SNO-STR-90-110

ACRYLIC VESSEL ACTIVITIES

AUGUST 1990

1 SUMMARY:

The concept of suspending the vessel from ropes or rods is being investigated and continues to look attractive. An estimate has been received from Swanson Corp. for the finite element analysis of the Monenco design.
Modeling of PMT implosions suggests that the eight inch tube will not threaten the vessel, but may be a problem for ajacent tubes. A study has been completed on light scattering in crazed acrylic, the effects appear significant. The material/bond property studies are progressing, but slowly.
The vessel committee visited the acrylic supplier, Rohm and three potential European fabricators for the vessel. Their findings were encouraging.
Possible materials for use in the vessel suspension are being counted, so far synthetic ropes look cleaner than metal rods. CRL continues to improve their confidence in their measurement techniques. Both CRL and Guelph see evidence that contamination is on the surface of the acrylic.

2 DESIGN STATUS:

The concept of suspending the acrylic vessel from either rods or ropes attached to the vessels equator, as proposed in the Swedlow report is being investigated in sufficient detail to allow comparison to the existing design in which the vessel is suspended from an acrylic collar, and a decision made as to which design to choose.
Due to the desire to study the neutrino flux for at least one solar cycle, the design life has increased to at least 15 years. It has been recommended [1] that the vessel now be placed in compression to avoid the possibility of extensive crazing and the uncertianties associated with bond joints under tension.

It now becomes important that we understand the buckling properties of the vessel and consequentialy, our understanding of the long term properties of acrylic now become even more critical. To this end, Jerry Stachiw has produced a memo [2] which recommends that the modulus of elasticity after 10 years be taken as 210,000psi (vs. 450,000psi initialy). This information is based on data from three independent studies.
Phil Cumyn has produced a schematic of the vessel which incorporates a simple way of attaching ropes to the equator of the vessel. This design, along with the design criteria document [3] for the acrylic vessel will be used as input for the finite element studies to be carried out by Swanson Corp. The first stage of this design will concentrate on determining the stress levels associated with the rope suspension technique, the wall thickness required to give a safety factor of ~ 6 against buckling after 15 years service. Another area of concern is the stability of the chimney. It may prove neccessary to strengthen it with some buttress arrangement, or to increase it's diameter, [4] as would be desirable for the neutral current counter installation and insertion of the neutron callibration source. The report on the findings of the Swanson study should be avaliable December 1990; it would be useful if a statement on the physics implications of the design were avaliable then, considering the radioactivity, light attenuation, width of chimney etc. This will be neccessary for the selection of the final design.

3 R&D STATUS:

The LANL creep machine has been assembled and tested. The water bath is stable to $\pm 0.2°C$ in the temperature range $10 \rightarrow 60°C$. Loads of up to 9,000psi can be applied to standard test specimens and a technique to waterproof strain gages has been mastered. The device is currently being used to obtain a time to failure envelope for acrylic test specimins immersed in water.
Now that the vessel may be operated in compression, the longterm creep properties of acrylic assume greater importance and consideration should be given by the Vessel Committee to the priority of the tests to be carried out using this apparatus. It is likely that the vessel suspension ropes would also be studied in this apparatus.

A study of light scattering in crazed acrylic has been complete by two LANL summer students [5]. For incident angles between $\pm 30°$ the scattering is significant. This if further encouragement to place the vessel under compression, which greatly reduces the possibility of crazing. It would be useful to implement the scattering of crazing into the Monte Carlo to determine what level of crazing can be tolerated.

With Walter Davidson in Bonn for the next two years we have lost our leadership in the optical R&D for acrylic. It is important for the Vessel Committee to identify a lead institution/person for this, as well as to review the proposed program itself.

Numerous studies have been carried out on the effect of imploding PMT's [6]. This was instigated by an engineer at CRNL questioning the finding of the Swanson study of the effect of imploding PMT's on the acrylic vessel. Numerical modeling by two groups at LANL and at City University, London/Oxford, support the findings of Swanson. With the withdrawal of the 50cm PMT from consideration for SNO the threat of an imploding PMT to the acrylic vessel appears insignificant, even if the tube implodes against the wall of the vessel. It is not clear from tests conducted at Oxford and Queens University [7] whether it is neccessary to protect the PMT's from sympathetic implosions, and more studies are needed.

Candidate materials for the suspension ropes for the vessel have been identified and are in the process of being counted for activity. The Vessel Committee should determine what are the appropriate mechanical tests that must be carried out to compliment the existing data on the rope.

4 CONSTRUCTION:

In mid August the Vessel Committee, consisting of Cumyn, Doe, Earle and McFarlane visited Rohm Plastics, a potential supplier of the acrylic, and three possible fabricators of the vessel, Kumpel and Fritz, in W. Germany and Stanley Plastics in the UK. Based on what was seen, all three fabricators should be included in the first round to select a fabricator for the vessel. A report of the visit is avaliable [8].

