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Informal Report

Acrylic vessel cleaning tests.

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Introduction:

The acrylic vessel as constructed is dirty. The dirt includes blue tape, Al tape, grease pencil, gemak, the glue or residue from these tapes, finger prints and dust of an unknown composition but probably mostly acrylic dust. This dirt has to be removed and once removed, the vessel has to be kept clean or at least to be easily cleanable at some future stage when access becomes much more difficult.

We report on the results of a series of tests designed a) to prepare typical dirty samples of acrylic b) to remove dirt stuck to the acrylic surface and c) to measure the optical quality and Th concentration after cleaning. This report does not address the concerns of how to keep the vessel clean after an initial cleaning and during the removal of the scaffolding. Alconox is recommended as the cleaner of choice.

Tests samples:

Acrylic samples were covered with the three tapes and baked in an oven to approximate the heat conditions during the curing of the acrylic vessel bonds, the tapes were removed leaving behind visible residue, grease pencil was applied to a clean area and all residues were cleaned off. These samples, prepared in at Laurentian University, were shipped to CRL where the optical quality and Th content of the cleaned acrylic were measured.

Optical samples:
- 5 cubes of Polycast UVT acrylic, 2" by 2" by 2", identical to the vessel material.
- 3 cubes had both optical surfaces covered, one with Al tape, one with blue tape and one with gemak. All three were then heated to 87 C for 15 hrs.
- 1 cube had surfaces covered with grease pencil.
- 1 cube was simply rinsed with distilled water to serve as a reference.
- The 4 cubes had the tape or grease pencil removed, the residues were removed with one of the three cleaning solutions and then the cubes were rinsed with ample amounts of distilled water.
- Since three cleaning solutions were used, there was a total of 15 cubes.

Th samples:
- 4 sheets of CRL shop acrylic, 12" by 12" by 1/8"
- Both surfaces of each sheet were covered with two 2" wide strips of Al tape, a 2" wide strip of blue tape, a 3" wide strip of gemak and 3" of grease pencil.
- They were heated to 86 C for 15.5 hrs. The grease pencil was applied after the heating step.
- All tapes, except one of the 2" wide strip of Al tape were removed and the acrylic sheets reheated to 86 C for 2 hrs.
- The final strips of Al tape was then removed.
- Each of the three sheets was cleaned with one of the three cleaning solutions. The 4th sheet was not cleaned but was rinsed with distilled water and air dried.
- A 5th sheet, untreated with dirt but rinsed with distilled water, was used as a reference.

Cleaning solutions
- A 5% solution of clear Ivory Liquid Detergent.
- A 5% solution of Radiacwash, supplied by Biodex Medical Sys, 20 Ramsey Rd., Box 702, Shirley, NY, 11967
- A wet paste of Alconox powder.

All three solutions have passed Stachiw's crazing tests and are OK for acrylic.

Cleaning procedure:

Samples were scrubbed with a plastic scouring pad (brand name "The Scourer") until the residues were removed except, in a few cases, scattered small spots of residue remained. They were rinsed with large amounts of distilled water, air dried and wrapped in saran wrap for shipment to CRL.. All of the surfaces could be cleaned. Using fresh Al tape to remove previous Al tape residue worked fairly well and resulted in less time being required to remove the last of the residue. It took 20-25 minutes to clean both surfaces of the sheets i.e. 2 square feet. The radiacwash and the alconox gave a cleaner surface quicker than the ivory detergent. The alconox paste scratched the surface more than the other two. The ivory detergent required more rinsing because of the suds.

Results:

Optical transmission:

The optical transmision of the cubes of acrylic as a function of wavelength were measured at CRL with a spectrophotometer. A figure of merit [1)], which is a measure of the fraction of the Cerenkov light to which the SNO photomultipliers are sensitive passing through the acrylic, was determined for each sample. Table 1 lists the figures of merit (FOM) for two measurements of the same samples. The difference between the blank sample and the samples with the removed residue are also tabulated. Clearly, the alconox is the superior cleaner.

