Sudbury Neutrino Observatory
Underground Spray Testing
Urylon Polyurethane Coatings
Creighton Mine, January 29,30 1993

Final Report

E.D. Hallman, Laurentian University

March 22, 1993
SNO STR 93 - 010

Introduction

Spray tests of the proposed liner material for the SNO cavity were successfully carried out by P. Diebel and S. MacPherson from Urylon Plastics, Guelph Ont. in the personnel room of the SNO Laboratory, on January 29 and 30 1993. Procedures and test areas planned for this work are described in Appendix 1. A Fail-Safe review, conducted by Inco Limited, is outlined in Appendix 2, and the mine procedures which resulted from this review are given in Appendix 3. A report from Urylon Plastics is included in Appendix 4. A report from Inco Limited on ventilation measurements and on the monitoring of air contaminants is included in Appendix 5. Mechanical pull tests, establishing the adhesion of the coatings to the shotcrete/rock base were conducted by J. Archibald, Queen's University - a report is given in Appendix 6. Tests of radon transmission through a typical two-layer coating on the normal shotcrete and rock base are being carried out in the personnel drift. Panels of various coating thicknesses and types are being analyzed for radon emanation & transmission and for physical properties of the coatings.

This report summarizes the procedures, schedule and results of the polyurethane coating test spray.

1. Test Summary

The tests were set up to check the properties of the polyurethane coating, sprayed in the underground environment on a shotcrete (sprayed concrete) and rock base, similar to that planned for the SNO cavity. A two-layer coating - 0.25 inches base of Urylon HH453 Mineguard (white) and 0.05 inches top layer of Urylon 201-25 - was proposed by SNO personnel, since earlier laboratory tests suggested that radon permeability and emanation and leaching from this coating would be satisfactory. A test area of approximately 300 sq ft was coated with this two layer material, and an additional area of approximately 100 sq ft was coated with the 201-25 coating (thickness 0.30 inches) only. In addition, test panels of about 100 sq ft were also sprayed with the two layer coat (3 panels were prepared with 201-25 coats only). Two drums (45 US gallons) - one for each of the A and B components for the HH453 material were applied in about 1.5 hours of spraying from 9:30 am to 11:00 am on

Saturday January 30. Approximately 2/3 of the two drums of 201-25 material was applied as a top coat to the HH453 base and in the 100 sq ft single layer test area. This top coat spraying took about 1.5 hours, from 12:00 noon to 1:30 pm. Two pull test plates were applied to the HH453 material while still soft, and coated with additional layers of both materials. A radon monitoring box was also attached on top of the two layer coat and coated with an additional 0.30 inch layer of 201-25 material.

The polyurethane chemicals were delivered underground in a steel box containing the 4 - 45 gallon drums, accompanied by the hot mix sprayer, using a special cage trip. Materials and equipment were delivered the day before the test, following a Creighton Mine orientation for the Urylon Plastics crew.

2. Ventilation, Health and Safety, and Monitoring Arrangements

Because the isocyanates in the polyurethane chemicals are designated substances under Ontario Ministry of Labour regulations, special shipping, storage and application procedures were followed as discussed with Ministry inspectors and outlined in the Failsafe review (Appendices 2 and 3). In summary, shipments underground were made in a steel container, accompanied by personnel with respirators in case of a spill, and a spill kit. Storage areas were roped off. During spraying operations, the 6800 ft level was evacuated to the door on the # 9 shaft side of the return air raise, with all personnel present at the spray site having supplied air respirator equipment. A clearance time of 40 minutes following the completion of spraying was set, before personnel without respirators could enter the test area. Monitoring of temperatures, humidities, dust levels, air flow and for expected chemicals - triethanolamine and isocyanates was carried out by Inco, SNO and Urylon personnel. Results are summarized in Appendix 5, and in a later report section. At the completion of the test spray, equipment and surplus chemicals were removed again by a special cage trip, using the steel box container.

3. Measurement Results

(a) Air Monitoring During Spray Tests

Inco and Urylon measurements of air temperature and humidity, indicated temperatures at the test site close to 82°F (28°C) and relative humidities averaging 60%. Airflow into the personnel drift at the end of the spray test was found to be 8200 cfm, with an air velocity of 30.2 ft/min out of the drift. Sampling for airborne chemicals was carried out by Inco personnel at 4 locations near the spray site. Results for triethanolamine showed levels at about 4 % of the time weighted average exposure value (TWAEV). Levels of methylene bisphenyl isocyanate (MDI) 282 % and

130 % of the TWAEV (0.0050 ppm) were recorded at monitoring stations downwind of the spray site in the drift (A) and downwind of the drift just past the ramp (D), respectively.

