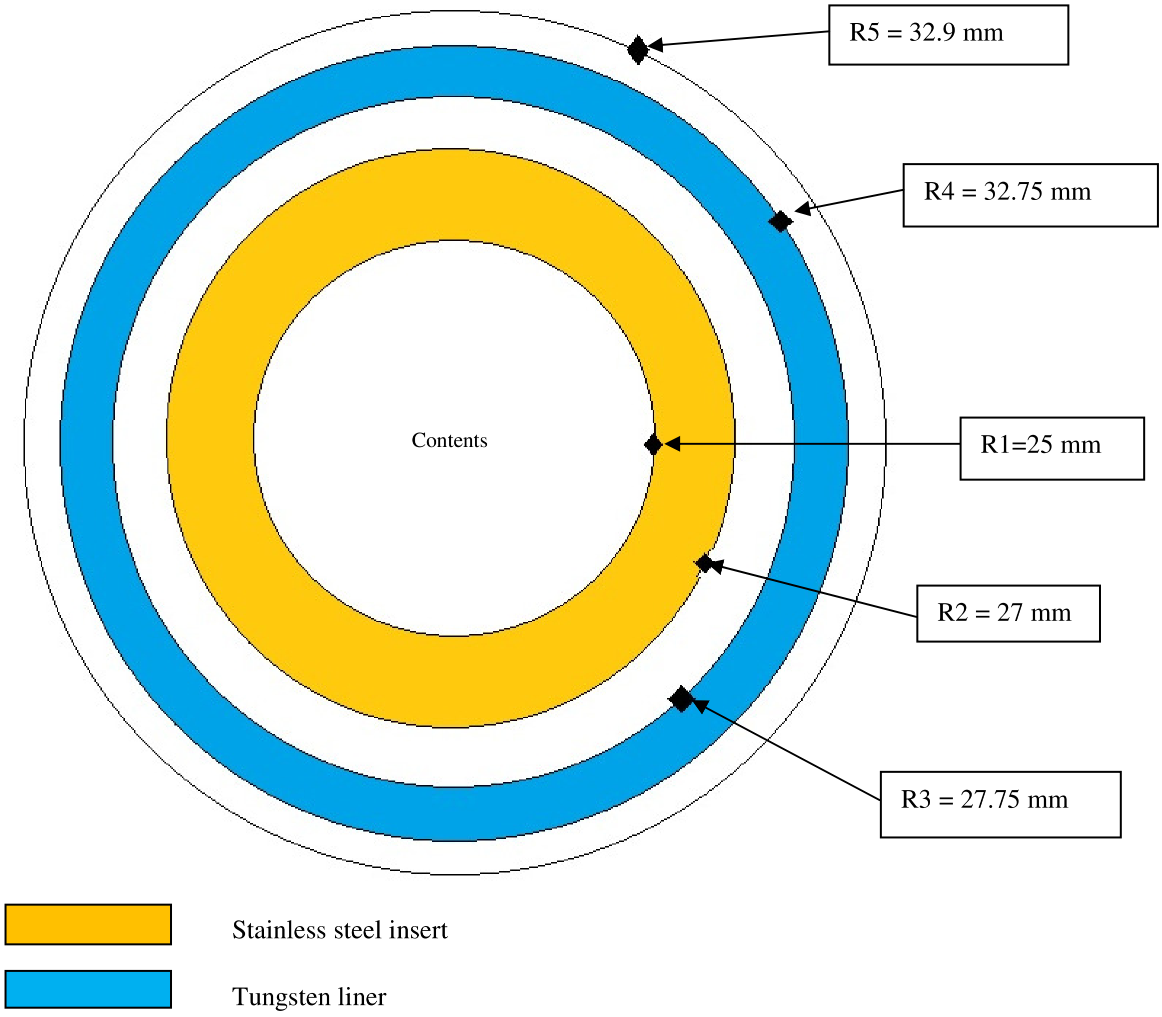
Project No Y15/09/18	**Design/Drawing No 3977A**
Temperature of Mo-99 Contents in the HS Package	See WI 03-04 for guidance

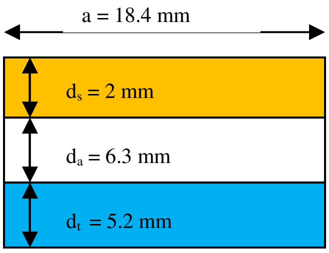
Objective

The objective of this calculation sheet is to determine the heat of the Mo-99 contents in the HS package. The contents are limited to an activity that generates 5 Watts of heat.

Loading conditions
Side of the Insert



Bottom of the Insert



Assumptions

It is assumed that the contents have a constant heat generation rate of 5 watts, in reality this will decrease over time.
The temperature at point R5 is assumed to be constant at the maximum temperature reached of 78°C during normal conditions of transport and 136°C under accident conditions of transport, this is taken from the thermal report [Ref 1].
It has been assumed heat can only be transferred from the straight side wall (L=105 mm) and from the bottom of the insert, the top of the insert has been ignored, any heat loss to evaporation has also been ignored. Both assumptions mean that a higher temperature of the contents will be calculated.

The thermal conductivity has been taken as:

- Stainless steel = k_s =16 W/mK
- Air = k_a = 0.024 W/mK
- Tungsten = k_t =168 W/mK

Results
Using the equation for cylindrical sections [2]:

$$q = \frac{2\pi L(T_c - T_{CV})}{\ln(r_2/r_1)/k_s + \ln(r_3/r_2)/k_a + \ln(r_4/r_3)/k_t + \ln(r_5/r_4)/k_a}$$

Using the equation for the bottom of the insert [2]:

$$q = \frac{\pi a^2(T_c - T_{CV})}{\frac{d_s}{k_s} + \frac{d_a}{k_a} + \frac{d_t}{k_t}}$$

The temperature of the contents was calculated using both equations, the value of q was then adjusted to determine the value required to lead to the same contents temperature for both the side and the bottom of the insert. The q values combined had to be 5W which is the heat generating power of the liquid contents.

For normal conditions of transport the q value for the side of the insert was 3.2362 W and the q value for the bottom of the insert was 1.7638W this produces a contents temperature of 84.56°C.

For normal conditions of transport the q value for the side of the insert was 2.77754 W and the q value for the bottom of the insert was 2.22246 W this produces a contents temperature of 143.83°C.

Comments

The maximum temperature of the contents is 84.56°C for NCT and 143.83°C for ACT, this is higher than the actual temperature because we have neglected the full heat transfer area of the insert. It has been assumed the heat output of the contents will remain constant at 5W which would not be the case in reality. Convection and radiation heat transfer have also been neglected with only conduction taken into account.

References

[1] Thermal Analysis of the SAFKEG HS Design, AMEC/6335/001, Issue 1
[2] Heat Transfer, JP Holman, McGraw Hill

Prepared	Checked
Approved	Date 4th July 2016