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"Cleaning History" (15 pages)

SNO-STR-92-086

Maintenance of Clean Conditions during Fabrication of the Acrylic Vessel -Preliminary Thoughts-

26 October, 1992

Peter Doe - LANL

Philosophy: The quality of the acrylic vessel is crucial to the success of the SNO project, so also is the maintenance of clean conditions. These requirements could appear to be mutually exclusive. We wish to provide working conditions for the fabricators of the vessel which will ensure the greatest probability of a successful vessel, while at the same time ensuring the minimum possibility of contamination to both the vessel and the rest of the detector.

The Problem: Finishing the bonds of the vessel require (traditionally) the liberal use of abrasives and water. The abrasives are expected to have a generally higher level of radioactive contaminants than the other construction materials of SNO, furthermore these particulate materials are easily transported to other regions of the detector from which they are not readily cleaned. The problem is to allow the vessel fabricators to proceed in a manner with which they are most comfortable and efficient, while at the same time maintaining clean conditions in SNO.

The bonds have to be finished, since the presence of irregularities on the surface give rise to local stress concentrations which weaken the structure. Finishing a bond first requires the use of a hand-held electrical plane. This generates relatively large (1-2mm) chips of acrylic, the bulk of which can be caught in a vacuum bag attached to the plane. Those which escape are easily visible to clean-up crews. In addition the chips consist of acrylic and adhesive, both comparatively radioactively clean.

After planing the bond, the next stage is to sand the bond with progressively finer grades of paper, finishing in a #600 grit. To prevent local heating of the surface (which induces stress and eventually crazing of the acrylic), plenty of water is used. The water

is applied by squirt bottle in the case of small area, manual sanding, or is piped (at roughly a few liters per minute) in the case of mechanical sanding. Both techniques will probably be used in the manufacture of the vessel.

The use of water during sanding is desirable also from the cleanliness aspect, since as long as the sanding residue (grit and acrylic) is wet, it will not enter the atmosphere and move around. Furthermore, water in controled conditions moves in well defined paths and this can be used to transport the residues to a central collection site.

Problems arise when conditions become uncontrolled - splashing and puddling in unexpected places. This water residue then can be stepped in and spread around, or, when it dries out, the dust can enter the air and spread even further. To some degree this is going to happen anyway.

We are unlikely to develop a waterless, dust free way of finishing bonds, therefore we must come to terms with handling the water residue.

Possible Solutions: We can attempt to control the water residue locally to the bond being worked on or globally, in the whole region of the vessel.

Local Control: It is expected that only 10'-20' linear feet of bond would be worked on at a time (this has to be confirmed by the fabricator). A device must be made which will restrict the water to the region being worked. This device(s) must be capable of being used on vertical and horizontal bonds, inside and outside of the vessel and upwards and downwards with respect to gravity (the latter problem may be quite difficult to solve). In addition, this device must not excessively hamper the work of finishing the bond, since this will impact the quality of the vessel and the time ($) in finishing it.

It is possible that guides will be used to aid in the control of the sanding machines, if so, it is possible that these guides (likely to be in the form of strips running parallel to the bond) could form part of the local water control. In addition it may be possible to use some wet/dry vacuum recovery system in the region of the tool being used. These possibilities must be discussed with the fabricator and developed during the qualification program.

No local control will be 100% successful. Therefore procedures must exist to handle spills and splashes

Global Control: In this case. global referes to those areas where bond finishing will take place. This is largely in the immediate region of

the sphere, but could also include the drift, where prebonding of some panels will take place. At this stage we will assume that all bond finishing will take place on the sphere. Schedule considerations may require us to reconsider the question of finishing in the drift.

Global control will allow relatively free use of water. This water would run down the sides of the sphere and drip off its underside (or run out the hole in the lower hemisphere). The residue then falls through the grating of the construction platform to the floor of the cavity, where it flows to the sump. Some of the residue will adhere to the construction platform and its support structure, for this reason, liberal use of water is prefered to prevent the residue drying out before it is washed to the central drain in the floor.

Some of the residue on the construction platform will adhere to workers footwear - it is difficult to imagine this not happening, to some extent, in any plan. Therefore, workers will be required to don coverall booties when entering the construction area and dispose of them as they leave. Tack-mats will also be needed at the entrance(s) to the construction area.

As with local control, the bonding area will need to be tented off from the rest of the cavity, to prevent any splashes leaving the control area. It may be that the mine will require an air exhaust for this tent which passes through a charcoal filter (to control MMA vapors) if so, we could supplement this filter to control airborne particulates as well.