Cleaner	Residue	March FOM	April FOM	blank-residue March	blank-residue April
ivory	blank	0.726	0.722		
	Al tape	0.699	0.695	0.027	0.027
	Blue tape	0.707	0.703	0.019	0.019
	Gemak	0.703	0.701	0.023	0.021
	Grease pencil	0.694	0.694	0.032	0.028
radiacwash	blank	0.748	0.747		
	Al tape	0.714	0.722	0.034	0.025
	Blue tape	0.736	0.718	0.012	0.029
	Gemak	0.735	0.72	0.013	0.027
	Grease pencil	0.719	0.72	0.029	0.027
alconox	blank	0.729	0.727		
	Al tape	0.732	0.735	-0.003	-0.008
	Blue tape	0.731	0.732	-0.002	-0.005
	Gemak	0.732	0.732	-0.003	-0.005
	Grease pencil	0.724	0.73	0.005	-0.003

Fluorescence:

Because alconox contains organic-chemical surfactants, which might have fluorescence or Raman transitions, there was concern that alconox residues on the cleaned acrylic-vessel surfaces could distort the spectrum of Cerenkov light passing through the acrylic. To investigate this possibility, a spectrophotometer at BNL was used to look at light that was scattered and/or emitted from samples in the backward direction, at about 150 degrees to the incident beam.

A sample of Polycast UVT acrylic was scoured with a 1% solution of alconox and rinsed thoroughly with distilled water; the scouring pad (brand name "ScotchBrite") was abrasive, so that the acrylic surface resembled a sanded bond region on the acrylic vessel. Another piece of acrylic was rinsed with water, without any scouring with alconox. As a reference, some of the alconox solution was put into a spectroscopy cuvette.

Spectra of the samples in air were taken with incoming beams of 300, 400and 500 nm (400 nm is at the peak of the SNO detector's response). The main structures observed in the spectra from the scoured acrylic sample were due to backscattering at the interface between the roughened surface and the air. Backscattering was much less from the clear acrylic piece that had not been scoured. Also, the spectrum of the 1% alconox solution in the cuvette was different from those taken with the acrylic samples.

Reference spectra, taken of organic compounds that are known to fluoresce, were characterized by large peaks. By comparison, the fluorescence and Raman effects in the acrylic and alconox samples were very small, at the level of about 0.01% of the primary backscattered beam.

These results agree with the optical transmission data above, where any absorption/re-emission effects from the treated acrylic pieces were miniscule.

Th concentration:

The sheets of acrylic were cut into 2" wide strips and packaged to fit into the cylinder for neutron activation at CRL. After neutron activation with a small quantity of Th serving as a monitor, the four cut edges of each strip were milled off and the rest of the sample was vaporized in the usual way[2)]. The residue was gamma counted for ^{233}Pa (311 keV). There was significant activity on the sample after irradiation (probably ^{24}Na) so the edge milling had to be delayed for a week and the gamma counting also was delayed a week because of the high short lived background.

The gamma ray spectra for the five samples are shown in the Figures 1-7. The background under the 311 keV peak is fitted with a linear background to obtain the background value to be subtracted from the peak area. The peak area, duration of run and weight of sample are recorded in each figure. The Th concentration in pg/g and in pg/ft^2 are also noted. The sample taken directly from the CRL shop (Fig. 1) had a Th concentration of 61 pg/ft^2. This can be assumed to be the base line for the measurements of the dirtied samples. The uncleaned sample (Fig. 2) had a Th concentration of 2500 pg/ft^2 and is a measure of the worst case situation. This Th may be coming from one of the tape residues or the grease pencil or from all four sources of dirt. The sample cleaned with Ivory detergent (Fig. 3&4) had a Th concentration of 250 pg/ft^2. This sample was counted twice. A comparison of Figs. 3&4 shows the effect of waiting for the short lived background to die away. The radiacwash sample (Figs. 5&6) had a Th concentration of 120 pg/ft^2 and the alconox sample (Fig. 7), 88 pg/ft^2.

Sample preparation	Th in pg/ft^2
Virgin, untreated	61
Dirtied & uncleaned	2500
Ivory cleaned	250
Radiacwash cleaned	120
Alconox cleaned	88

Assuming that the acrylic sheet contained 60 pg/ft^2 of Th to start with, then the sheet after cleaning with ivory detergent, radiacwash and alconox each had a surface residue of 190, 60 and 30 pg/ft^2 respectively. The vessel specifications require the Th in the vessel to be less than 1 ppt or 30 microg. The surface area of the vessel is about 10,000 ft^2 so a Th concentration of 2500 pg/ft^2 would contribute 25 microg. to the vessel Th inventory. Clearly too much Th, not that the entire vessel inside and out will be covered with the offending residue(s). All three cleaning solutions reduced the surface contamination by more than an order of magnitude which is probably acceptable. The difference between the radiacwash and the alconox may not be statistically significant especially when one considers the systematic uncertainties in these NAA measurements. The ivory detergent may be inferior to the other two.

