# ADJUSTABLE LARGE RANGE ROTARY DEPLOYMENT DAMPER

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**ABSTRACT**

This paper presents an adjustable large range rotary deployment damper. Viscous rotary dampers are for limiting deployment rates of spring driven mechanism.
Two major activities of this project are to increase the deployment range up to 270 degrees and to enhance the adjustability of the stiffness characteristic, using an easily handable adjustment device.
However, this type of damper necessitates application of highly viscous silicone oil as working fluid. To avoid contamination of the adjacent equipments leak tightness is an important point.
The device as presented is designed for temperature ranges for operation of -30 to +50 °C and for survival of -150 to +150 °C.

## 1. INTRODUCTION

The new Adjustable Large Range rotary Deployment (ALRD) Damper (Figure 1) is a further development of the Viscous Rotary Damper (RD1), which has considerable flight heritage. This viscous passive damper, which was developed under an ESA contract, is designed for a deployment angle up to 90 degree.

Directly driven viscous rotary dampers for limiting deployment rates of spring driven mechanisms provide sufficient resistive torque without mass and reliability penalties associated with high ratio gears as required for equivalent devices such as centrifugal brakes or eddy current dampers.

The function of the Rotary Viscous Damper is a passive damping system, in order to limit the shock at the end-stop via controlling the angular rate of the appendage during deployment.

Two major activities of this project are:

- Increasing the deployment range up to 270 degrees
- Adjustment unit to modify the damping rate easily

The Rotary Viscous Damper essentially consists of housing and shaft with vane (rotor). Rotation of the shaft relative to the housing causes displacement of working fluid by the vane ahead of the working chamber in the direction of rotation and an equal amount of increase of volume behind the vane. Since the fluid can be considered incompressible, it is forced through the gaps between rotor and housing, and through the bypass, corresponding to the changes of the volumes ahead of and behind the vanes associated with its movements. The resistive torque generated mainly results from the pressure difference across the vane (in the direction of rotation), which is a consequence of the fluid flow, and the seal resistive torque. The resistive torque is nearly proportional to the rotor speed and the fluid viscosity.

*Figure 1 – ALRD damper*

## 2. DESIGN DESCRIPTION

The objective of the new damper was to develop and qualify a viscous rotary damper which is easily

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adjustable in damping rate and has a deployment angle of about 270 degree.

Another aim was to develop a damper with a simple design and small number of parts. The viscous deployment damper consists mainly of the housing and the rotating shaft. When turned, the rotor forces highly viscous working fluid through narrow gaps and the bypass. The resistive torque thus generated is proportional to shaft angular rotation rate and fluid viscosity.

Main characteristics of the damper:

- The transmittable torque is up to 25 Nm
- Low startup torque
- The operation temperature range is from -30°C to +50°C
- Survival temperature range is from -150°C to +150°C
- Low mass of approximately 290g and low envelope
- Leak Rate in space environment less then 3x10-8g/s

The adjustment shaft is the modified shaft from the previous design. Inside the shaft is a bolt. By turning the bolt, which is connected to the shaft by a thread, the cross- section of the throttle by-pass between the high pressure chamber and the low pressure chamber can be changed. With this screw device the damping rate can be adjusted in the range of ±25% without changing the oil.

The Adjustment Unit is necessary, because the part dimensions after manufacture revealed that the gap heights in practice were slightly greater than designed. To establish the characteristic as designed, the cinematic viscosity at 25° C of the working fluid as applied was increased to 300000 mm²/s. With the adjustment device we can gauge the characteristic without changing the oil.

To achieve the deployment angle of 270 degree, the shaft of the old damper has to be redesigned. This damper has a symmetric two vane rotor. The ALRD rotor is a one vane rotor, so the pressure inside the damper is doubled. New stronger bearings have to be chosen. A stronger shaft and housing have to be developed.

The high temperature range for the damper causes a thermal expansion and a thermal shrinking of the fluid. An expansion chamber is included to ensure that the pressure inside the damper will be at nominal value.

The interface of the damper between damper shaft and payload is an internal serration, allows accurate angular adjustment of the payload. The flange of the housing is the other interface (Figure 2).

The "double-seal" concept featured by two seals arranged "in series", has been taken over the old damper design. This concept applies to the shaft seals and the static seals. The dynamic shaft seal material are two PTFE washers reinforced with glass fibers. The static seals are PTFE and the adjacent threads are filling with RTV 691, this is the second seal.

The design is assessed by analysis and by tests.