Prefered Solution: In my opinion (PJD) a local solution that does not fail is likely to be relatively complex and interfere with the work of bonding. Any local solution that does fail, quickly becomes a global problem...therefore I recommend going to the global solution (we should not stop thinking about local control of residue - who knows what may be possible).

Cleanliness Using the Global Solution: The following is a rough outline of the steps in the construction program using the global solution. It assumes that no wet joint finishing will be carried out in the drift.

1) Fabrication of Chimney and Upper hemisphere: It is assumed that the bulk of the panels for the upper hemisphere and the three chimney sections are stockpiled in the drift. Bonding of some panels may be taking place in the drift. The PSUP upper geodesic is complete and hoisted into position. An opaque sheet has been installed across the bottom of the hemisphere. A transparent, cylindrical plastic curtain is now installed between the rim of the

PSUP and the fabrication floor, as shown in figure 1. This now forms the tent, which may have to be provided with local air conditioning since it is a total enclosure. The entrance to the tent has a tacky-mat plus coverall bootie supply and disposal. Clean (potable standard, as used by the fabricator in earlier tests) water is available at the rate of at least 50 gallons per hour.

The three chimney sections are bonded and the bonds finished. The chimney and fabrication floor are hosed down and after a final clean (yet to be defined) the chimney is hoisted through the opaque sheet and out of the way.

The jigging and other construction equipment is now erected on the fabrication floor and construction of the upper hemisphere begins. Finishing a bond would employ plenty of water, this ensures that any residue on the floor of the cavity is likely to be washed away down the drain. Having finished a bond, it is hosed down and sponged dry. At the end of a shift during which bond finishing has taken place, the fabrication floor and cavity floor are hosed down along with any jigging etc.

It is very important that the rope grooves are plugged in order to prevent accumulation of residue. After upper hemisphere has been completed and the chimney has been bonded into position, the final cleaning of this section can begin. It is difficult to see how this could be accomplished without liberal use of water - this is another reason to use the "global approach". Before starting the final clean it is important to ensure that the general construction area is clean. This would be accomplished by spraying down not just the structures, but also the plastic curtains which will have accumulated dust to some degree. This is important since the plastic sheet protecting the PSUP and forming the tent will now be removed to allow the installation of the ropes, as shown in figure 2. It may be that the PMT's require an opaque sheet in position during the short time that the ropes are installed. This complicates matters, but is not impossible.

To install the ropes, the tents are removed and the hemisphere raised by means of the fabrication platform - another reason why the platform must be easy to clean. After installation and tensioning of the ropes, the platform is lowered and the PSUP again sealed with an opaque plastic sheet.

2) Fabrication of Lower Hemisphere: The jigs and hardware are now installed on the fabrication floor. The cylindrical plastic sheet is now replaced to re-establish the tent, as shown in figure 3. Construction of the lower hemisphere continues using the same procedures as the

upper hemisphere with the exception that the "final" cleaning will not take place until the two hemispheres are bonded together.
3) Joining of Two Hemispheres: The top of the upper hemisphere is now covered with plastic sheet, extending to the lower edge of the PSUP. Much of the fabrication hardware is now removed (hoists etc.) and the lower hemisphere, fabrication platform, plastic sheeting and cavity floor is given a good spraydown cleaning. The opaque sheet at the bottom of the PSUP is removed and the lower hemisphere raised to meet the upper hemisphere and the two halves are bonded together, this situation is shown in figure 4. Finishing this circumferential bond will contaminate the outer and inner surfaces of the hemisphere. At this stage the whole inner surface of the sphere is given its final clean, the waste water which escapes through the hole in the bottom of the lower hemisphere, falls through the grating of the fabrication platform and onto the cavity floor where it runs away through the drain. This is shown in figure 3. The construction hardware is now extracted through the hole in the lower hemisphere, without contaminating the inner surface. This will require people to enter and exit the vessel through the chimney - a possibly difficult procedure.
4) Installing the Lower Plug: The vessel is now clean, but it remains to plug the hole at the north pole, which will introduce some local contamination. Exactly how this is done is not clear, but it seems that it must involve lowering a technician about 70' to the bottom of the vessel, since installation of the plug requires access from both sides. The technician will have to work from some small, clean platform, capable of carrying most of the supplies needed, including electrical power. The final finish of the bond will be done from this suspended platform and will probably require the use of wet/dry vacuum devices etc.