Conclusions:

All three cleaning solutions reduced the Th concentration to acceptable levels with the alconox slightly better than the radiacwash. In spite of the observation that the alconox paste scratched the acrylic more than the other two during cleaning, the optical transmission figure of merit shows it to be superior to the other two. If alconox in solution is as good as the paste then it is the cleanser of choice.

1) Evaluation of Optical Properties of Acrylic Samples from Different Suppliers. E. Bonvin & D. Earle, SNO-STR-92-068

2) Measurements of Th and U in Acrylic for the Sudbury Neutrino Observatory, D, Earle & E. Bonvin, AECL-10749 & SNO-STR-92-061

Fig. 1 ID 325 Acrylic sheet, not treated, clean

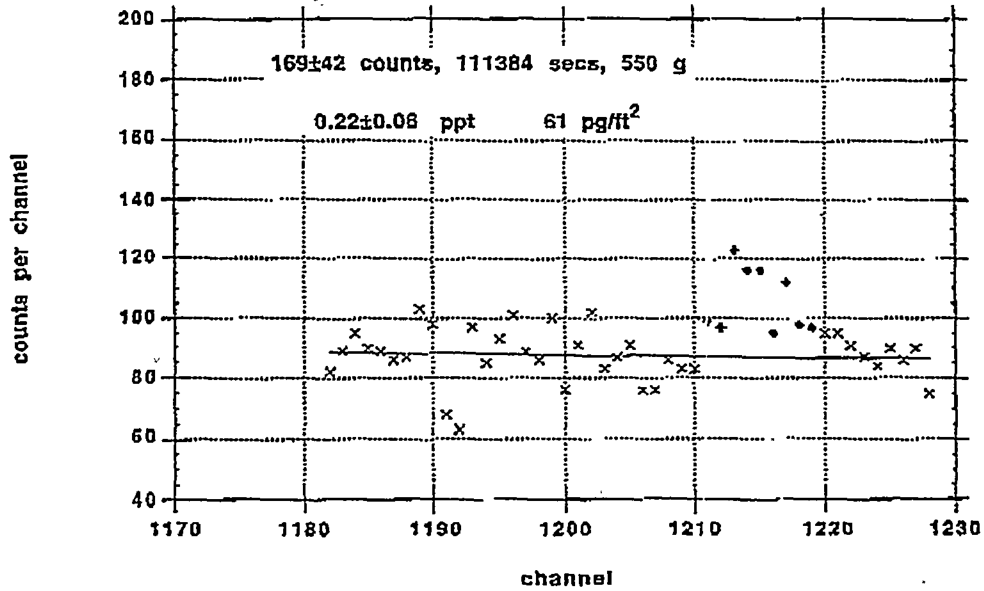

Fig. 2 ID 329 Acrylic sheet, tape gum etc. uncleaned

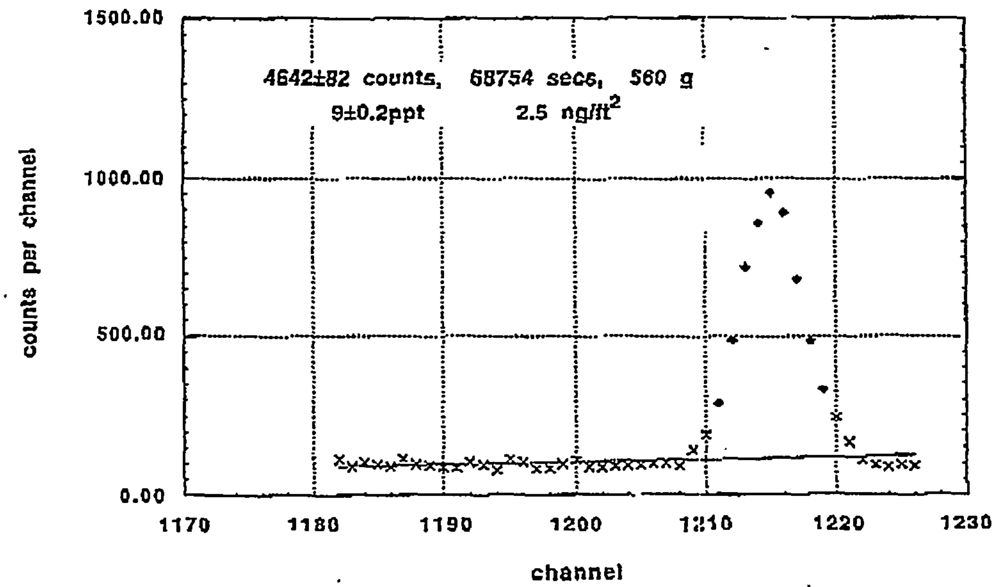

