# Temperature effects on baffles and valves installed near cryotraps

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## Introduction

In AdV 4 cryogenic traps will be installed near FP towers and 2 other cryogenic traps will be installed near the INJ tower and the DET tower. Optical baffles will be positioned nearby cryogenic surfaces, and will be subjected to some cooling below the room temperature. Similar cooling effects are to be considered for the vacuum valves installed close to the cryogenic traps. See also the AdV Technical Design Report https://tds.ego-gw.it/ql/?c=8940

Concerning baffles, the cooling extent has been already discussed and it is expected to be within some degrees C, negligible to induce water vapor condensation on baffle surfaces and normally tolerable when considering mechanical stresses on the baffle material.

Concerning valves, they are installed at larger distances from cryogenic surfaces and are in thermal contact with outer structures at room temperature. The cooling effects are expected to be of lower extent with respect to baffles.

Here we show a calculation of the temperature expected for a typical baffle arrangement. Then we give an evaluation for the vacuum valve case.

Beside the mentioned 'cooling' effects, we remind that baffles and valves installed close to the cryotrap will be also heated, in vacuum, up to 120-150°C during regenerations and bake-outs (order of a week per year). So the baffles and valves shall be designed to withstand this temperature range.

## Calculated model

It is shown in fig.1. It includes the tube cryotrap (2m long with 0.9m aperture), a layer of thermal shielding and an optical baffle, with an aperture of diameter=650mm, installed very close to the cryotrap (conservative case, the temperature effects are lower if increasing the distance from cryotrap).

The baffle is considered as 'suspended', exchanging heat only through radiation. It is conservative with respect to the case of rigid mount in thermal contact with the pipe walls. The thickness of the baffle has been assumed = 2mm.

The aim is to get an estimation of temperatures in a typical 'unfavorable' baffle installation, to put in evidence possible cooling issues.

Other assumptions: vacuum pipe walls = 304L stainless steel not fired (emissivity=0.16); thermal shield = aluminum (emissivity=0.1); cryogenic surface = 77K, emissivity =0.3 .

Concerning the baffle material, two different cases have been considered to exploit the range of the possible cases: Case 1 = polished stainless steel (thermal conductivity k=15 W/m K , emissivity=0.1) ; case 2 = ‘pyrex’ glass  ( k = 1.0 W/m K, emissivity=1)

Results are shown in fig.2 and fig.3 , achieved with a commercial FEM software.

The minimum temperature occurs at the tip of the glass baffle, calculated as -10°C. In case of metallic baffle the cooling effect is lower.