Once the final band is complete and the vessel cleaned, it is sealed by a plastic membrane across the bottom of the PSUP, all remaining hardware is removed, the area given a final spray down and once the water has dried, the cylindrical curtain is removed. The cavity is now ready for the installation of the remaining PSUP components.

The liberal use of water can be expected to produce a relatively high humidity, however this is not expected to be a problem if the tent enclosure is provided with its own air vent.

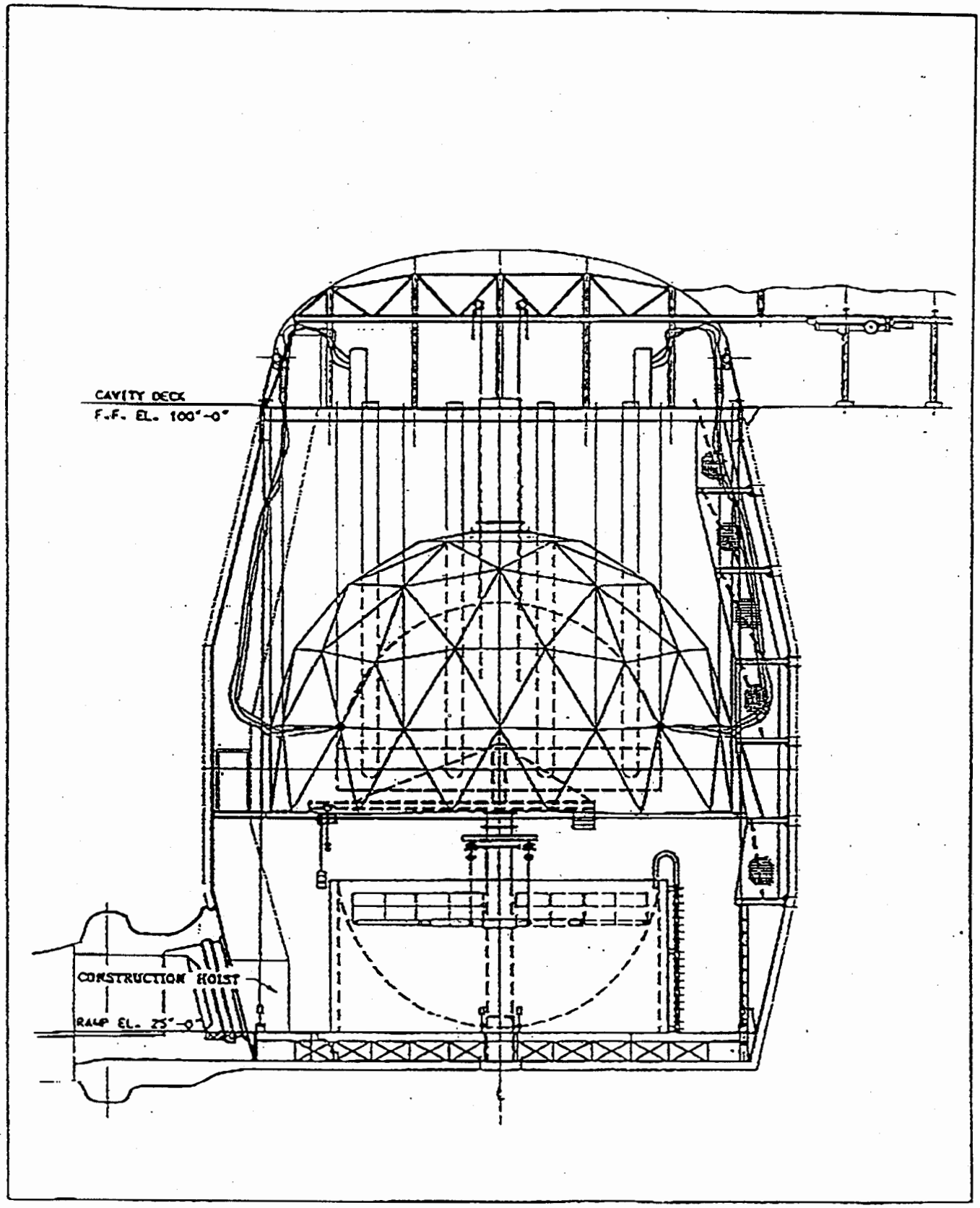

Figure 3: Fabricating the lower hemisphere.

