SNO-STR-91-16

SNO COLLABORATION MEETING

VANCOUVER
19-24 Feb. 1991

STATUS OF THE ACRYLIC VESSEL PROGRAM

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OVERVIEW:

At present there are still two vessel suspension systems under consideration; the original acrylic collar design and the rope suspension design. Although there appear to be physics, engineering and fabrication advantages to the rope suspension, a final decision awaits the results of the preliminary design study which will be avaliable in a few weeks.

The basic R&D on the long-term properties of acrylic is advancing, but slowly. There is some concern that the findings of these studies may arrive too late to be considered in the main design effort and we will be forced to use more pessimistic values for the long term properties.

Other R&D activities are proceeding on schedule.

Two analysies are underway, the preliminary analysis of the design of the rope suspended vessel and the analysis of seismic waves in the water. Both these studies are significantly overdue and the cause of the delay must not be allowed to occur in the main design studies.

The design criteria document for the vessel is complete and drafts are avaliable of the design plan and the material specification documents. These documents along with the QC proceedures will be required in order to go out to bid on the acrylic supplier and the fabricator.

A draft of the installation proceedure, prepared by Monenco, appears, with some revision, to be workable. Another possible proceedure with changes to accomodate the installation of the PSUP, is being considered. Unfortunately a number of fundemental decisions will have to be made in the absence of review by the fabricator of the vessel.

Major activities in the first half of 1991 will be the preparation for the selection of the acrylic supplier and the vessel fabricator plus the main design.

R&D:

The study of the variation of the bond strength with thickness is complete and a report is avaliable (SNO-STR-91-3). The findings of

this study will be used to specify the allowable range of bond thickness in the finished vessel which will give optimum strength.
A report is avaliable (Stachiw, 2-14-91) which describes a new bonding technique yielding a surface finish which does not require significant adittional work and can accomodate slight variations in panel thickness and alighment. Further R&D will be undertaken to determine the strength of bonds made with this technique. A test program has been written by Stachiw (2-13-91) and reviewed by Reynolds. These tests will be implemented immediately. If the bond strength is satisfactory, the technique will be further refined by the selected fabricator.
The acrylic creep tests are proceeding, though at an unsatisfactory rate.These tests will provide the long term properties of acrylic which has been immersed in water and are required before the final design of the vessel begins(6-91). It is not clear that we will have all the desired long-term data by then. The default is to use long term data on the acrylic modulus which has been obtained over ten years exposure to an outdoors environment. This is considered to be conservative, since the rate of deterioration in water is expected to be less than that air exposed to UV, polution and large temperature fluctuations. Although this existing data is considered to be conservative, the present study will continue to ensure that there are no suprizes.
A machine has been built that measured the creep of rope while immersed in water. Samples of Kevlar and Vectran are currently being tested. Aged samples of these ropes are being prepared for comparison. In the case of Kevlar, which has seen considerable service, sufficient long term mechanical data exists.
Stachiw is currently conducting tests of possible acrylic cleaning agents and their effect on the strength of acrylic. Once samples have been identified they will then be tested for their radioactivity residue that they may leave on the acrylic and the best agent selected.
Two designs for attaching the suspension rope to the vessel have been analysed (see below). Once the results have been reviewed it is proposed that a rope attachment point be constructed from acrylic and loaded to determine if the stress levels given by the analysis are correct.
Outstanding R&D items which have not been addressed are the technique to leak-check the final vessel and long term monitoring techniques. The timescale for these items does not appear to be critical.

PRELIMINARY DESIGN:

Two analysis efforts are underway, the preliminary design of the vessel by Swanson and a study of seismic wave action by Quest. Both these studies are overdue and major decisions are pending on their findings. The results of the preliminary design will be used to decide if the rope suspension technique is to be chosen, the seismic study will indicate whether any special precaution need be taken to protect the vessel from wave action. The delay could perhaps have been avoided if closer contact had been maintained with the contractors. This must be remeded in the future if significant slippage of the schedule is to be avoided.

The Swanson preliminary design has considered two rope attachment designs, the effect of rope failure, the stability of the chimney, stresses on the vessel while full and empty and the vital question of buckling. Preliminary results, obtained during a visit on 15 Feb., are encouraging in that the overall stresses appear lower than with the acrylic collar suspension technique, also the vessel would be simpler to fabricate. The chimney appears to have adequate stability without the need for additional support. Two rope grooves have been analysed, the closed groove has lower stresses (as expected), but neither design is eliminated. Buckling studies have been carried out with two codes, ANSYS and BOSOR4, both give similar results with a critical buckling factor of about 7. However, this does not take into account geometrical imperfections in the vessel, and this tricky question will be raised with the experts at LANL. The final report which will be avaliable end of Feb. will be used to make a final decision in the vessel suspension and guide the final engineering design. The prognosis looks good for continuing with the rope suspension concept.

The findings of the preliminary design will form part of an information package to AECL to update them on our progress and direction.

