Acrylic Vessel Geometry

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1 Introduction

The Acrylic Vessel, AV, is one of the most important geometric pieces of SNO+ to correctly model. It is also one of the most complex, and the details of the implementation in RAT are split into this document, a separate document for the tiles[1], a further document for the belly plates (tiles)[2] and a final document for the NCD anchors[3]. This document details the geometry and implementation of the acrylic sphere, acrylic neck (chimney) and acrylic neck boss (joint between the sphere and neck). The RAT factories that build this geometry are also detailed.

The acrylic sphere and neck geometry was part of the SNOMAN simulation as detailed in [5]. A rat implementation was first implemented by J. Rodelo[6], however the dimensions used were incorrect. This was then updated by P. Gorel in 2009 using correct dimensions[7]. The implementation of the sphere detailed in this document is the same as the P. Gorel model, however the neck differs.

The neck boss geometry was not part of the SNOMAN simulation. It was first implemented in rat by P. Gorel in 2009[7]. The implementation detailed in this document does not match the P. Gorel model.

The RAT or PSUP coordinate system is used throughout, see [4] for details.

2 Geometric properties

The acrylic vessel is nominally a 55mm think 6005.0mm inner radius sphere with a 6800mm high 730mm inner radius chimney placed on top[8]. This is drawn up in figure 1. The size of the chimney or neck is given as 6360mm high 730mm inner radius tube in SNOMAN contrary to the stated measurements in [8]. I expect the chimney height to have a negligible effect on the simulation of SNO+ events and hence I have chosen to use the 6800mm value[1].

The joint between the sphere and the neck/chimney is called the neck boss and is quite complex as seen in figure 2(a). In rat it is represented as shown in figure 2(b), i.e. as a larger inner cylinder unioned with a smaller outer cylinder which is then unioned with the outer av solid and subtracted from the inner av solid. This simplification of the real geometry is justified as I expect the exact details will have a negligible effect on the simulation of SNO+ events. Additionally the outer radius of the top neck boss is constrained to match the quoted neck outer radius of 785.0mm, and the inner radius is then constrained to be 1" smaller than the quoted inner radius of 730.0mm i.e. 704.6mm. Neither of these constraints match the drawing, figure 2(a) which quotes 793.75mm and 703.6mm for the outer and inner respectively. This discrepancy is not expected to cause any observable difference to data.

The acrylic vessel geometry as visualised using ROOT's GDML viewer via conversion into GDML by the geo2gdml tool[13] is shown in figure 3.

2.1 Geometric position

The acrylic vessel ideally sits at the centre of the PSUP coordinate system, however it is expected to move therefore all other geometries tied to the av position should move with it (not the other way round) for

[1] The Outer surface will also be 6800mm long giving the outer top at 6060.0 + 6800.0=12860.0mm.

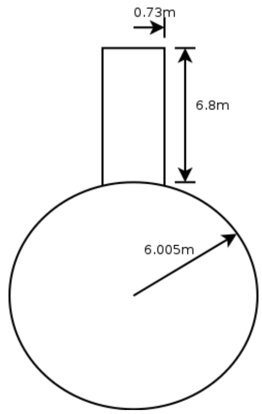
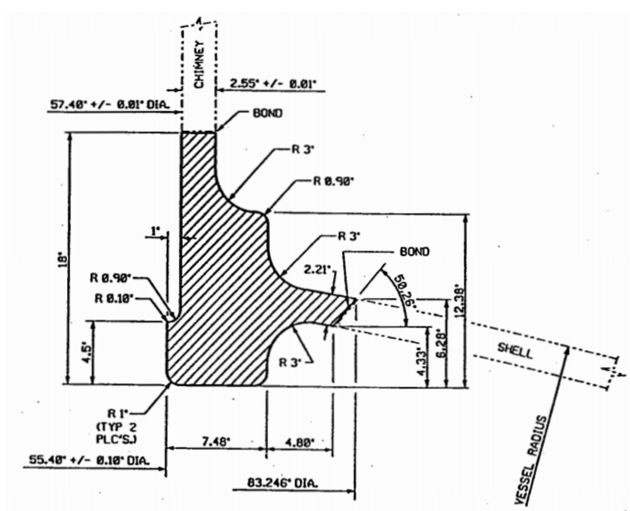
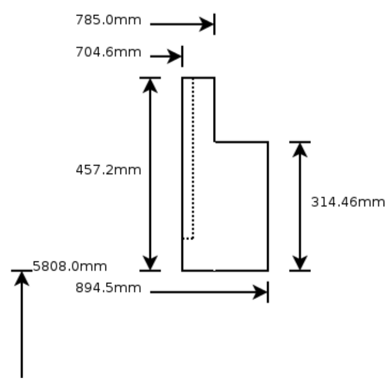