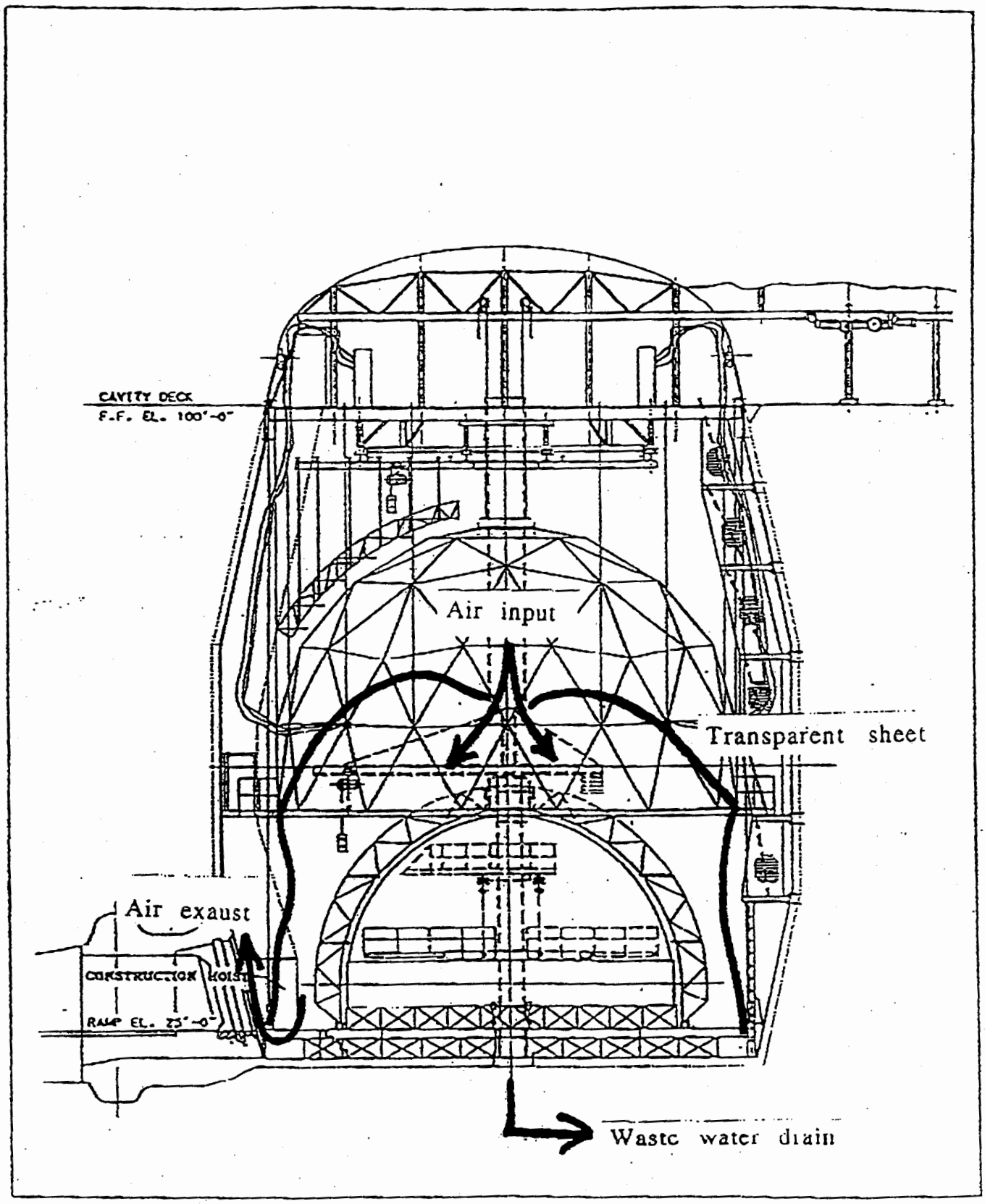

Figure1: Fabricating the upper hemisphere and chimney.

