STATUS REPORT OF THE TTF CAPTURE CAVITY CRYOSTAT

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ABSTRACT

We describe the capture cavity cryostat, for the Tesla Test Facility at DESY in Hamburg, which was designed and is presently under assembly in France. We also discuss the construction of an ancillary feed box which is required for a preliminary cryogenic test prior to delivery.

INTRODUCTION

The capture cavity is the first cryogenic device on the beam line of the Tesla Test Facility (TTF) at DESY in Hamburg and will connect the "warm" injector to the first cryomodule.

Design, manufacture and integration of the different parts of the cryostat are substantially done in France and will be completed locally in order to perform two cryogenic tests prior to the delivery to DESY. This decision, however, implies the construction of major ancillary equipment for supply and control of the cryogenics in this first phase.

REFRIGERATION

The capture cavity is mounted in a separate cryostat at the end of the injector. For its final installation at DESY (1) a common feed box provides the cooling for Cryocap as well as for the subsequent cryomodules, connected partly in parallel, partly in series at the following three temperature levels :

- a supply of two-phase He at 1.8 K, 16 mbar which maintains a constant level of superfluid LHe around the cavity,
- a second loop, fed with supercritical He at 3 bar, enters at 4.5 K and cools a heat sink on the RF input coupler,
- a third loop uses He gas at 14 bar and 60 K for cooling a single radiation shield.

For initial cool-down or final warm-up of the cavity a small feed line is connected to the bottom of the LHe tank.

CRYOSTAT

Figure 1 shows the composition of Cryocap.

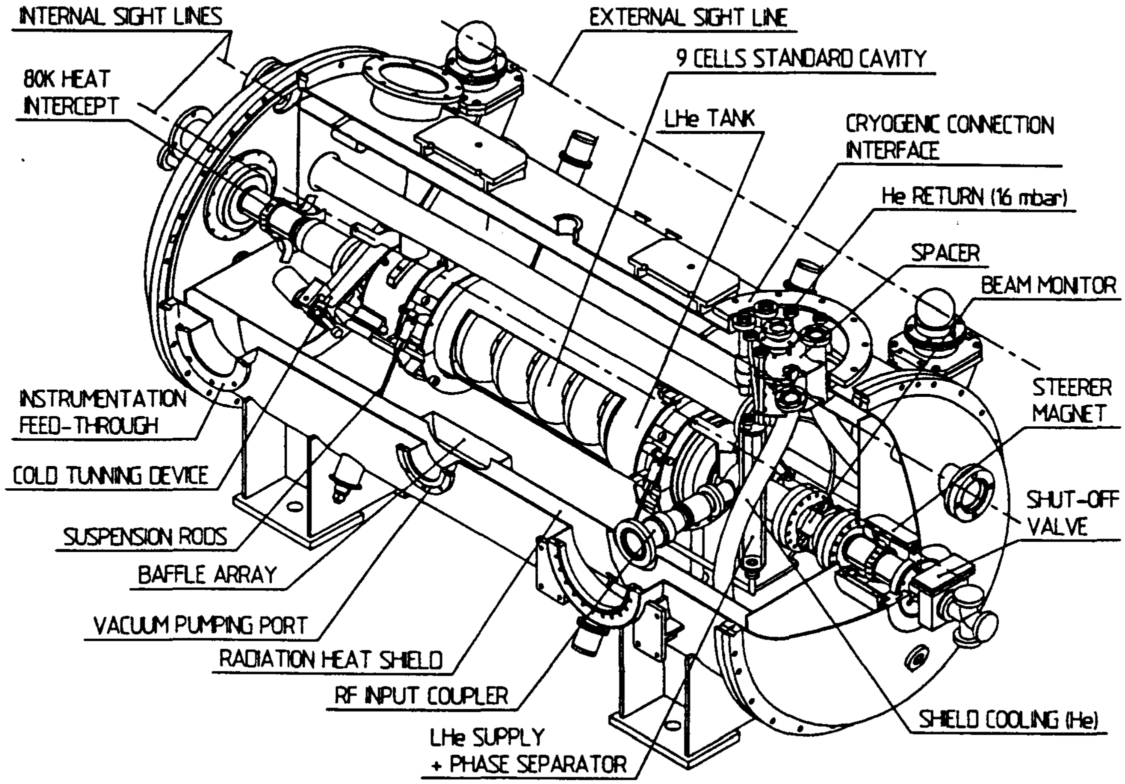

Figure 1. Capture cavity cryostat (CRYOCAP).

LHe tank with cavity

The capture cavity consists of a single but standard 9 cell 1.3 GHz cavity and features the new concepts developed for the TESLA project, i.e. integration into a cylindrical helium vessel with a reduced capacity (23L), with all RF couplers located outside in the vacuum space and thus cooled by conduction only through the niobium walls of the cavity.