Quest Structures, who are carrying out the seismic sloshing analysis were visited on 14 Feb. A finite element model of the cavity and the acrylic vessel has been constructed and subjected to the "standard" blast in the mine. This is relatively high frequency with periods of 10's of ms, whereas the natural response frequency of the vessel is on the order of seconds. The situation in terms of the dynamic pressure on the acrylic vessel was culculated every 5ms, but due to the cost of data storage, only every 5th data point was recorded. It is possible therefore that the peak pressures were missed. With this in mind, the maximum dynamic overpressure on the vessel due to blast induced ground motion is 90psi occuring at the bottem. The

maximum height of the wave crest above the free surface of the water is 2.6 inches. Another difficulty associated with computing time and data storage is that the sequence of events was only followed for 0.7 seconds. This contained the maximum of the ground motion, but only just - it would have been better to carry the analysis out to 1 second.
All this took 90 minutes on a Cray XMP located at the Minneapolis Supercomputer Center (MSC) which accounted for 70% of the cost of the study. LBL is looking into the possibility of getting time on the Livermore Crays to complete the study.
The next stage of the work is to allow tension only in the rope member to see if the vessel bobs up, culculate the overpressure for every 5ms for a duration of 1 second and culculate the stresses in the ropes and vessel shell. It would be desirable to study the effect of natural seismic activity, since this has a longer period approximating that of the vessel. The response of the PSUP will also have to be studied.

MAIN DESIGN:
The main engineering design will be carried out by Monenco with further analysis possibly contracted to Swanson. This work will not begin until a decision has been made on the preliminary design.

ACRYLIC SUPPLIER:
Four possible suppliers of acrylic have been contacted and measurements of the radioactive and optical properties of their material favour two of them.
A material specification document has been drafted which will be used in the final selection of the supplier.
A QC document will be required and a draft is being prepared.
Tenders for the supply of the acrylic will be sent out 15 June 1991 and preliminary evaluation of the tenders will begin 15 August 1991. Delivery of the acrylic to the fabricator will begin 15 March 1991.

VESSEL FABRICATOR:
A total of six fabricators have been visited, one has definitely been excluded on the grounds that the project is too large for their existing facilities.
Before we can go for bid on the fabrication of the vessel, the chosen concept (rope or collar suspension) will have to be reviewed by AECL, Engineering drawing and QC documents must be prepared. A

draft plan of the R&D to be carried out by the fabricator will also be needed. The design criteria document exists.
Tenders for fabrication of the vessel will be sent out 15 July 1991, with evaluation of the tenders begining in 15 October 1991. The order for fabrication of the vessel will be placed 15 December 1991. A period of about six month is allocated to R&D into bonding by the fabricator. The fabricator is also expected to design the necessary jigs and installation hardware.
Shipment of the vessel to the mine will begin 15 March 1993.

INSTALLATION:
A draft installation plan has been completed by Monenco and with some refinement may be acceptable as a "straw man" for the installation of the vessel. A possible alternative from LBL is under consideration which will ease the installation of the PSUP but may present difficalties for the installation of the vessel. The acrylic vessel committee will hold a workshop to make recomendations on installation and the use of the lower access to the cavity. Unfortunately, a decision will have to be made in the absence of input from the fabricator.
A philosophy of minimal component cleaning at the mine is being considered. Most of the cleaning will take place at the fabrication facility and efficient bagging relied on to maintain cleanlyness. R&D is continuing to select the optimum cleaning agent and technique for both the individual components and the finished vessel.

VESSEL ACCEPTANCE:
A Leak check plan, stress monitoring plan and dimension checking technique are needed for acceptance of the vessel. Only rough concepts exist for these at the moment. Likewize, long term monitoring techniques must be planned.

DESIGN PLAN SCHEDUAL

PRELIMINARY

1) PREPARE AND ISSUE DESIGN CRITERIA		
2) CARRY OUT DESIGN REVIEW	91-2-15	91-02-28
3) COMPLETE PRELIMINARY VESSEL STRESS ANALYSIS		91-02-28
4) COMPLETE ROCK BURST ANALYSIS		91-02-28
5) PRODUCE SECONDARY VESSEL STRESS ANALYSIS	91-03-01	91-04-30
6) ALL RESEARCH DATA ON HAND		91-04-01
7) PREPARE DESIGN CHECK ANALYSES	91-04-01	91-07-01
8) PREPARE OPTIMISATION STUDY	91-04-01	91-05-01
9) PRODUCE FAILURE MODE ANALYSIS	91-04-01	91-05-01
10) PREPARE DESIGN CONCEPT CHANGE SUMMARY	91-04-01	91-05-01
11) UPDATE AND ISSUE STRESS REPORT	91-05-01	91-06-01
12) PREPARE TECHNICAL SPEC & DRAWINGS (MATERIAL AND SPECIFICATION)	91-03-01	91-05-01
13) PREPARE DESIGN SOLUTION & HOLD SECOND DESIGN REVIEW	91-05-01	91-06-01
14) REVISE AND ISSUE SPECS. & DRAWINGS	91-06-01	91-07-01
15) OUT FOR TENDER:		
ACRYLIC MATERIAL	91-06-15	91-08-01
VESSEL FABRICATION	91-07-15	91-10-15
16) PREPARE DESIGN DESCRIPTION	91-08-01	91-09-15
17) PRELIMINARY TENDER EVALUATIONS:		
ACRYLIC MATERIAL	91-08-15	91-11-15
VESSEL FABRICATION	91-10-15	91-11-15
18) MODIFY ACRYLIC TENDERS TO SUIT VESSEL TENDERS AND ORDER ACRYLIC	91-10-15	91-11-15
19) PLACE ORDER FOR VESSEL FABRICATION		91-12-15
20) DELIVER ACRYLIC MATERIAL	91-03-15	92-07-15
21) SHIP VESSEL TO MINE	93-03-15	93-07-01
22) PREPARE DESIGN MANUAL	93-01-01	93-04-01