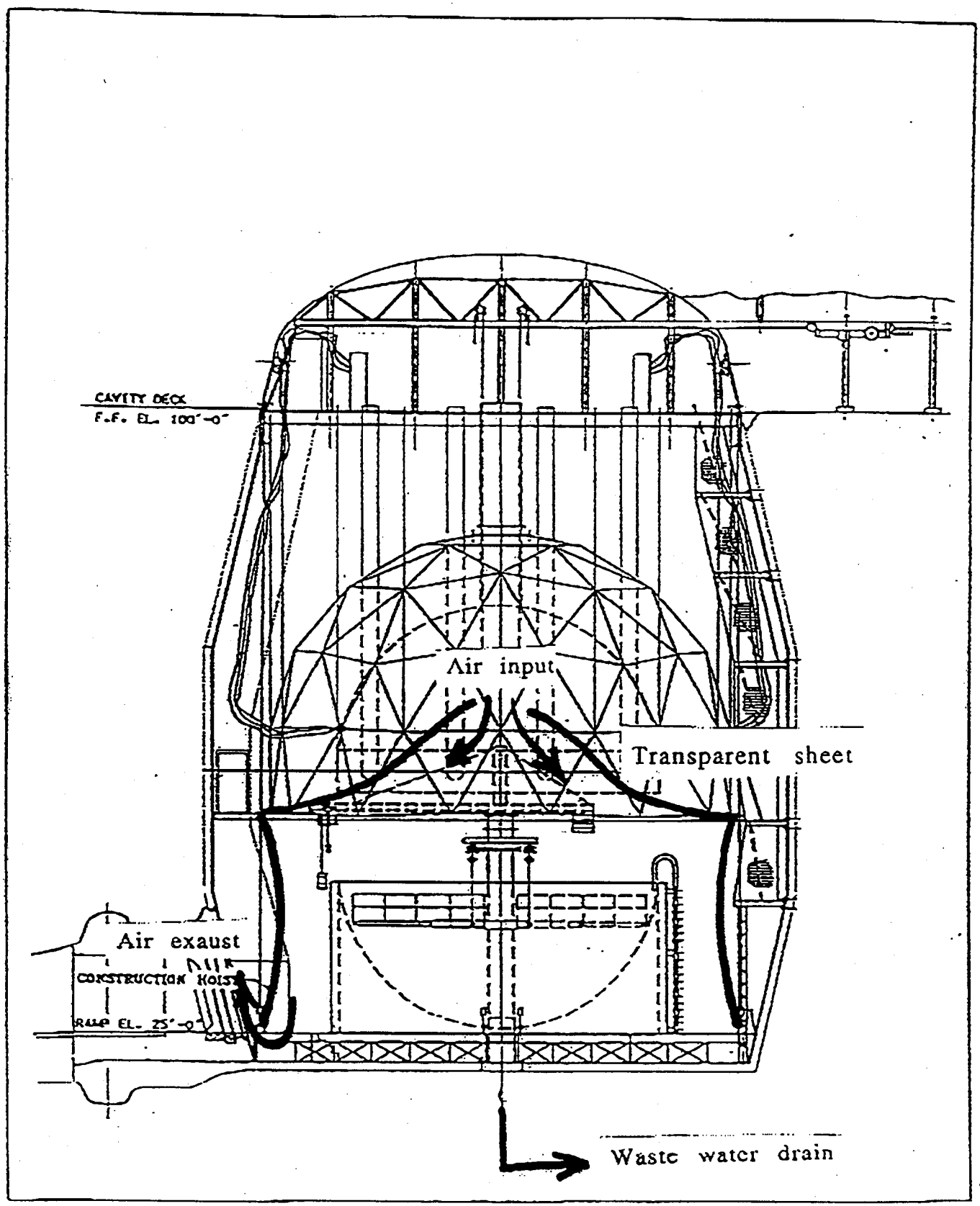

Figure 3: Fabricating the lower hemisphere.

