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SOME INTERESTING OBSERVATIONS DURING VERTICAL TEST ON ESS-HB-704 SRF CAVITIES*

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Abstract

The vertical test stand in use at Daresbury has three cavities loaded horizontally at different heights. The jacketed cavities are supplied with liquid helium (LHe) from a header tank at the top of the configuration. A few cavities have been tested in different positions and the results have been analysed.

The pressure of the helium inside the jacketed cavities is affected by the height of the liquid helium column above the jacket. Using results from earlier analysis during cooldown enables the pressure of the cavity to be determined from the frequency of operation. Analysis of the effects may allow for corrections to the frequency to be made.

In addition, there have also been some challenges at higher power as the phase of the self-excited loop driving the system, has been seen to change.

This paper discusses some of the observations and challenges that are being addressed in the continuing use of this facility.

INTRODUCTION

High-β superconducting cavities for the European Spallation Source (ESS) are being tested in Daresbury Laboratory. The cryostat used [1] can be populated with up to three jacketed cavities that can be tested during the same run. The jacketed cavities are mounted horizontally but are stacked vertically on a Cavity Support Insert (CSI) (see Fig.1). For the accelerating gradient tests, the temperature of all cavities are assumed to be at the same superconducting temperature of 2.0 K. The pressure in the cavities will not however, be the same due to the different hydrostatic pressure as the height of liquid helium above each cavity will be different.

The separation of pairs of cavities is 0.62 m (h) and the height of the top cavity is 0.984 m below the height of the header. For the cavities the separation of 0.62 m can be used to calculate the change in the hydrostatic pressure. Assuming the density of LHe (ρ) is 146 kg/m^3 at 2.0 K [2], this gives the increase in pressure (p) going down to a lower cavity:

$$p = \rho\, h\, g \qquad (1)$$

where (g) is the gravitational potential.

Thus the increase in pressure going down to a lower cavity will be approximately 8.9 mbar.

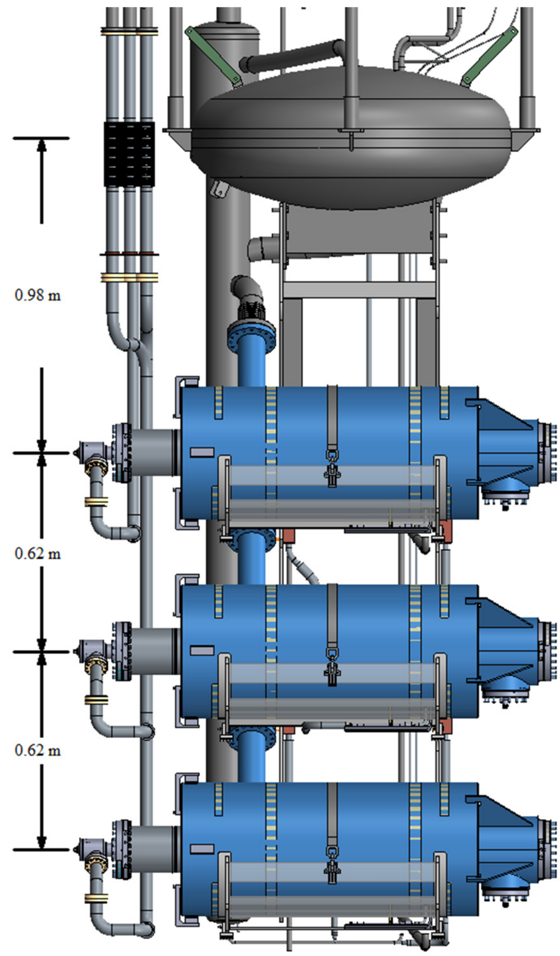

Figure 1: Arrangement of the cavities on the CSI.

During the commissioning phase of the test system there were a couple of opportunities to test the same cavity in different locations. This has yielded evidence of the effect of the pressure dependence: one cavity has been tested in all three possible locations.

As part of the specification tests the surface resistance of the cavities is measured at several temperatures between 2.0 K and 4.0 K: in practice the upper temperature is restricted by cryogenic operations depending on whether a top or bottom fill is used but the results presented here only show the results from after the LHe becomes superconducting. The resonant frequency of the fundamental mode of the cavity is measured at low power as the temperature decreases: this is achieved by pumping down on the LHe to bring the temperature down.

