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Forces from the MONALISA double bellow system: Reports from initial tests.

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Abstract

The forces which may be generated by the MONALISA double bellows system on the Shintake monitor and quadrupole magent QD0 to which it designed to be attached are of great interest. In this report we present test results from measurements of the double bellows system at both atmospheric pressure and in its compensated evacuated state. A lateral spring constant of 35 ± 5 N.mm^{-1} was measured. The pressure compensation system was also tested in two cycles; from ambient pressure down to the compensated evacuated state and back. Longitudinal forces were measured during both cycles and found to remain below 50 N at all times.

1 The Double Bellows System

The MONALISA double bellows system (DBS) forms the vacuum enclosure coupling between interferometer components at each end of a compact straightness monitor, intended to provide nm resolution measurements of relative motion between the focusing quadrupole magnet, QD0 and the Shintake monitor.

The double bellows system (DBS) consists of two concentric cylindrical chambers with a bellow connection at each end to flange pieces which couple to attachment pieces on the Shintake monitor and QD0 magnet. The DBS is roughly 53 cm long; the inner chamber has roughly a 15 cm diameter and the outer chamber is roughly 30 cm in diameter. The inner chamber is to be evacuated during interferometer operation. The outer chamber is over-pressurised to achieve a minimisation of the resulting longitudinal forces[1].

2 Pressure compensation

A system is used to provide compensatory over pressure in the outer chamber whenever the inner chamber pressure falls below ambient. The aim is to compensate the longitudinal force on each end flange of the double bellow system; the inner chamber low pressure sucks the end flange towards the centre of the double bellow system while the outer chamber over-pressure pushes the end flange away. For an ambient pressure due to the weather, W the forces are in balance whenever;

[1]It also happens that this over-pressure helps maintain a much lower lateral spring constant than would have been achieved with just the inner chamber and bellows.

$$(W - P_{\text{inner}})A_{\text{inner}} + (W - P_{\text{outer}})A_{\text{outer}} = 0 \tag{1}$$

for inner chamber pressure P_{inner} and area A_{inner} and likewise for the outer chamber.

Measuring the pressure difference between ambient and inner chamber gives a control signal for the pressure feed to the outer chamber. This signal is proportional to the required overpressure $P_{\text{outer}} - W$ and is used to modulate the operation of a valve which regulates the over-pressure of the outer chamber using a supply of compressed air. The pressure compensation system will be described in more detail in a later version of this report.

3 Large dynamic range tests

The tests described in this section were performed with the DBS free and not coupled together with any other parts of the MONALISA vacuum enclosure. This allowed a much greater degree of freedom of movement than would have otherwise been possible, allowing the bellows to be studied in isolation from the support frame and enabling the spring constant and other force measurements to be made over a wider range of displacements. For measurements made at non-ambient pressures, the pressure compensation system was operational.

3.1 Lateral spring force measurements

The lateral spring force was measured at one end of the double bellows system. The cylindrical structure was laid with its main axis parallel to the floor and a small lateral bias displacement was induced by lifting the one end away from the floor against the lateral spring of the double bellows system. The extra force needed to increase the lateral displacement was measured for each extra displacement and the proportionality between these two sets of data gave a lateral spring constant of 35 ± 5 N.mm^{-1}. The spring constant value lay in this range for both chambers at ambient pressure and also for inner chamber evacuated (pressure less than 10 mbar) and an over-pressurised outer chamber.

3.2 Longitudinal forces

The longitudinal forces induced by evacuating the inner chamber are compensated by a feedback control system as described briefly in Section 2. Any residual forces are due to imperfect compensation. These forces have been measured as the inner chamber pressure was cycled from ambient pressure down to evacuated (less than 10 mbar) and back to ambient. For these test the double bellows system was stood up, (with the cylindrical axis vertical) and one end flange resting on the laboratory floor. A weight gauge was held in mild tension between the top surface (upper end flange) of the double bellow system and a higher support beam.

The change in tension (from the initial bias value) has been attributed to forces caused by imperfect pressure compensation. These forces are shown in Figure 1 as the inner chamber pressure is ramped down and then back up, in two cycles.