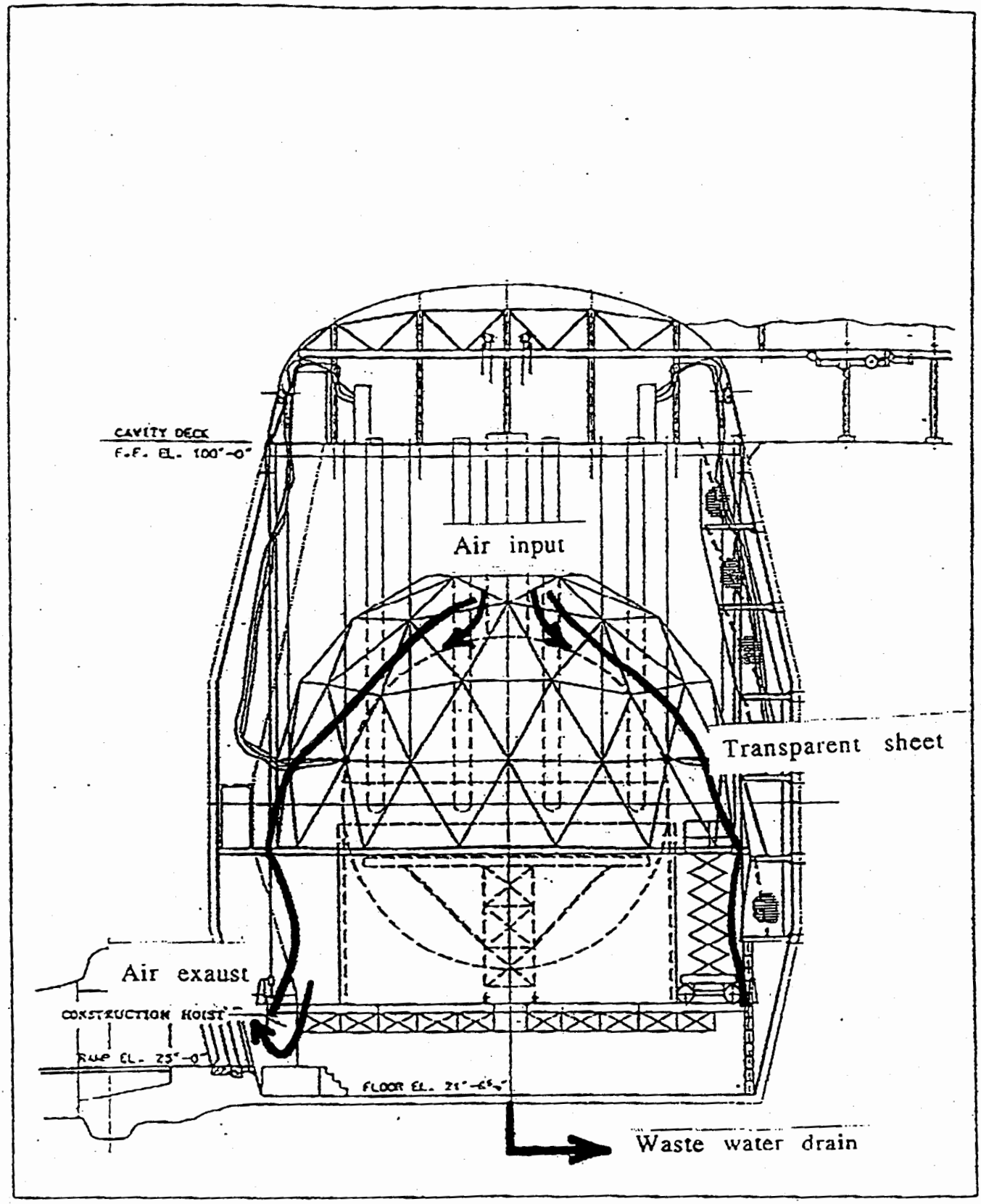

Figure 4: Bonding the two hemispheres.

CLEAN THOUGHTS

Peter Doe, LANL, February 1992

The following are comments on the Final Clean-up Plan, as proposed by Bob Stakstad in the memo to the Final Clean-up Working Group, February 7. 1992. The comments mainly relate to the acrylic vessel.

COMMENTS

1) **Initial condition:** We need to keep a close watch on how RPT will clean the acrylic panels before they are brought to the mine. There may be some residual cleaning substances on the acrylic which may not be removed by our final cleaning process and which may be a bug food or result in some optical interference.
It would be good if we can decide on a cleaning agent and technique at an early stage and determine if it is acceptable to RPT. This removes one variable.
2) **Cleaning the upper hemisphere and chimney:** Clearly we must do a lot of research on the choice of biocidal wash and its removal - this is discussed under tests below. I am concerned that after the upper hemisphere and chimney are fabricated, the existing scaffold may not give easy access to all parts of the outside surface of the vessel (I don't worry so much about the inner surface since the long duration biocidal wash and rinse should be very effective). We must clean the outer surface in one short period of time then cover it as soon as possible (how soon?), this assumes that the access is easy and convenient.
3) **Washing the exterior:** Apart from the usual concerns of effectiveness etc. I wonder what is going to happen to all that water that runs off the vessel. We will have a false floor (other wise our el-cheapo plastic liner will be trashed). Under the floor sounds like a soup kitchen.
4) **Cover-up:** I really like the stepwise covering as construction advances, especially dividing the volume into upper and lower hemispheres with the doughnut ring and the natural order in which they are removed. I cannit decide between Bobs helical coil and a single form fitting sheet with a long valcro seal for covering the hemispheres. I think we should also cover the lower hemisphere, i.e. give it the same treatment as the upper hemisphere and a simple hemispherical bag attached by valcro loops to the suspension ropes doesn't seem like a big deal.