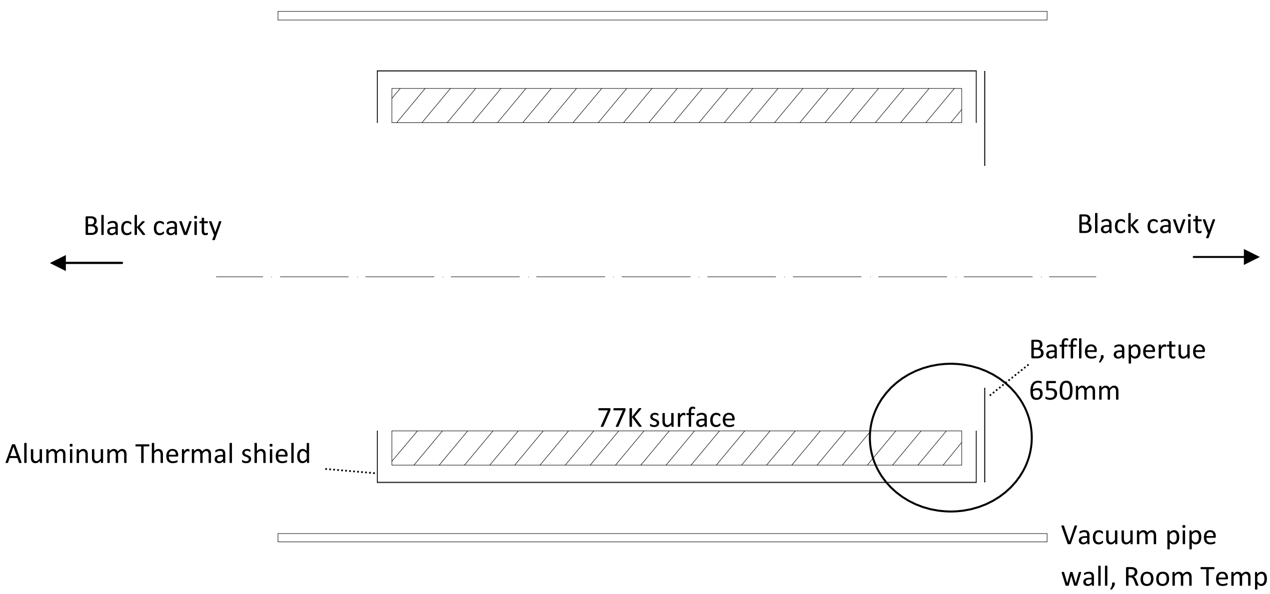


*Fig.1 2D axial-symmetric sketch of tube cryotraps (2m long x 0.9m aperture) with one optical baffle at one extremity. The circled detail is the one reported in the next figures.*

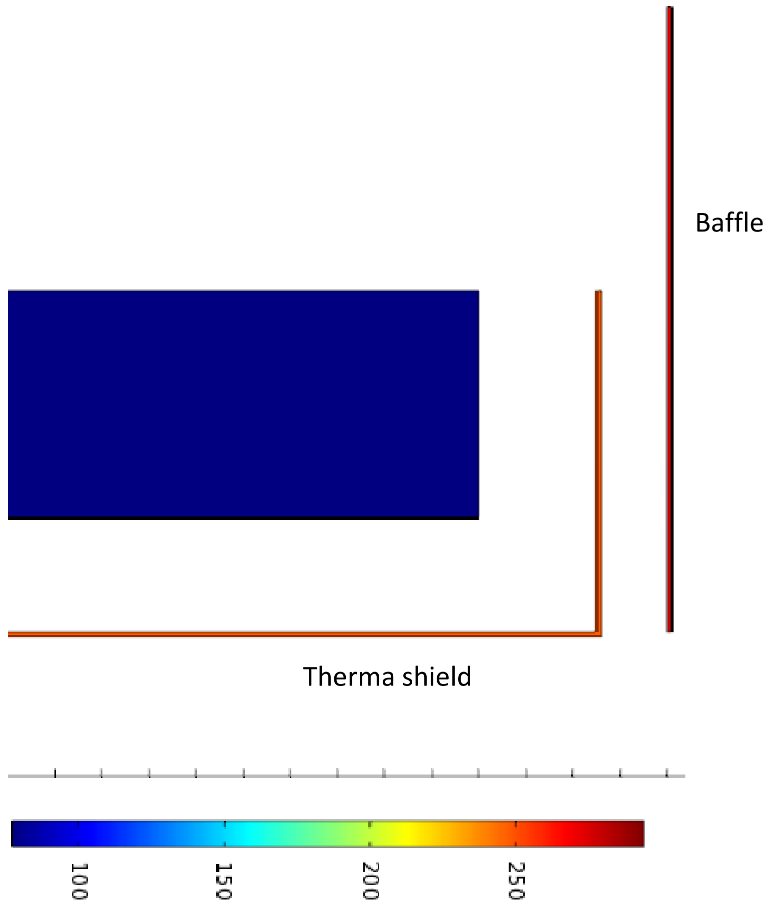


*Fig.2 calculated temperatures, detail of the baffle (lower right corner of fig 1). Case of baffle realized in polished Stainless Steel (emissivity=0.1, thickness=2mm). The temperature of the baffle is around 272K, rather uniform.*