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MEASUREMENTS

The vapour pressure of the gaseous helium (GHe) is measured during this test. The resulting resonant frequency as a function of the GHe vapour pressure when the LHe is superfluid is shown in Fig. 2. These show that the frequency increases uniformly with the pressure inside the jacket around the cavity. The reason is that the higher the pressure surrounding the cavity deforms it to become physically smaller and hence will operate at a fractionally higher frequency. Thus the predicted difference of 8.9 mbar between cavity locations suggests a frequency change of approximately 750 Hz (85 Hz/mbar).

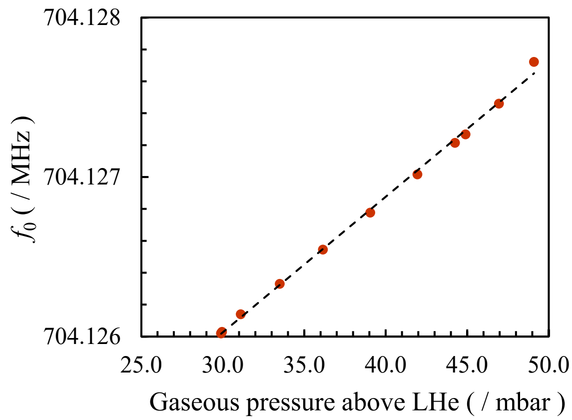

Figure 2: Measurement of cavity during cool-down showing frequency dependence on vapour pressure over LHe in CSI.

Accelerating Gradient Tests

One of the cavities has been tested in the 3 available locations (see Table 1).

Table 1: Runs involving the same cavity.

Position	**Run**	**Date**
Top	10	10/3/2021
Middle	9	22/1/2021
Bottom	15	17/6/2021

The result for the accelerating gradient tests are presented alongside in Fig. 3. The accelerating gradient tests do not guarantee that the height of the LHe column is exactly the same since tests can be carried out with LHe levels well below the height of the header tank. However, for all of the runs the cavity was tested first after the fill.

It should be noted that the level of the LHe does change slightly during the test as LHe evaporates. The header is designed such that the cross sectional area is greatest for most of the operation. It is normally possible to repeat the measurement a couple of times without any noticeable change in the resonant frequencies. The date in Fig. 3 shows a reduction in the resonant frequency as the cavity is operated at progressively higher accelerating gradients but this is outside the scope of this article.

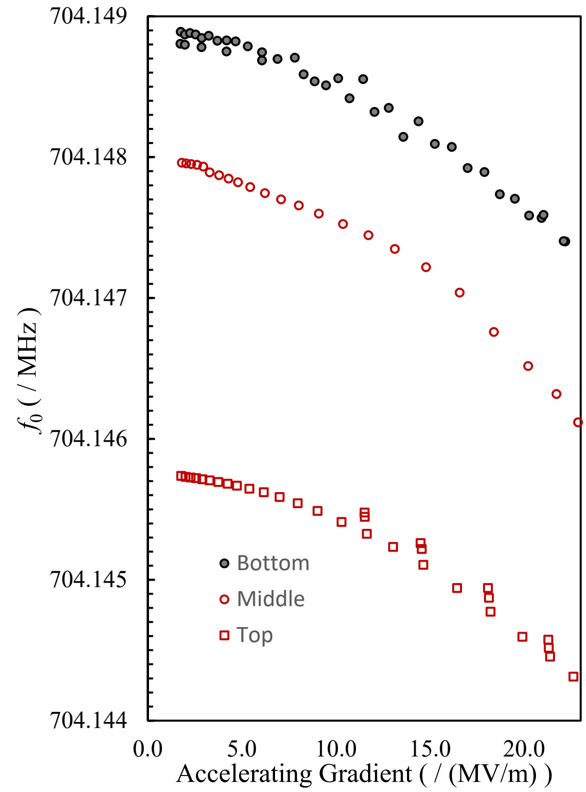

Figure 3: Accelerating gradient results from the same cavity in different locations.

The results show that the lower the physical cavity position the higher the frequency of operation. This arises since the pressure in the jacket when in a lower position will be greater than when the same cavity is in a higher position at the same temperature due to the increased height of the LHe.

CONCLUSIONS

The position of the cavity in the stack does have a small effect on the operating conditions of the cavity due to the pressure change. This effect is repeatable and a small adjustment can be made to compensate for this effect.

ACKNOWLEDGEMENTS

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