5) **Cleaning volume 1:** This volume must be cleaned manually at the end of construction of each hemisphere. The questions are, can we then effectively bag it in the same manner as the outer surface, or should we later use the spray technique to remove accumulated dust? It would be good if we didn't have to spray then we won't have to worry about stabilizing a hi pressure head on the end of a 14 meter pipe or hassle with sump pumps (we need one to remove the heavy water). It would be great too if we could use a biocidal gas to sterilize the inside of the vessel while the lower PSUP is being assembled. It will not be much fun cleaning the inside of the 8 meter long chimney - I wonder if a hoop-like bottle brush/squeegee would work? The decision to spray or not to spray awaits the results of our tests of the effectiveness of the manual cleaning of surfaces and a neat solution for an internal bag. Remember that the inside may have at least 109 attachment points for descrite NC counters plus possible lines and pulleys for moving sources around inside the shell. These are potential dirt traps plus snagging point for bags. There will also be recirculation lines, water sampling lines and NC read-out line arrangement hoops in the neck (starts to sound like a junk yard!).

TESTS

1) The obvious tests - once we have chosen the cleaning agent, possible biocide and fumigant, what are their effects on the acrylic, mechanically and optically? For the mechanical tests we must use the same technique that Jerry Stachiw used for his tests of cleaning agent - **the test sample must be under stress in the region where the agent is applied.** This is a standard ASTM test which we should stick to.
2) Optical tests - I hope that the spectrometer used to investigate the effects of various substances on the acrylic will also be sensitive to wavelength shifting and florescence - that would be a big surprize when we threw the switch on D-day!
3) I'm curious as to how effective a slowly (mm/hr) rising water level is in removing electrostaticaly adhering dust from the surface of acrylic. I'm not sure how to do this since it seems one must remove the acrylic from the water to measure the effect. I don't agree with Chris when he says there will be no free floating biological substances when we fill - I'll bet that the surface of the water on the initial fill will give people some sleepless nights. Hopefully this stuff (if it exists) will be sterile and based on IMB

experience it groups together in regions where there is "zero" water movement.

ACTIONS

1) Hydro-stress crazing: Doe, Stachiw. Initial tests results will be available at the end of February. These results will be "initial" since I want to leave the acrylic drying out for a month or so as I get a handle on how the stress builds up under various humidity conditions. At the minimum this will tell us whether we have to spray water. I will probably conduct further experiments to see if there is a humidity threshold, but the important thing is to determine if we need to spray.

6a) Application and removal of exterior dust covers: Doe, RPT. This is a fun problem and I will pass it by RPT. The design and application of the covers is a SNO responsibility - however it impacts on the RPT work so we must keep in close touch with them. Is is meaningful to try to devise some experiment to evaluate dust transfere as we strip off a cover - if the dust make an electrostatic jump our covering efforts are questionable, that's why I would like to know what happens to adhering dust as the water level rises.

6c) Application and removal of equatorial cover: Doe, Stokstad. Ditto above, I'll sketch up some ideas and thoughts for review. We should investigate the type of company we should approach to make these (awning, tarps, balloons, boat covers?)

7) Determine the effectiveness of dust removal by rinsing: Doe, Stachiw. I will talk with Jerry to dream up some tests. We will pass our ideas around for comment. What is the timescale? I have some student power which would be ideal starting in June '92.

8) Hardware for volume 1 dust removal land rinsing: Doe, Brewer. We must determine if we want to rinse, this depends on the result of the manual cleaning and the efficiency of bagging. However, while these tests are going on we can shake the commercial trees and scope the problem plus what is will entail and cost. Tests of the efficiency should start as soon as we get initial results on the manual cleaning (by the way, who is doing this?).