A SNO sampling pump was set up 10 ft inside the personnel drift entrance, to monitor for MDI isocyanate. Analysis of the impinger sampling solution (Ministry of Labour colorimetric procedure 455/83) was carried out by Clayton Environmental Consultants (Windsor, Ont.).

Sample	MDI (mg)	Notes
1. blank	<0.001	Minimum detection limit = 0.001 mg
2. impinger solution	0.010	MDI air level = 0.0040 ± 0.0005 ppm

For a 190 L air sample (based on pump calibration after the test), a temperature of 28 C and pressure of 950 mm Hg, the MDI level in air at the sampling site averaged 0.0040 ± 0.0005 ppm (80 % of the TWAEV). This value is lower than the Inco sampling results for station A (5 ft from this site), but because of a power supply problem, the SNO sample was only collected during the 201-25 spray period (afternoon).

To estimate the total dust which could be trapped in the polyurethane coating during spraying, airborne dust was measured upwind of the spray site, at the duct fresh air exit.

Sample	Air Volume (L)	Dust on filter (g)	Air Dust Level (mg/m^3)
afternoon	1272 (110)	0.00118	0.93 (0.10)
morning	630 (100)	0.00040	0.63 (0.10)

An average air dust level of 0.80 ± 0.20 mg/m^3 was present during the test spray.

(b) Coating Thickness Measurements and Shotcrete Considerations

Measurements made by Urylon personnel during the spray indicated average thicknesses of the HH453 material to be 0.280 inches ± 0.040 inches, after an initial reduction in spray 'passes' from 10 to 6. The top coat of 201-25 material was accomplished in two fast passes, with average thickness of about 0.060 inches +/- 0.015 inches. A 1 ft x 1 ft section (plastic backed) was later cut from the wall on the west wall section. It averaged about 0.40 inches HH453 and 0.06 inches 201-25

material.
Some test panels showed a wavy texture even though backing material was smooth. Given the thickness of this application, it appears as if a longer recoat time between passes is advisable.

The quality of the shotcrete texture in the test area was quite variable. In a limited area, near the radon box site, the shotcrete had been trowelled, and was acceptably smooth for the coating procedure. A pull test plate was mounted in this area. Other rougher shotcrete surfaces were 'bricked' or smoothed, and also proved satisfactory for the coating. Normal 'popcorn' finish shotcrete was present in some test areas - this surface proved unacceptable for a uniformly thick coating. Since several shotcrete mixtures had been tried, it is recommended that a 'sand mix' shotcrete be used with sufficient trowelling to match the texture in the vicinity of the pull plate and cut-away sample.

(c) Tensile Strength and Pull Test Results

Tensile strength tests of the two-layer coating from a test panel sample, were carried out by Urylon Plastics Inc. Results showed that materials were within specifications, with a tensile strength of 2408 (102) psi, elongation limit of 104.8 (10.7) % and a Young's Modulus value of 22810 (716).

Pull tests by J. Archibald, Queen's University, on two test plates embedded in the two-layer coating, showed (for one sample on the west wall), that bonding strength was quite similar to those found in previous Mineguard HH453 tests -
. More detail is given in the preliminary report (Appendix 6). Bonding between plate and coating was found to be only partial - perhaps 30 % to 50 % of plate area only. Thus an even stronger bond is probably present. It appears as if bonding to the smoother texture shotcrete is satisfactory.

4. Recommendations

Based on the above information and separate observations, it appears as if the procedures used during the test spray ensure a satisfactory coating and suitable safety for personnel. It is hoped that with several ventilation changes, only a portion of the 6800 ft level near the SNO site entrance will have to be evacuated during the cavity liner application period.

Coating thicknesses and textures were satisfactory, although the rippling effect should be further investigated, so that optimum recoat times can be established for the achievement of the smoothest surface. Clearly, the shotcrete backing must be smooth as well - it is likely that some trowelling will be necessary as the final layer shotcrete is applied. A 'sand mix' shotcrete material is recommended, since one test of this material yielded a satisfactory texture with no or little trowelling. Since the thickness of the final liner coating is critical to its blocking of radon from the rock walls, it is recommended that an ultrasonic thickness monitor be used to carry out quality control examinations of the coating. If necessary, additional layer thickness could be applied in a subsequent spray operation.