4 Summary

A series of tests have been performed on the double bellows system (DBS) to investigate the likely forces it may generate when in-situ between the ATF2 Shintake monitor and quadrupole magnet QD0. The DBS has been fitted with a pressure compensation control system which

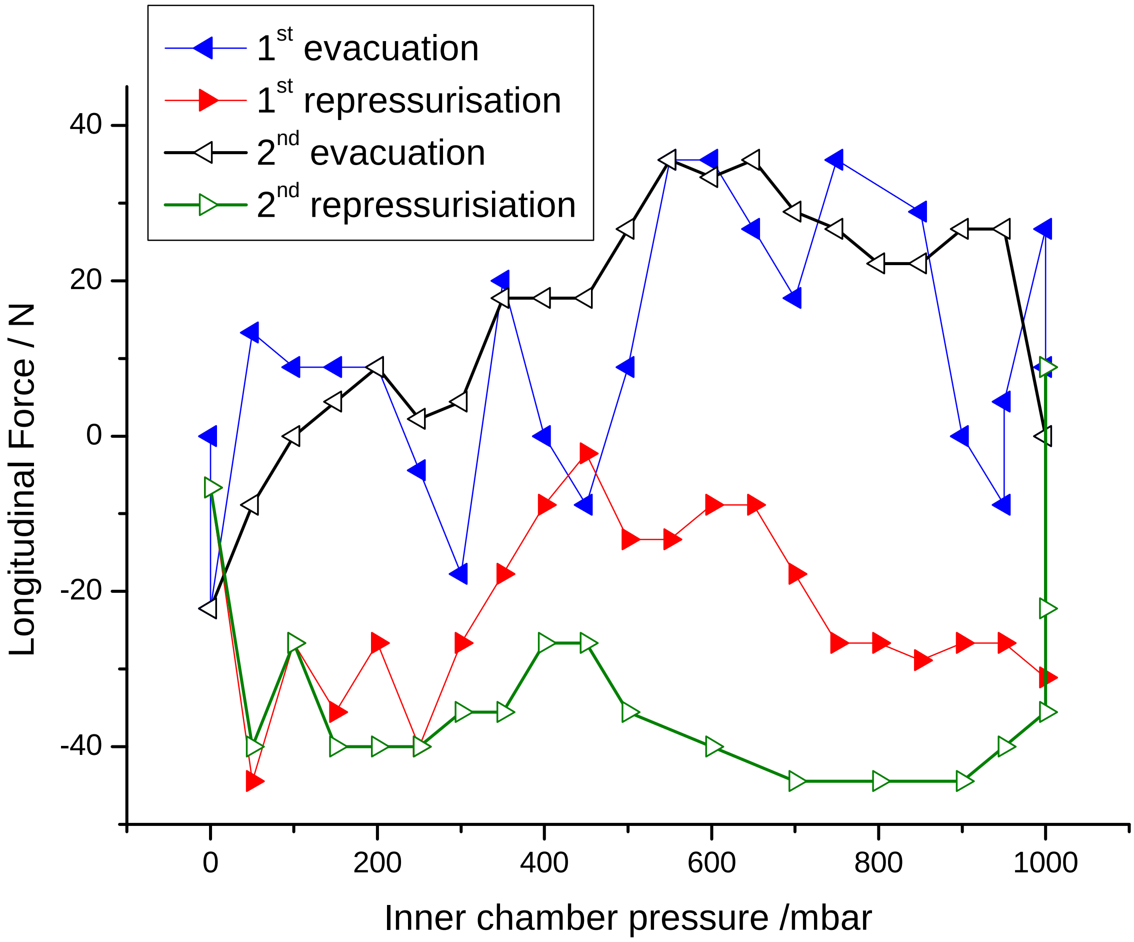

Figure 1: Residual forces during cycling the pressure of the inner chamber of the MONALISA double bellows system, with the pressure compensation system in operation.

maintains an over-pressure in the outer chamber of the bellows system when the inner chamber is at reduced pressure. A lateral spring constant of 35 ± 5 N.mm^{-1} was measured at ambient pressure and in the evacuated state. The residual longitudinal forces were shown to remain below 50 N during two cycles of inner chamber pressure from ambient down to evacuated and back. The results are made available to the ATF2 community as requested in previous discussions and at the weekly ATF2 meeting of Wed 17 June 2009.

A Documentation revision history

Revision	When	Notes
1.0.0	Mon 22 June 09	First started document

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