SAC-STR-90-12

JAN 91

3500R1 - MECHANICAL PROPERTIES

(Breakdown of responsibilities)

RDS

SCOPE: Evaluate the mechanical properties of bonded UVT acrylic sheet, this task shall consist of;

TASK1: MATERIAL SELECTION.

- Obtain from selected manufacturers (see 3500R5: Supplier-Acrylic Sheet) samples of high quality UVT acrylic sheet of dimensions representing that to be used in the construction of the vessel. Each sheet is to be uniquely identified and tracable. Selection and purchase of the acrylic sheet is the responsibility of LANL.

TASK 2: FABRICATION - BONDS & TEST COUPONS.

- Bond the sheets using the same technique that will be used in the fabrication of the vessel. This work will be carried out by RPT.
- Fabricate test coupons to measure the following properties; Tensile strength (ASTM D638), flexural strength (ASTM D790), compressive creep (ASTM D2990). A minimum of 10 test coupons are required for each mechanical test. The mechanical test coupons will contain unfinished bond joints as this represents the most likely condition of the bond joints in the finished vessel. This work to be carried out at the most appropriate place, possibly RPT or LANL depending on facilities, costs and turn-round time.

TASK 3: MECHANICAL TESTS.

- Conduct the tensile, flexural and compressive tests listed above on virgin, unaged bonded samples. LANL will carry out this work.

- Subject unstressed test samples to accelerated aging in pure water at an elevated and constant temperature in order to simulate a minimum of 10 years of operation at 10°C. Repeat the mechanical tests listed above for the unaged samples. **Note;** it may be desirable to test samples that have been aged for 5, 10 and 15 years in order to establish the relationship between aging and rate of change of mechanical properties. This work is the responsibility of LANL.

- Subject test samples, under stress comparable to that expected during normal operation of the vessel, to accelerated aging in pure water and repeat the mechanical tests listed above. This work is the responsibility of LANL.

DELIVERABLE: A report detailing the results of the above tests with recommendations as to;

- The acrylic source which offers mechanical properties suitable for constructing the acrylic vessel. These results will be used in conjunction with the results from 3500R5 (radioactivity and optical properties) in selecting the acrylic supplier.

- Comparison of the mechanical strength of the unfinished bond joint to the existing information concerning the strengths of finished joints, with recomendation as to whether finishing of the bond joints should be considered.

- Determine if subjecting the bond joints to stress significantly increases the rate of deterioration of the mechanical strength of the joint.

- Quantify the rate of change in the mechanical properties of the acrylic bonds. This information to be used in the engineering design of the vessel.

NOTE: Primary responsibility for writing the report will be carried by LANL in collaboration with RPT.

3500R2 - FABRICATION TECHNIQUES

(Breakdown of responsibilities)

SCOPE: Prototype the fabrication and related quality control processes as will be used in the construction of the vessel.

TASK 1: OBTAIN MATERIALS.

- Obtain a sufficient number of sheets of UVT acrylic: These sheets will be purchased by LANL and shipped to RPT in California. How many sheets are required?
- Uniquely identify sheets, measure thichness on a grid pattern laid out over surface, characterize residual stress in sheet using polarized light: This will be carried out by RPT.
- Sample each sheet to determine their optical and radioactive properties: Samples will be taken by RPT, uniquely identified and shipped to the appropriate SNO institute for measurement.
- Measure residual monomer content - should we specify PVHO standards for monomer levels in the sheets, will thermoforming of non standard sheets reduce the residual monomer content to PVHO levels?

TASK 2: THERMOFORMING.

- Sheets will be thermoformed to a radius comparable to (or the same as) that of the acrylic vessel: This will be carried out by RPT. Should the form be a section of the sphere as in the final configuration? This will provide precise information. Cost of fabricating form could be later recovered.
- Repeat grid measurements of thickness to determine changes due to thermoforming. Determine redistribution of stresses using polarimeter: RPT to carry out this work.

- Determine residual monomer content after thermoforming, if sheets are not PVHO standard (see above).

TASK 3: MACHINING & QA SAMPLES.

- Machine components in preparation for bonding under conditions and tooling approximating those used in the final manufacture of the acrylic components of the vessel. Retain swarf from machining using a non-contaminating collection process. Ship swarf to appropriate SNO institute for radioactive analysis if deemed neccessary: RPT to be responsible for this.