Fig. 3 ID 326 Acrylic sheet cleaned with ivory detergent

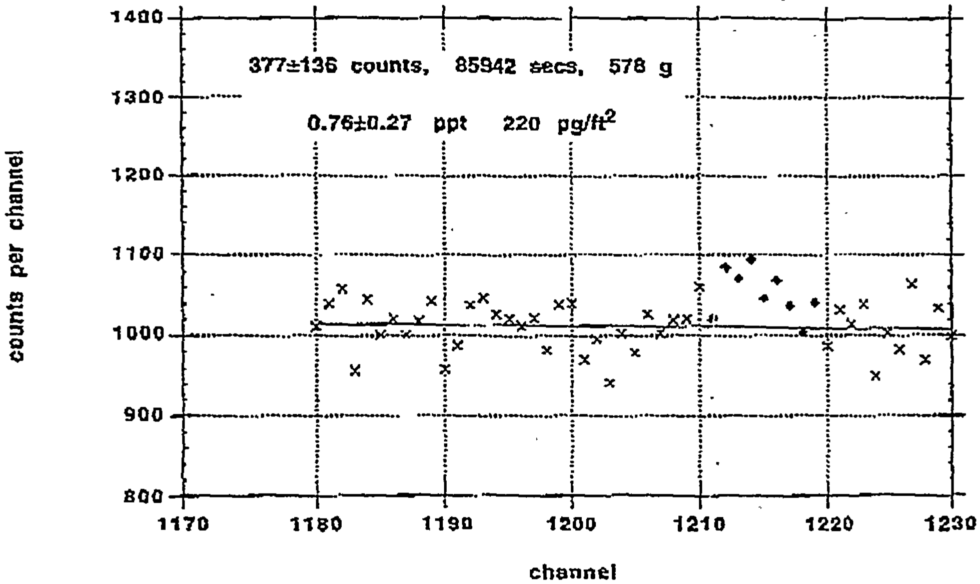

Fig. 4 ID 326 Acrylic sheet cleaned with ivory detergent

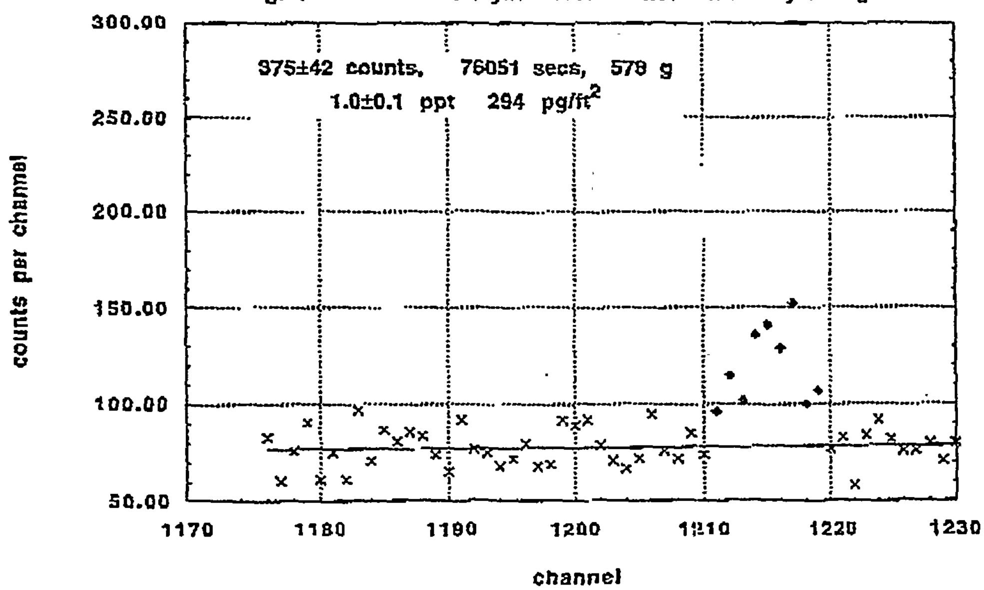

Fig. 5 ID 327 Acrylic sheet cleaned with radiacwash

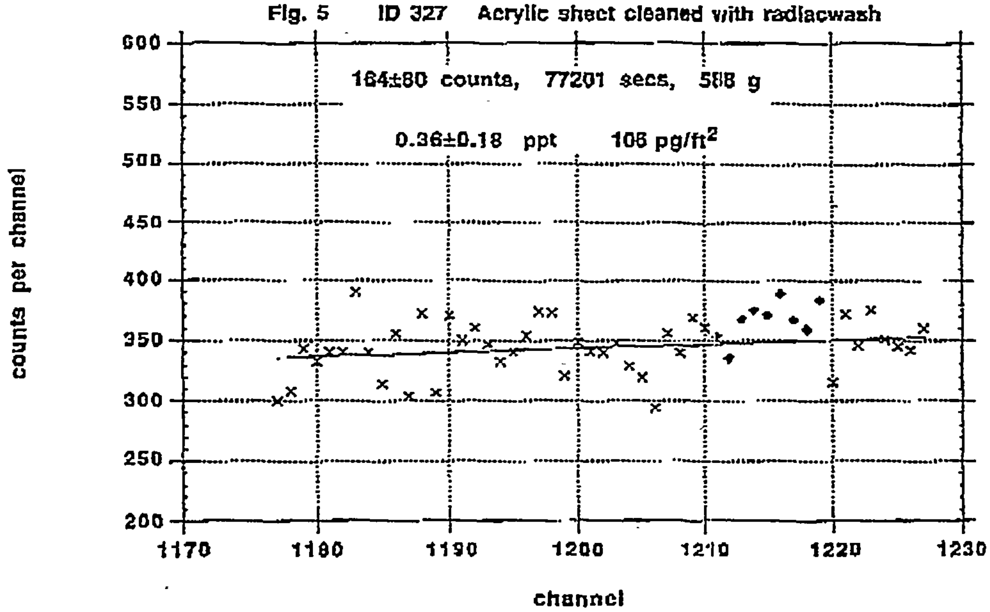

Fig. 6 327B Acrylic sheet cleaned with radiacwash

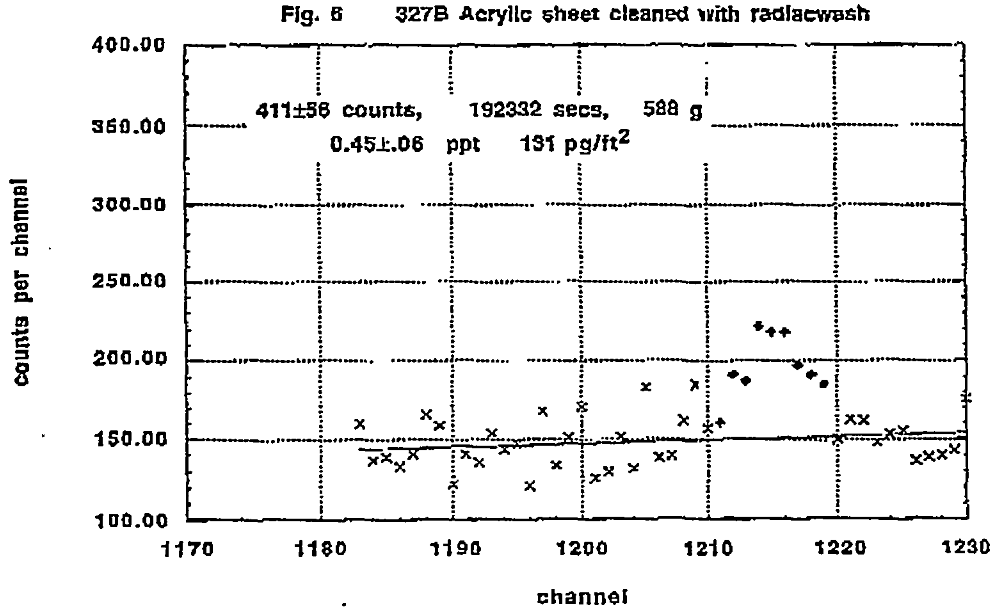

Fig. 7 ID 328 Acrylic sheet cleaned with alconox