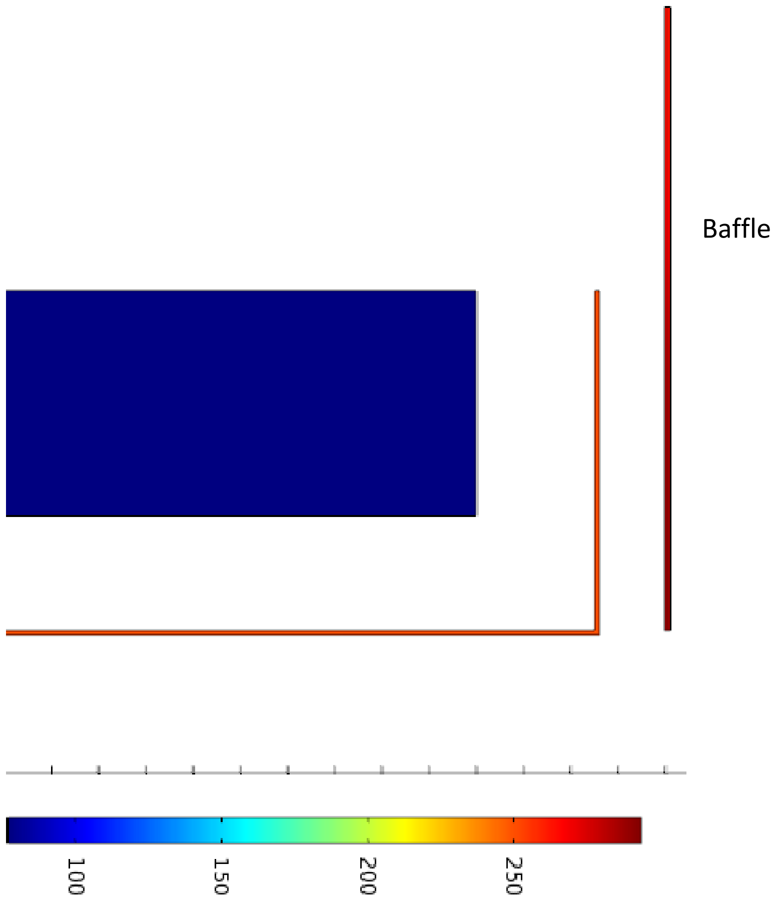


*Fig.3  Case of Pyrex glass baffle (thickness 2mm). Temperature varies from -10°C at the exposed baffle edge to near room at the baffle outer boundary (respectively 263K to 290K in the sketch; the thermal shield temperature is about 245K)*

In case of ‘frost’ cryotrap (=presence of a deep ice layer on surfaces), that is not a foreseen conditions, the baffle minimum temperature would become -25°C (at the tip of the glass baffle, whit cryogenic surfaces emissivity =1).

An example can be considered for comparison: a disk (a full disk of diameter=1m , made in a thermally conductive material , emissivity=0.9) facing another disk at 77K (emissivity 0.3) placed at a distance of 10cm undergoes to an average temperature of about = +13°C.  The temperature would become -13°C in case the 77K disk emissivity is =1

For the vacuum valve case, an estimate is done for the valves installed in front of the small traps at IB and DT tower . Those valves shall be installed quite close to cryogenic surfaces (here we consider at 0.2m distance) and will incorporate a large glass window (here we consider Ø=200mm, fused silica k=1.4 W/m K, emissivity=1) in the metallic gate (aluminum alloy, 2cm thick, Ø=400mm, emissivity=0.1).

The valve is considered in closed position (in open position it is not exposed to the cold surfaces) with vacuum on both sides of the gate. In the calculation, the gate is considered as a metal disk with a central glass part (thickness = 20mm, thermal contact through an elastomer seal 5mm x 5mm). The gate outer boundary is thermally connected to the stainless steel vacuum pipe (external convective heat transfer coefficient = 4 W/ $m^2$ K, thermal contact through an elastomer seal 5mm x 5mm).

The calculated temperature is near the room one (16°C for the gate metallic part, minimum = 10°C in the center of the glass disk ).

Even considering a safe margin, that is worth due to the model simplifications, these values are within the valve specifications.

Considering the practical case of DT or IB tower venting, the effects are even mitigated by the air heating by convection on the vented side of the valve gate. An unwanted effect could be the condensation of air moisture on the glass surface, since the estimated minimum glass temperature is close to the room air dew point.

If existing, this effect could disturb the alignment operations, when a laser beam is passing through the glass window. A warm-up effect may be provided by the laser beam itself (not evaluated here), in particular heating directly the drops if present on the glass surface. In case, condensation could be avoided with a slight external heating of the valve.

## Conclusions

Cooling effects on optical baffles installed near the cryotraps are expected to be limited; the estimated minimum temperature is a few tens of °C below the room one (the minimum calculated temperature is -10°C at the edge in case of glass baffle suspended very close to the cryotrap). Even assuming a safety margin, the level of temperature reached on baffles is not important with respect to pumping of water vapor and developing of ice layers. Temperature gradients are limited, and should be acceptable with respect to induced stresses in the material (considering also the long accommodation time during the system cooldown=several hours). The final baffle arrangement could be anyway checked (*).

With regards to the vacuum valves, the cooling effects are lower, order of a few °C below the room temperature. The cooling effect is not concerning about the valve functionality.

*(*) A conservative calculation of the layout foreseen for AdV has already been done, with the baffle positioned at about 1m from the 77K cryostat (details not reported here). The resulting cooldown effect estimation is quite low, just a few °C below room temperature. A.Rocchi (private communication, Jan 2013)*