ballast on the co-pilot seat (point 1) and a total of 9 kg on the passenger seats (points 2 and 3), the center of mass is then at 27.3% MGC.
- In order to check the correctness of the pressure gauge, it is necessary to carry out a test on the ground of the airport "Utva" Pančevo by taxiing on the runway at 70% of rotation speed and perform sudden braking
- After the ground test, reset the pressure gauge and fly to "Vršac" airport.
- When landing on the concrete runway of the "Vršac" airport, brake suddenly so that the landing distance is as short as possible. This test should be performed as part of the runway length test during landing.
- As soon as possible, take the DT8011H laser thermometer, point it towards the brake disc, measure the temperture, record it and take a picture with a camera
- Write down the measured value and take a picture with the camera.

Test results:

During braking, before wheel slippage, pressure values of 29 ÷ 32 bar were measured in the brake system (figures 1 – 3).

p=32 bar

p = 30 bar

p=29 bar

Figure 4. Measured pressure values during braking

The operating pressure in the brake system installation is 40 bar. The system was designed and tested for a pressure 2.5 times higher than operating pressure, which is 100 bar. It was demonstrated that all joints can withstand the pressure values obtained by braking on a concrete runway during landing.

3. CONCLUSION

Different means of compliance are used during the aircraft certification process. Consultations with test pilot, writing test plans, pre-flight and post-flight checks, the testing itself and finally analyzing the obtained data make the flight testing very interesting and demanding.

Utva engineers are very proud and thankful for having such a good test pilot and flight test team which made it easy to successfully perform all necessary flight tests in order to certify ‘’Sova’’ aircraft.

References

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