It will be necessary for the selected fabricator to demonstrate a technique which can be used to bond the components of the acrylic vessel. Jerry

Stachiw has reviewed the problem and suggested a possible qualification program [9].
A possible installation scenario has been proposed by Phil Cumyn: The deck structure is in position and the cavity may be accessed from either the deck or by the excavation ramp at the bottom. A platform runs up and down the wall of the cavity. A polar crane may also be avaliable. A false floor is positioned in the bottom of the cavity, and upon this, the upper hemisphere of the PMT support structure is constructed and instrumented. This is then hoisted into position and the area beneath it protected by sheeting. The fabrication of the acrylic vessel now begins. The chimney is bonded then hoisted into poisition. A hemispherical "igloo" is then constructed as a former over which the panels are positioned and bonded, down to and including the suspension points at the equator. After checking, the hemisphere is hoisted into position and the the fixtures for the lower hemisphere positioned. After bonding the lower hemisphere to the upper, the whole assembly is hoisted into it's final position and the assembly of the lower PMT hemisphere begun. This scheme has the advantage of partly telescoping two long timescale items as well as ensuring that no major construction activities take place above the acrylic vessel. A review of three field assembly proceedures has been carried out by Stachiw [10], who concludes, based on experience bonding Nemo Spheres, that idealy all panels should be bonded at the same time. It may be that the two hemisphere approach is the closest to satifying this ideal.

5 RADIOACTIVITY:

CNL continues to improve their understanding of their measurement techniques. Vapourization of 1 Kg acrylic samples followed by mass spectroscopy are giving consistent results for both Rohm and Polycast material at the 5ppt level. The NAA and RNAA techniques on 20 gm samples, which used to suggest very high concertrations of Th are now indicating levels of 5 to 10 ppt, but more samples must be processed. There is some evidence (based on two samples of Polycast material) that the Th is concentrated on the surface of the acrylic sheet, but more samples must be processed. This is also supported by indirect evidence from Guelph. There is still no evidence for significant disequilibrium in the Th and U chains and the Ra recovery efficiency for these measurements has been improved to 70%, similar to the Th and U recovery efficiencies. Although it does not yet appear that any technique is at the stage where it can be applied with confidence to measurement of the final acrylic sheets, things are now coming together quite fast.

At Guelph a set of 10 samples were examined for a correlation between Th and U and other trace elements. No correlation was found. There is a suggestion that during the handling of 8 gm samples, handling contamination may be contributing to high Th levels. A proceedure for NAA of large (400 gm) samples has been successfully carried out and the results on the first two Polycast samples (part of the large sheet distributed by Peter Doe as a "standard candle") are very encouraging, i.e. <2 ppt U and <1 ppt Th.

At LANL a number of Swedlow samples have been measured by RNAA to be over 10 ppt Th and 2 ppt U. Two Polycast samples from the same block were measured to be <2 ppt and 15 ppt Th, suggesting significant inhomogenity or handling problems. Efforts to get better quality material from Swedlow have not been successfull, but some home made samples of spiked acrylic have been made and irradiated to test the efficiency of the technique.

A "standard candle" in the form of large peices of acrylic cut from the same sheet has been distributed to the four radioactivity institutes to cross correlate results. It is still not known if a large sample of acrylic cut from the edge of a sheet represents the average activity in that sheet. Therefore, although the different measurement techniques look promising, we do not have any confidence in our ability to state what the activity in a sheet is, and hence what the background from the vessel will be. This will require close cooperation with acrylic suppliers.

LBL and Guelph have carried out direct counting of potential suspension materials for the acrylic sphere. LBL found their sample of Titanium to be hot, 1.5ppm U, 20ppb Th. This was to be expected for this alloy of Ti, and better alloys may exist. The K-monel counted at LBL came in at U<3ppb, Th<20ppb. Samples of Kevlar, Oleofin, Spectra and Dacron ropes direct counted at Guelph were yielding roughly $\leq 20 \rightarrow 30$ppb of U and Th. Samples are now being neutron activated for more accurate measurements. Therefore the prospects still look promising for suspension materials.

6 REPORTS & MEMOS:

Copies of the following reports and memo's can be obtained from SNO Institute, Queens University or from Peter Doe, LANL. The numbers also correspond to those documents refered to in the text.

1. **"Technical Position for Selection of Engineering Concept for SNO Sphere"**, J. Stachiw, August 9, 1990.

2. **"Effect of Time and Temperature on Modulus of Elasticity"**, J. Stachiw, August 25, 1990.

3. DC.17.310.01.A, Acrylic Vessel, Prepared by P.B. Cumyn, July 26, 1990. **"Acrylic Vessel, Summary of Analysis Work"**, P.B. Cumyn, August 1, 1990.

4. **"Neck Structure for Acrylic Sphere"**, J. Stachiw, August 21, 1990.

5. **"Light Scattering in Crazed Acrylic"**, Scott Johnson, James Bibb, SNO-STR-90-87, 20 July, 1990.

6. **"PMT Implosions and the Acrylic Vessel"**, Peter Doe, SNO-STR-90-90, 31 July, 1990.

7. **"Report on PMT Implosions Carried Out at Queens"**, C.A.W. Hearns *et al*, Queens University at Kingston, August 14,1990.

8. **"Visit to European Acrylic Manufacturer and Fabricators"**, K. McFarlane, August 1990.

9. **“Bonding Proceedures for Acrylic Sphere”**, J. Stachiw, August 30, 1990.

10. **“Field Assembly Proceedures for Acrylic Sphere”**, J. Stachiw, August 12, 1990.