Figure 1: Schematic representation of the AV in rat; inner dimensions shown, outer dimension is an additional 55mm thickness on this.



(a) Drawing of the Neck Boss cropped from [9].



(b) Schematic of the RAT representation.

Figure 2: Neck Boss drawing and representation in rat. Note that the full neck boss is a 2 pi revolution of this cross section about the y axis (in the drawing, z axis in the PSUP or local rat coordinate system).

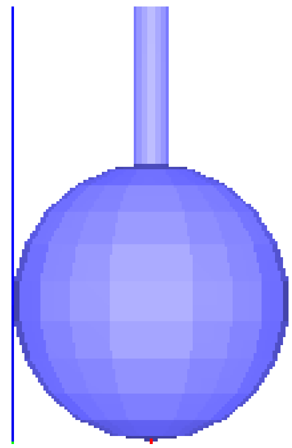


Figure 3: The acrylic vessel geometry as visualised using ROOT's GDML viewer.

example the hold up and down ropes. The neck boss is positioned via the centre of the larger inner cylinder and sits at z=6036.6mm above the centre of the AV on the axis of symmetry.

3 Material properties

The acrylic vessel is made of acrylic which is defined as 7.03% Hydrogen, 55.8% Carbon and 37.17% Oxygen in RAT and as 8.05% Hydrogen, 59.99% Carbon and 31.96% Oxygen[10]. This difference is less concerning than the difference in the optical properties, which have been the subject of some debate[11]. Currently rat uses `acrylic_sno` by default unless rat is being matched to snoman when `acrylic_snoman_salt` is used. This document recommends rat continues to use these materials.

The neck or chimney material is also subject to some debate[12]. Currently rat uses `acrylic_grey` by default unless rat is being matched to snoman when `acrylic_dark_snoman` is used. This material fills the 55mm thickness throughout the neck starting at z=6265.2mm in default rat and z=6005.0mm if rat is matching snoman (positioned at z=9562.5mm and z=9432.5mm respectively). This results in the height of the material being 6595.0mm in default rat and 6855.0mm if rat is matching snoman (using a 6800mm high neck).

4 RAT factories

To represent the acrylic vessel in geant4 both a outer volume and inner volume must be defined, with the inner volume a daughter of the outer volume. The volumes will hence differ in material and size, with the outer 55mm larger and made of acrylic. These volumes in rat are built by the acrylicVessel factory with the fields given in table 1. Alternatively a very simplistic representation of the acrylic vessel can be constructed by using the solid factory and the acrylic_vessel_inner and acrylic_vessel_outer definitions.

Name	Type	Description	Optional
inner	int	Value is 1 if the factory is to build the inner AV	No
acrylic_vessel_definition	string	Index of the SOLID table that defines the snoVessel shape	No
add_belly_plates	int	A value other than 1 cause the belly plates to be omitted.	Yes, default to 1.
add_belly_grooves	int	A value other than 1 cause the belly grooves to be omitted.	Yes, default to NOT inner. (Ignored if inner)
belly_plate_definition	string	Index of the SOLID table that defines the belly plate shape	No
belly_groove_definition	string	Index of the SOLID table that defines the belly groove shape	No (Ignored if inner)
belly_plate_locations	string	Index of the GEO_LOCATIONS table that defines the positions and rotations of the belly plates	No
add_neck_boss	int	A value other than 1 cause the neck boss to be omitted.	Yes, default to 1.
neck_boss_definition	string	Index of the SOLID table that defines the neck boss shape	Yes
neck_boss_z	double	Value that defines the position of the neck boss	Yes
add_ncd_anchors	int	A value other than 1 cause the ncd anchors to be omitted.	Yes, default to 0. (Ignored if outer)
ncd_anchor_definition	string	Index of the SOLID table that defines the ncd anchor shape	Yes (Ignored if outer)
ncd_anchor_locations	string	Index of the GEO_LOCATIONS table that defines the positions and rotations of the ncd anchors	Yes (Ignored if outer)

Table 1: List and description of fields for the acrylicVessel factory.