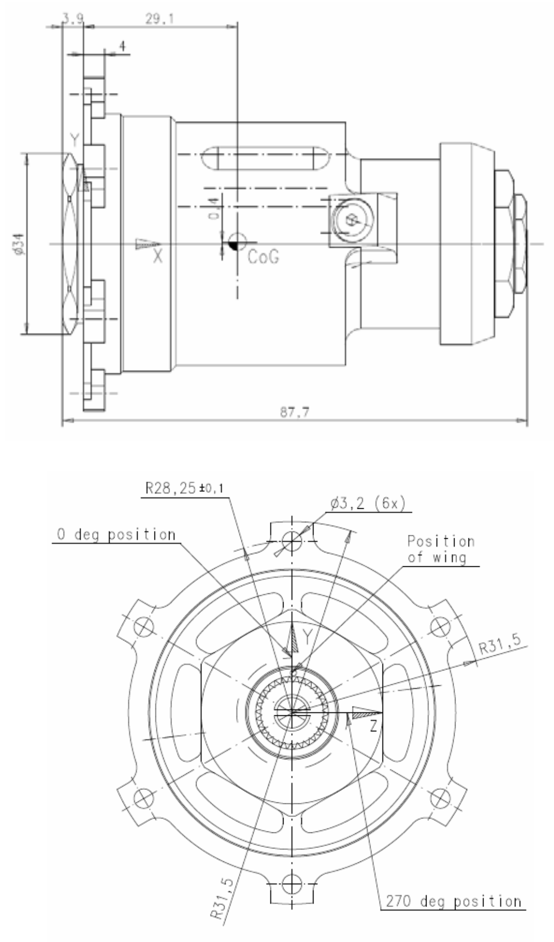


*Figure 2 –I/F ALRD damper*

### 3. FUNCTIONAL DESCRIPTION

In Figure 3 illustrate a cross-section through the viscous rotary damper. This design is a combination of a “gap-flow” type with a tunable “throttle-flow” permits an adjustment of the damping rate. The cross-section of the bores can be modifying by the adjustment devise.

Rotation of the shaft causes displacement of the working fluid which in turn is forced to flow from one part of the fluid chamber into the other through narrow gaps between vane and housing.

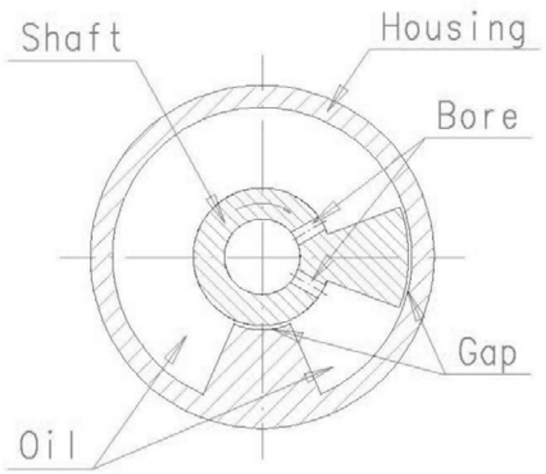


*Figure 3 –cross-section of ALRD damper*

For both operating principles applies that the pressure difference across the vane (in the direction of rotation), as a consequence of fluid displacement and the resulting flow, accounts for most of the resistive torque acting on the rotor. Contributions of the shear stresses acting on the rotor can be neglected. Seal and bearing resistive torques are much smaller than the torque of the required spring motor.

To study the characteristics of such a damper, the flow from one part of the working chamber into the other when the rotor is turned is assumed to occur solely through the small gaps between vane and housing when the cross-section of the bores is closed (Figure 3). Calculation of the pressure difference across the vane can be based on the assumption of laminar flow. The optimum working fluid with respect to keeping mass of the damper as low as possible is thus featured by very high dynamic viscosity and small change of viscosity with temperature. The silicone oil Baysilone M 300000 has the corresponding properties.

An expansion vessel connected to the working chamber with a bore is required to compensate the considerably higher thermal expansions of the fluid compared to the metallic parts of the damper. Furthermore, sufficient internal pressure is required to prevent formation of vapor bubbles in the damper working chamber.

## 4. TEST RESULTS

The following tests are realized:

- Friction Test without fluid
- Helium Leak Test
- Performance Tests at -30°, 0°,RT, +50° & 5Nm, 10 Nm, 15Nm, 20Nm, 25 Nm
- Random Vibration Test
- Thermal Vacuum Cycling Test

The objective of the Performance Test is to demonstrate that the ALRAD Damper is in compliance with the performance requirements at -30°C / 0°C / RT / +50°C and at applied torque of 5Nm, 10Nm, 15Nm 20Nm and 25Nm.

