# Supported Foil Solution for Legacy Helium-Cooled Targets When An Alternative to Havar Foil Material is Desired

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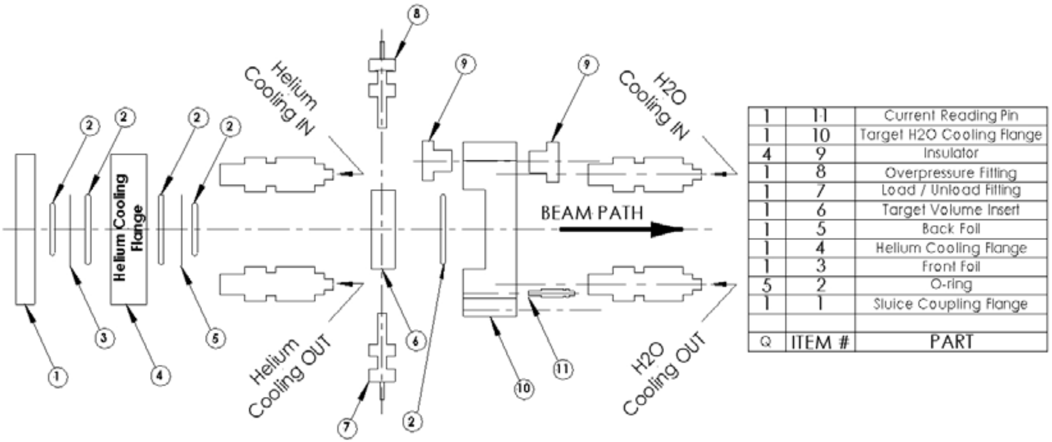
For any given radionuclide target system, the choice of targetry is often made as a compromise between Quantity and Quality. Quantity refers primarily to higher target yield or in the case of smaller volumes, higher specific activity. Quality, for the purpose of this discussion, refers to radionuclidic and chemical purity. Most recent target system design innovations have been driven by the need for increased target yield per run. In no application is this more evident than in the evolving design of $^{18}$F targetry [Eriksson, et al; Zyuzin, et al]. This pursuit of “quantity” has resulted in numerous target design innovations. Most notable are improvements in target geometry, optimization of target cooling thermodynamics and designs modifications intended to reduce proton beam loss due to interceding structures and foils. But for those facilities whose overall production does not require target yields beyond a few Curies, the helium-cooled, two-foil target systems (fig 1) have remained in service, even if only for backup or research $^{18}$F production. These legacy targets are characterized as having two foils along the beam path terminating in the target volume (gas or liquid). The front foil separates the tank vacuum from a helium cooling flange. The back foil separates the helium cooling flange from the target volume chamber.



| Q | ITEM # | PART |
|---|---|---|
| 1 | 11 | Current Reading Pin |
| 1 | 10 | Target H2O Cooling Flange |
| 4 | 9 | Insulator |
| 1 | 8 | Overpressure Fitting |
| 1 | 7 | Load / Unload Fitting |
| 1 | 6 | Target Volume Insert |
| 1 | 5 | Back Foil |
| 1 | 4 | Helium Cooling Flange |
| 1 | 3 | Front Foil |
| 5 | 2 | O-ring |
| 1 | 1 | Sluice Coupling Flange |

**Figure 1. Representative image of a two-foil helium-cooled $^{18}$F target design.**

Our facility produces $^{18}$F and other radionuclides solely for our own clinical and research needs; thus our production needs are modest. But to satisfy our low-level research production needs while also improving the yield of our low-efficiency radiopharmaceutical syntheses (eg. [$^{18}$F]FLT) we have directed our targetry efforts towards reduction of radionuclidic and chemical impurities. Regardless of target type, improvement in product purity may have significant implications to the efficiency of radiopharmaceutical syntheses as well as patient/participant dosimetry. To achieve this we have retrofitted our two-foil $^{18}$F target to utilize Niobium for both the back foil (0.003” thick) and the body material of the target volume chamber [Nye, et al]. The significantly lower strength of Niobium when compared to Havar for the back foil presented an additional hurdle to the retrofit. Additionally, local heating of the Niobium foil by the proton beam further threatens its ability to perform without failure. To address these issues we opted to include another modern target feature, the grid support.