- Retain and identify suitable pieces of scrap from the machining process to be used for QA of subsequent bonds. Pieces must of size sufficient to fabricate a minimum of 10 appropriate test samples: RPT responsiblility.

- Determine stress levels in machined sheets using polarized light: RPT to carry out this work.

TASK 4: BONDING.

- Bond sheets in such a location and orientation as to simulate a typical situation in fabricating the acrylic vessel. The bonding technique shall represent that intended to be used in fabrication of the vessel and will serve as a demonstration of the suitability of the technique: RPT to carry out this work.

- At the same time as two sheets are bonded, bond the respective samples retained from the machining process. The samples to be bonded at the same time, under the same environmental conditions and using the same adhesive as the main panels: RPT to carry out this work.

- Determine stress levels in bonded sheets using polarized light. Attempt localized annealing of highest stress area to examine the possibility of localized annealing of the finished vessel: RPT to carry out this work.

TASK 5: MECHANICAL TESTS.

3500R3 - MACHINING-RADIOACTIVITY

(Breakdown of responsibilities)

SCOPE: Evaluate the amount of radioactive contamination associated with the machining and finishing of the acrylic components of the vessel. Determine the optical quality of a finished surface.
Note: Certian components of the vessel will require extensive machining and finishing. The acrylic support collar may taper from 3 inches to 1.5 inches thickness. This could be achieved by machining 3 inch thick sheets of cast acrylic. A machined surface results in gross optical dispersion, this dispersion in the acrylic collar may be intolerable and require polishing. Likewize, the intersection of the access port and the collar with the sphere will be radiused and will require machining and possibly polishing. In addition, all bonded surfaces of the acrylic will require machining. To evaluate the radioactive and optical consequences of this requires the following tests;

TASK 1: OBTAIN MATERIALS.

- Obtain 1Kg each of three possible acrylic polishing compounds. RPT to provide samples commonly used and suggest additional possibilities. Send samples to the appropriate SNO institutes for measurement of radioactivity.

- Obtain a uniquely identified sheet of UVT acrylic of the appropriate dimensions. This sheet will be purchased by LANL. Remove samples and send for optical and radioactive analysis at appropriate SNO institutes.

TASK 2: MACHINING.

- Machine remaining sheet to the dimensions approximating those of a major machined component of the vessel, e.g. the tapered support collar or the intersection of the port with the sphere. Machining will be carried our under conditions and using tooling approximating those

- Manufacture sufficient test coupons from the appropriate location(s) in the bonded panels. Note that these test samples must contain *unfinished* bond joints since this represents the most probable condition of the joints in the panels. Conduct tests: This work will be carried out at the most appropriate place, possibly RPT or LANL depending on facilities, costs and turn-round time.

- Manufacture sufficient test coupons from the bonded QA samples. These test coupons should have *unfinished* bond joints as do the samples obtained from the bonded sheets above. Conduct tests: RPT or LANL responsible for this work.

DELIVERABLE: A report detailing the results of the above tests including;

- Observations concerning the residual stresses in the acrylic as a result of the various fabrication processes.

- Record the changes in thickness which result from thermoforming the acrylic sheets. Information to be used in the final engineering design of the vessel.

- Observations and recommendations concerning the bonding technique to be employed in the mine, based on the above tests. Note the anticipated number, size and type of inclusion that occured in the bond joints and level at which inclusion must be rectified.

- Conclusions as to the correlation between the bond strengths of the panels and the test samples, with recommendations as to how this should be incorporated into the bond quality assurance program used in the actual construction of the vessel.

- The results of the radioactivity and optical measurements will be detailed in a subsequent report.

NOTE: Primary responsibility for writing report will be carried by LANL in collaboration with RPT.

3500R4 - ACRYLIC TUBES

(Breakdown of responsibilities)

SCOPE: Identify source of commercial extruded UVT acrylic tube with dimensions appropriate for the D_2O and H_2O recirculation pipes. This task consists of;

TASK 1: MATERIAL SELECTION.