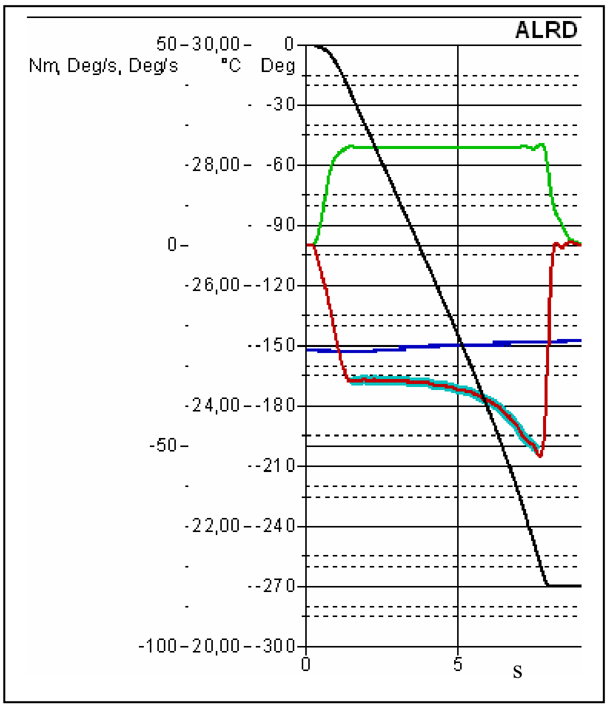


*Figure 4 – Performance Test*

The Figure 4 shows a typical Performance Test of ALRD. The test parameters are:

- Room temperature
- Resistive torque 25Nm
- Adjustment bolt is a little bit open

The constant torque (green line) of e.g. a spring driven motor is simulated by an electric motor. The black line shows the rotation angle of the shaft (0 to 270 degrees). The velocity of the rotation is indicated by the red line.
The increase of the speed depends on complicate fluid dynamic effects of increasing and decreasing volumes in the chambers. The damping rate (Figure 5) of the ALRD damper is indirectly proportional to the rotation speed. In the figure can be seen that the damping rate is not constant and depends on the position of the shaft.
The damping rate at the end of deployment, as specified according to customers requirements, can be adjusted with the adjustment tool.

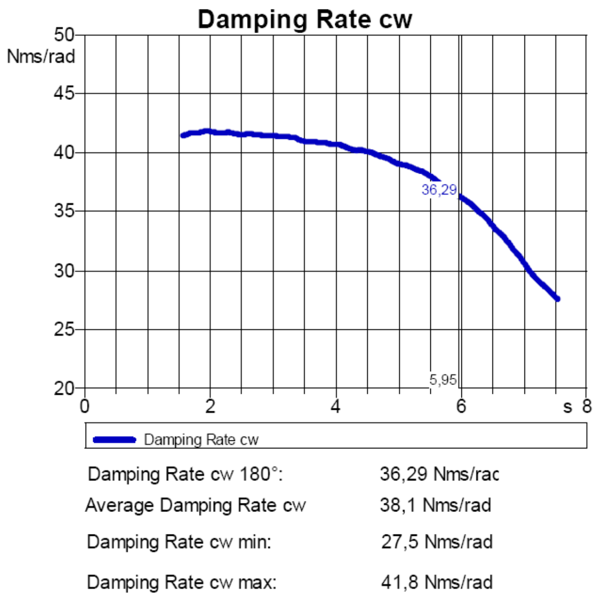


*Figure 5 – Damping Rate*

## 5. SUMMARY AND CONCLUSIONS

Viscous rotary dampers for limiting deployment rates of spring driven mechanisms are featured by simple designs and a small number of parts compared to equivalent devices such as centrifugal brakes or eddy current dampers.

Directly driven viscous rotary dampers, which have been successfully flown on several spacecrafts, provide sufficient resistive torque without mass and reliability penalties associated with high ratio gears.

RUAG Aerospace Austria has developed for space application a lightweight Adjustable Large Range rotary Deployment (ALRD) damper which provides speed-dependent resistive torque to a corresponding spring actuated mechanism in order to prevent high shock loads when the end stop of the mechanism is reached.

The ALRD essentially consists of housing and rotor. When turned, the rotor forces highly viscous working fluid through narrow gaps. The resistive torque thus generated is proportional to shaft angular rotation rate and fluid viscosity. The damper thus eliminates the need for high ratio gears and their corresponding mass.

The viscous rotary damper as presented is designed for temperature ranges for operation of -30 to +50 °C and for survival -150 to +150 °C. Double independent seals arranged in series for the shaft seals (dynamic) and for all static seals, each capable of retaining the working fluid in the damper. The shaft seals and the working principle of the damper generate exceptionally low starting torque, thus requiring significantly less deployment spring torque and thus reduce spring mass of the corresponding mechanism.

The combination of viscous dampers and spring motors can be applied for powering mechanism in a similar manner as electrical drives. The deployment range of 270 degree will be increased the applications for space flight.

This damper concept has been assessed as very versatile and suitable for space applications.

## 6. REFERENCES


1. F. Koller, T. Nitschko: “Viscous Rotary Damper”, Proc. 'Fifth European Space Mechanisms and Tribology Symposium'. ESTEC. Noordwijk, The Netherlands. 28-30 October 1992 (ESA SP-334, April 1993)