5 Ratdb table

```
{
name: "GEO",
index: "av",
valid_begin: [0, 0],
valid_end: [0, 0],
enable: 1,

factory: "acrylicVessel",

mother: "h2o",

inner: 0,
acrylic_vessel_definition: "acrylic_vessel_outer",
belly_plate_definition: "belly_plate_outer",
belly_groove_definition: "belly_groove",
belly_plate_locations: "belly_plates",

neck_boss_definition: "neck_boss",
neck_boss_z: 6036.6,

material: "acrylic_sno",

vis_invisible: 1,
vis_style: "wireframe",
vis_color: [0.0, 0.0, 0.0],
}

{
name: "GEO",
index: "scint",
valid_begin: [0, 0],
valid_end: [0, 0],
enable: 1,

factory: "acrylicVessel",

mother: "av",

inner: 1,
acrylic_vessel_definition: "acrylic_vessel_inner",
belly_plate_definition: "belly_plate_inner",
belly_plate_locations: "belly_plates",

neck_boss_definition: "neck_boss",
neck_boss_z: 6036.6,

ncd_anchor_definition: "ncd_anchor",
ncd_anchor_locations: "ncd_anchors",

material: "heavywater_snoman_salt",
```

```
vis_invisible: 1,
vis_style: "wireframe",
vis_color: [0.0, 0.0, 0.0],
}

{
name: "SOLID",
index: "acrylic_vessel_inner",
valid_begin: [0, 0],
valid_end: [0, 0],

solid: "snoVessel",

r_sphere: 6005.0,
r_neck: 730.0,
z_neck: 6800.0,
}

{
name: "SOLID",
index: "acrylic_vessel_outer",
valid_begin: [0, 0],
valid_end: [0, 0],

solid: "snoVessel",

r_sphere: 6060.0,
r_neck: 785.0,
z_neck: 6800.0,
}

{
name: "SOLID",
index: "neck_boss",
valid_begin: [0, 0],
valid_end: [0, 0],

solid: "neckBoss",

r_min1: 704.6,
r_max1: 785.0,
half_height1: 228.6,

r_min2: 785.0,
r_max2: 894.5,
half_height2: 157.23,
}

{
name: "GEO",
```

```
index: "neck_snoman",
valid_begin: [0, 0],
valid_end: [0, 0],

factory: "solid",

mother: "av",

solid_definition: "neck_snoman",

material: "acrylic_dark_snoman",

position: [0.0, 0.0, 9432.5],

vis_invisible: 1,
vis_style: "wireframe",
vis_color: [0.67, 0.29, 0.0],
}

{
name: "GEO",
index: "neck",
valid_begin: [0, 0],
valid_end: [0, 0],

factory: "solid",

mother: "av",

solid_definition: "neck",

material: "acrylic_grey",

position: [0.0, 0.0, 9562.5],

vis_invisible: 1,
vis_style: "wireframe",
vis_color: [0.67, 0.29, 0.0],
}

{
name: "SOLID",
index: "neck",
valid_begin: [0, 0],
valid_end: [0, 0],

solid: "tube",

mother: "av",

r_min: 730.0,
```

```
r_max: 785.0,
half_z: 3297.5,
}

{
name: "SOLID",
index: "neck_snoman",
valid_begin: [0, 0],
valid_end: [0, 0],

solid: "tube",

mother: "av",

r_min: 730.0,
r_max: 785.0,
half_z: 3427.5,
}
```

References

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[8] N. Jelley, A. B. McDonald and R. G. H. Robertson, Ann. Rev. Nucl. Part. Sci. **59** (2009) 431.

[9] SNO Collaboration, 17-702-F-6499-01_Rev_02

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[12] B. Davis-Purcell, "Neck Optics Analysis Report", SNO+-doc-2065

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