- Contact suppliers of suitable extruded UVT acrylic tube and obtain samples. This will be carried out by LANL with input concerning desirable fabrication properties provided by RPT.
- Determine radioactive and optical properties of material by sending samples to the appropriate SNO institutes for analysis. This will be overseen by LANL.

TASK 2: FABRICATION TECHNIQUES.

- Determine bonding properties of tube and the technique for fabricating bonds appropriate to the design of the acrylic vessel. This work will be carried out by RPT.
- Subject bonded tube to accelerated aging in pure water as described in 3500R1. Determine mechanical and optical properties after accelerated aging. This is the responsibility of LANL.
- Determine techniques for thermoforming tube to the dimensions required for the D_2O and H_2O recirculation systems. This is the responsibility of RPT with input provided by the designers of the vessel and the SNO collaboration.
- Investigate ways of attaching tube to walls of the acrylic vessel where appropriate. Investigate ways of making transition to the stainless

steel tubing of the D_2O and H_2O recirculation systems. This is the responsibility of RPT with input provided by the designers of the vessel and the SNO collaboration. Note that couplings used in the D_2O piping system must meet the security requirements of the D_2O owners.

DELIVERABLE: Report detailing the findings of items 1 to 5 and making specific recommendations as to;

- Suggested commercial source of extruded acrylic tube, its radioactive, optical and short/long term mechanical properties.
- Recommended technique to bond the tube.
- Recommended technique to attach the tube to the walls of the vessel where appropriate.
- recommended technique to couple acrylic tube to stainless steel piping of the recirculation system.

NOTE: Primary responsibility for writing the report will be carried by LANL in collaboration with RPT and the designers of the vessel.

3500R5 - SUPPLIER-ACRYLIC SHEET

(Breakdown of responsibilities)

SCOPE: In conjunction with 3500R1 (Mechanical Properties of Acrylic), work in collaboration with manufacturers of acrylic sheet to obtain material of superior radioactive and optical properties. This task shall consist of;

TASK 1: CONTACT SUPPLIERS.

- Identify suppliers of suitable cast UVT acrylic sheet. Contact appropriate person(s) involved in production of acrylic and arrange to inspect production facilities. This is the responsibility of LANL.

TASK 2: COLLABORATION WITH SUPPLIERS.

- With assistance of manufacturer, identify possible stages of manufacture in which contamination may be introduced or process improved. Obtain an estimate of the cost and time involved in possible correction of these situations. This is the responsibility of LANL.
- Obtain samples of raw ingredients and manufactured product for radioactive analysis to identify stage of production process in which contamination is introduced. This is the responsibility of LANL in conjunction with other SNO institutes.
- If improvement appears feasible and acceptable to manufacturer, obtain samples of acrylic produced under new manufacturing condition and subject to tests to determine radioactive and optical properties. This is the responsibility of LANL in conjunction with other SNO institutes.

TASK 3: QUALITY ASSURANCE.

steel tubing of the D_2O and H_2O recirculation systems. This is the responsibility of RPT with input provided by the designers of the vessel and the SNO collaboration. Note that couplings used in the D_2O piping system must meet the security requirements of the D_2O owners.

DELIVERABLE: Report detailing the findings of items 1 to 5 and making specific recommendations as to;

- Suggested commercial source of extruded acrylic tube, its radioactive, optical and short/long term mechanical properties.
- Recommended technique to bond the tube.
- Recommended technique to attach the tube to the walls of the vessel where appropriate.
- recommended technique to couple acrylic tube to stainless steel piping of the recirculation system.

NOTE: Primary responsibility for writing the report will be carried by LANL in collaboration with RPT and the designers of the vessel.

- Having established levels of radioactivity and optical quality that are achievable, in collaboration with the manufacturer, establish quality control proceedures for manufacturing the final acrylic sheets, the levels of quality and acceptable deviations from them. This is the responsibility of LANL.

DELIVERABLE: Reports detailing;

- Areas of the manufacturing process identified as being responsible for degrading the radioactive and optical properties of the acrylic. An estimate of whether it is feasible to rectify the problem and the cost and time incured.
- The results of implementing these improvements to the manufacturing process. Quantify the optical and radioactive quality of the acrylic.
- Specify the quality assurance techniques to be applied in manufacturing the acrylic sheet and the acceptable tolerances.

NOTE: Primary responsibility for writing the report will be carried by LANL.