FEED-BACK FROM RPT

Met with Roger Reynolds and William Nagurski to discuss fabrication contract. Also raised the question of cleaning which is summarized below:

1) RPT will clean the vessel using tap water, Ivory liquid soap, clean water rinse and wipe with toweling. They will be happy to substitute our solution for the ivory liquid. They don't use squeegees since these tend to scratch the surface.
2) I explained to William your scheme to cover up as we went. He will read your memo on this and I will report his reactions. Since the provision and installation of the covers is a SNO responsibility we need only be concerned that the covers do not interfere with the RPT work.
3) There will not be the "ideal" scaffolding giving access to all surfaces of the vessel for cleaning. For the outside of the upper hemisphere they proposed using a bosons chair type arrangement.
4) They warned us that when they join the upper and lower hemisphere and finish the joint, we will be alarmed at the streams of dirty water flowing down the sides. At this stage the last panel in the bottom of the vessel will not have been inserted so we can allow the dirty water to run out of the vessel and be disposed of.
5) During handling and bonding of the panels there will be a sheet of plastic wrap to protect the surfaces and only expose the border to be be bonded.
6) For their cost estimate that have assumed that they will clean the oven before every run. They have also put a filter on the make-up air input.
7) The reqirements for the packing case were relaxed. If the crate is not to enter the wash area there is no need to paint it.

PROCEDURES FOR INSTALLATION OF AV PROTECTIVE SHEET

The following are draft procedures for protecting the acrylic vessel from dust during construction.

1) CHIMNEY:

- After assembly:

  1) With the chimney sitting on the hoisting frame, clean the inner and outer surfaces of AV chimney using approved procedures. Access to inside and outside of chimney is via scaffold towers.
  2) After cleaning remove inner scaffold.
  3) Tie three 60' lines to the top of the top end of the outer chimney cover and through the hole in the deck, lower the cover until the whole chimney is enclosed. Temporary fasten the top of the cover to the upper chimney flange using the lowering lines. Use scaffold tower to access chimney.
  4) Tie 60' lines to each end of inner chimney cover and through the hole in the deck lower the inner chimney cover down chimney neck until the top of the cover is about 2' above the top of the chimney.
  5) Working from the scaffold tower remove the 60' lines and join the upper edges of the inner and outer covers using tape.
  6) Connect the chimney hoist lines to the chimney hoist frame and raise the chimney. Apply protection to the chemney as neccessary

- BONDING CHIMNEY TO SPHERE:

  1) Lower the chimney until it is approximately 1' above the chimney boss ring to which the chimney will be bonded.
  2) Roll up the inner and outer chimney covers sufficiently to expose the bond area for unimpeded work. Lower the chimney and continue with the bonding operation.
  3) clean the bond area using the approved procedures. Lower the covers to protect the clean area.
  4) Working from the north pole down, systematically clean the inner and outer surfaces of the upper hemisphere. Take particular care to ensure that debris is not trapped in the rope grooves.

AV NECK COLLAR

- COVERING THE UPPER HEMISPHERE AND INSTALLING THE ROPES:
  1) Install the AV neck collar around the base of the chimney. Ensure that the 60' long rip cord hangs free. Neatly coil the end of this line (it will be uncoiled as assembly of the lower hemisphere proceeds).

  2) According to the numbering on the collar, systematically attach the rolled up cover sheets to the AV neck collar using the "LBL pins". Ensure that the petal being installed overlaps the previously installed petal. When all ten are attached, unroll and lower the covers into place over the surface of the sphere. Ensure that the recovery lines hang freely for each cover.
  3) Arrange the covers carefully over the sphere. Where the cover passes over a rope exit point on the sphere slit the cover from the exit point down to the bottom of the cover.
  4) After the ropes have been installed, arrange the slit covers neatly each side of the suspension rope.
  5) Tie the 100" long drape from the equator back to the PSUP using the grommet holes to seal the region between the sphere and the PSUP

- INSTALLING THE NECK GASKETS:
  1) After the upper hemisphere has been hoisted into position the chimney covering must be removed to install the neck gaskets. Carefully raise both the outer and inner chimney covers and discard.
  2) Cover the top opening of the chimney with plastic sheet of the same specification used to cover the sphere. This can be obtained from the discarded outer chimney cover. Secure in place using ties through the bolt circle on the upper neck flange.

- REMOVING THE UPPER HEMISPHERE COVERS:
  1) When the vessel is complete and prior to proof testing it is necessary to remove the upper hemisphere cover. The petals should be removed in the reverse order to which they are installed. Firmly pull the recovery line until the cover separates from the chimney collar. Fold up and discard the cover.
  2) Remove the chimney collar by firmly pulling on its recovery line causing the Velcro strip to separate and fall free. Discard the chimney necklace.