This became the evolution of our novel retrofit grid support solution (fig 2). Support grids in modern targetry are generally made from copper or aluminum and cooled by the same water that cools the target volume chamber. This observation brings to light the final hurdle in our design – grid cooling. The solution is the existing Helium cooling system, but since a grid support, placed to support the Niobium foil, would block the flow of the Helium cooling, the grid must be modified. Therefore, we have included a vent hole through the grid perpendicular to the beam path to allow helium flow which now becomes the grid cooling mechanism of this retrofit design.

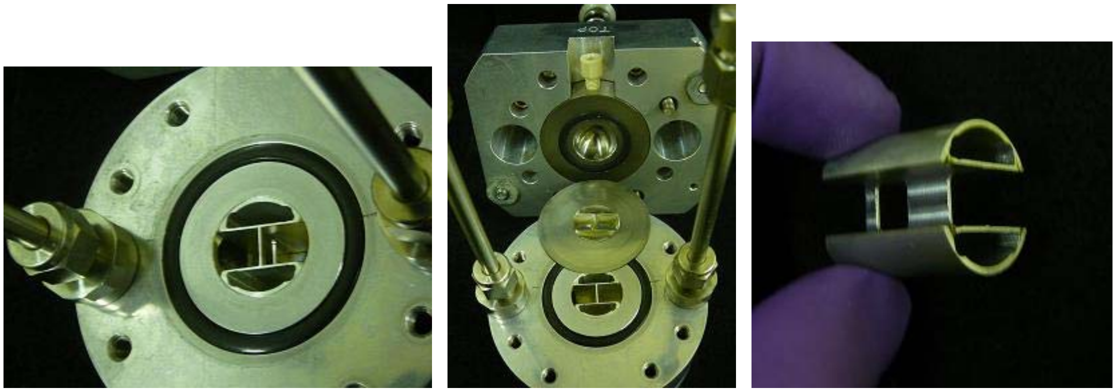


**Figure 2. Foil Support Grid representation and placement.**

The primary benefit of this design is its low cost. Commercially available targets may cost as much as $50,000, but the direct cost for this design was less than $3,000 for materials and machining. To achieve this inexpensive solution, the aluminum grid foil support we designed requires only that the beam aperture in the helium flange be widened slightly to hold the grid support captive. Additionally, this grid support can be fabricated using standard machining practices and a simpler rectangular grid design. This significantly reduced the expense when compared to the commercial copper or aluminum hex-grid supports which utilize a more expensive EDM machining technology.

A second benefit of this design is its ease of incorporation into the existing target. It may be either slipped or press fit into the widened Helium flange beam aperture.

Yet a third benefit is the utilization of the existing Helium cooling. Where previously the Helium flow was directed to cool both the front and back foils, that flow will now pass through the vented support grid to conduct its heat away. Because the grid is in direct contact with the back foil, it also acts as a heat sink to conduct heat away from the localized point where proton beam heating may weaken it. Also, because we utilize the existing helium cooling, it need not be defeated as a target interlock, as it is on many older cyclotrons. And lastly, there is no need to make additional modifications to the target to cool the grid using the water cooling system as is common in the commercially available systems.

As a final site specific benefit, our older, self-designed target allows easy replacement of the target insert (ie. the target load chamber). This has allowed us to very easily convert this target at any time for the in-target production of $[^{13}\mathrm{N}]$Ammonia [Krasikova, et al] by simply replacing the Niobium insert and foils with Aluminum versions of each and overpressuring with $CH_4$. Without the support grid, it would likely be impractical to use such thin (0.005" thick) aluminum foils, as they would be far too weak.

In conclusion, this grid foil support design is an economical solution allowing the use of more chemically advantageous, though weaker, foils materials while easily maintaining integrity, even with overpressure in excess of 300 psi. Additionally, no negative impact on the overall yield of the target was observed.

**Acknowledgement:** University of Iowa Medical Instruments shop and Tim Weaver for design support.

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