The LHe tank is made from titanium, easy to weld to niobium and of a similar thermal contraction. But as niobium turns brittle at very low temperature, the composed titanium-niobium reservoir is not accepted as a pressure vessel, therefore the outer vacuum tank has to assume the duty of a containment volume.

Fine RF tuning of the cold cavity is obtained with a mechanism which compresses the whole 9-cell assembly by approximately ± 1.5 mm.

Passive magnetic shielding of the cavity is provided with a sheet of Cryoperm placed on the LHe tank.

10 layers of superinsulation are wrapped around the fully equipped LHe vessel.

Suspension system

Two split suspension rings are clamped onto the LHe vessel. A radial suspension device with 2 x 4 rods of epoxy-fibreglass, in an antagonistic array which permanently blocks any thermal contraction, maintains the cavity in its adjusted initial position. Such a mounting is acceptable since the low Young's modulus of the composite induces only moderate thermal stresses which may occasionally be measured with a set of 4 strain gauges mounted in the upper fixture of the suspension rods.

In the axial direction, the LHe tank is blocked with a finger device which penetrates from the vacuum tank into one of the suspension rings.

Radiation heat shield

The thermal radiation from ambient temperature to the cavity is intercepted by a single copper radiation shield cooled to 80 K with forced flow He or LN circulation on its cylindrical part. It integrates into the vacuum tank where it stands on 4 nylon bases. Both removable end covers are conduction cooled.

Heat flow from the surroundings is reduced with a blanket of 40 layers of superinsulation.

The insulating vacuum is autonomous ; a specially devised barrier, located in the cryogenic connection line, separates it from the feed box vacuum space.

A blackened baffle array on the radiation shield allows an efficient evacuation of the innermost vacuum space.

Its basic function apart, the radiation shield also serves other purposes :

- it provides a heat sink for thermal intercepts,
- it supports a solenoidal coil for active magnetic shielding during cool down,
- it may be used to accelerate a warm-up of the cryostat with a thermocoax resistor soldered onto the copper cylinder.

Vacuum tank

The vacuum tank, made from stainless steel, is designed for a service pressure of 1.2 bar abs. As a containment vessel for the fragile cavity reservoir it is protected with a big safety valve against any excessive overpressure.

The removable end caps define the primary alignment axis for the cavity with two permanent sight lines through the entire cryostat, thus allowing an occasional check of the cavity position even in a cold state.

Heat load

A thermal budget estimate limited to the fully equipped CRYOCAP is given in Table 1.

Table 1. Heat load estimate for Cryocap

Temperature level (K)	Nature of heat flow	Static heat flow with no RF power (W)	Static heat flow with full RF power (W)
80	Conduction (supports, heat intercepts)	15	18
	Radiation	37	37
	Total	**52**	**55**
4.5	Intercept on RF input coupler	**0.3**	**0.5**
1.8	Conduction (supports, electric leads)	1.1	1.1
	Radiation	0.4	0.4
	RF power dissipation in cavity	-	1.3
	Total	**1.5**	**2.8**

ANCILLARY FEED BOX (AFB)

For the first cryogenic tests in France, a special ancillary feed box was built which substitutes for the DESY feed box and provides the cooling for Cryocap at 1.8 K and 4.5 K with liquid helium (LHe) and at 80 K with liquid nitrogen (LN) corresponding to the flow scheme of Figure 2.

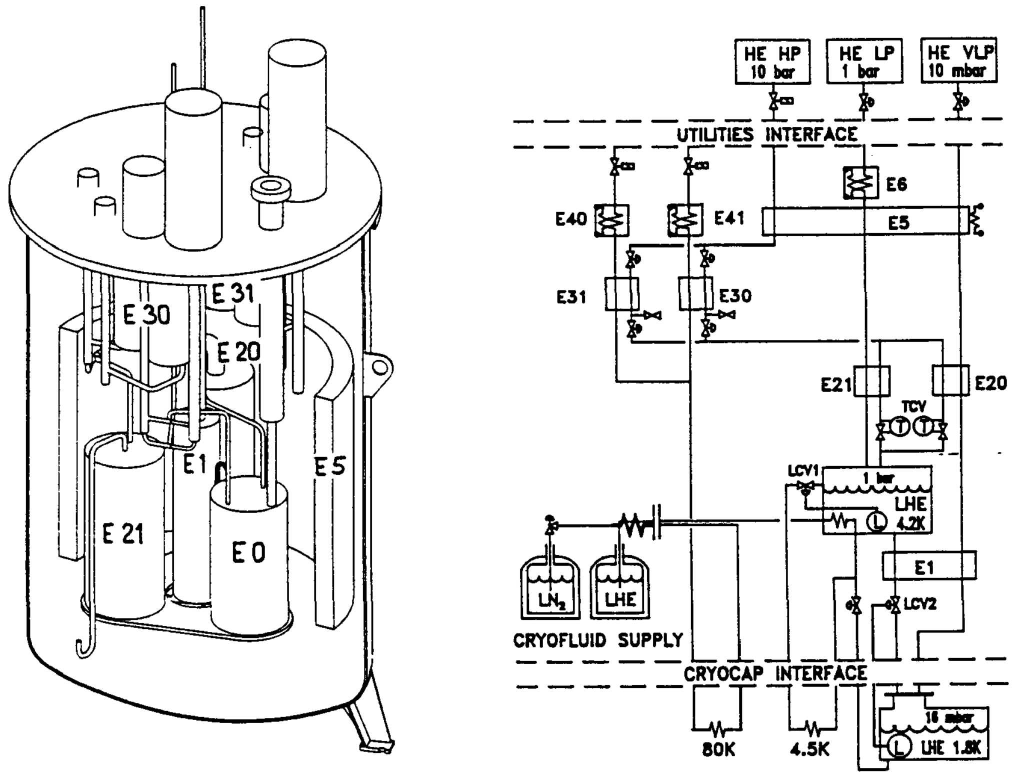

Figure 2. Ancillary feed box for Cryocap and its flow scheme

LHe under 1.2 bar is siphoned continuously from a standard storage vessel, passes a recondensing coil immersed in a LHe pool at 4.2 K and then divides into two flows.

The first flow is only used occasionally for an initial cool-down of the cavity.

The second flow supplies the 4.5 K cooling loop in Cryocap where it partially vaporizes, then returns to AFB where the residual liquid maintains a constant LHe level of the 4.2 K bath, adjusted with the control valve LCV1.

LHe for the 1.8 K bath is taken from the 4.2 K reservoir. A passage through heat exchanger E1 cools it to 2.2 K and thus substantially reduces the flashing losses during expansion to 16 mbar in LCV 2. This valve remotely controls a constant LHe level of the 1.8 K cooling bath in Cryocap.

A second storage vessel provides LN which is essentially used for radiation shield cooling. Thus a continuous feed of LN passes, first in an annular gap through the coaxial LHe transfer line, then through the cooling loops soldered onto the radiation shields of both AFB and Cryocap and finally cools the charcoal adsorbers, alternately E30 or E31, where it entirely vaporizes.

The cold He vapour from Cryocap and those from the 4.2 K cooling bath in AFB may be handled in two different ways :

a) they are simply warmed up to ambient temperature in an electric heater,
b) their potential cooling capacity is recovered in an economizer.

With the construction of the feed box we wanted to combine our long term interests with our short term obligations, so we decided to equip the cold box from the very beginning with a line of heat exchangers which might be operated arbitrarily as an economizer or as a simple heater.

The economizer principle consists essentially in a counter-current heat exchange of the available enthalpy in the escaping low pressure stream to an inflowing high pressure stream whose final Joule-Thomson expansion produces a substantial amount of LHe which in turn reduces the supply from the external storage for the same useful cooling capacity.

Our arrangement consists of two separate Hampson type heat exchangers of high efficiency, operating between 4 to 80 K and a single heat exchanger with a comparatively poor efficiency which operates between 80 to 300 K as a counter-current heat exchanger. The latter is made from two coaxial flexible hoses of 20 m length wound on a cylindrical mandrel. High (HP) and low pressure (LP) gas flows inside of the flexibles hoses, whereas the very low pressure (VLP) gas passes externally and perpendicular to the windings which are, moreover, equipped with an electric heater of 3 kW. Therefore, if no economizer is used, the same apparatus might only be used to warm up the cold vapours to ambient temperature.

Two sets of commutative charcoal traps are provided to purify the incoming high pressure He and to maintain its temperature down to 80 K.

For optimum performance of the economizer the HP mass flow has to be permanently adjusted to the fluctuating LP and VLP cold gas returns. Two identical autonomous control valves have been developed which maintain the temperature of the incoming HP flow at an optimum value (i.e. 6 K).

PRESENT STATUS (October 1995)

Some preliminary cryogenic tests with the ancillary feed box on its own with different simulated heat loads up to 10 W in the 1.8 K bath have been performed.

Some first efficency measurements of the economiser cycle produced encouraging results. Thus for a given heat load of 5 W in the 1.8 K bath the external supply rate for LHe could be reduced by a factor 3 to 4 compared to the feed necessary without economiser.

The assembly of Cryocap with a dummy cavity is in progress. A first cryogenic test for the completed set-up of Cryocap with its ancillary feed box is programmed next December.

REFERENCES

(1) G. Grygiel, U. Knopf, R. Lange, B. Petersen, D. Sellmann, J. Weisend "Status of the TTF Cryogenic System", presented at the CEC Conference, July 17-21, 1995, Columbus OH.