Dust, chemical, temperature and humidity levels were all satisfactory with this rate of ventilation. It is recommended that similar air flows be targetted for the cavity coating process.

The suitibility of this two-layer coating ultimately will be confirmed by radon emission and diffusion tests now in progress at Elliot Lake and at Queen's University, along with a radon emanation measurement with a sample box mounted at the underground site.

Appendix 1

Underground Tests of Urylon Liner
Creighton Mine

January 28-30, 1993

E.D. Hallman, Laurentian University

This report summarizes the underground tests of the polyurethane liner material to be carried out by Urylon Plastics on January 30, 1993. It has been prepared following a series of discussions with Urylon, Inco and SNO personnel. Detailed procedures to be followed during the tests are given in the Inco document "Procedure for the Application of MIROC Polyurethane at Test Site in Rooms 06 and 07" (January 7, 1993) and the minutes of the Failsafe Meeting held January 12, 1993. These documents are included in the Appendix.

Test Location & Coating Details

The liner tests will be carried out in the Personnel Drift (Room 07) at the SNO Laboratory site. Figure 1 shows the wall area on the west wall and back (ceiling) which has now been coated with shotcrete (3 inches) and a 1" to 2" thick surface coating of "sand-mix" - a shotcrete mix with -1/8" size aggregate instead of the normal -1/4" size material, topped with a thin (1/2") layer of mortar mix. Other adjacent areas have standard shotcrete surfaces.

Table 1 (below) summarizes the various coating areas and test panels planned. Two materials - Urylon HH453 Mineguard and Urylon 201-25 polyurethane will be used for the tests. Most of the test area will be coated with a 0.250" layer of Urylon HH453 (built up in approximately 10 spray passes) and topped with a 0.050" layer of Urylon 201-25 in 2-4 passes. The humidity of the air at the test site was recently measured at 60-65%. This value and the humidity in the SNO cavity planned during liner installation) are below the 70% limit beyond which HH453 is required for good adhesion and coating integrity. Thus a significant test section will be coated with a 0.300" layer of the 201-25 material only, to test for adhesion, layer integrity and satisfactory build-up to the full thickness. If this test is satisfactory, the more complex procedure of applying a base of HH453 followed by a topcoat of 201-25 can possibly be eliminated.

For the two material layer tests, separate colours for each material are required. It has been decided that the HH453 will be white (as was the case for leaching/radon test samples) and the 201-25 will be tinted light gray (also as per test samples). Contrast between the two coat appearances will be good. Material quantity requirements outlined in Table 1 are based on a conservative coverage rate of 800 sq ft (of 0.250" thick coating) per 180 gal (800 L) of the 50-50 mix of polyurethane A and B components (1.0 sq ft per litre).

Table 1: Test areas and coatings

Location	Area (sq.ft.)	Coating Sequence	Materials A/B (gal) HH453	201-25
A	200 (8x25)	0.250" HH453 base	20/20	
		0.050" 201-25 top		4/4
B	200 (8x25)	0.300" 201-25	24/24	
F	100 (8x12)	0.250" HH453 base	10/10	
		0.050" 201-25 top		2/2
C	20 (4x5)	0.250" HH453 base	2/2	
	Panel 1a	0.050" 201-25 top		0.5/0.5
D	20 (4x5)	0.300" 201-25		2.5/2.5
	Panel 1b			
floor	16 (4x4)	0.250" HH453 base	2/2	
	Panel 2	0.050" 201-25 top		0.5/0.5
	(plywood)			
floor	16 (4x4)	0.050" 201-25		0.5/0.5
	Panel 4			
	(plywood)			
floor	32 (2-4x4)	0.250" HH453 base	3/3	
	Panels 3a,3b	0.050" 201-25 top		1/1
	(stainless steel)			
floor	16 (4x4)	0.300" 201-25		2/2
	Panel 5			
	(plywood)			
E	75 (6X12)	0.150" HH453	(4/4)	
		0.150" 201-25		(4/4)
	(optional overlap test)			
		Total material*	37/37	37/37
			(4/4)	(4/4)

* 2 - 45 gal drums (A+B) for each coating type are available underground.

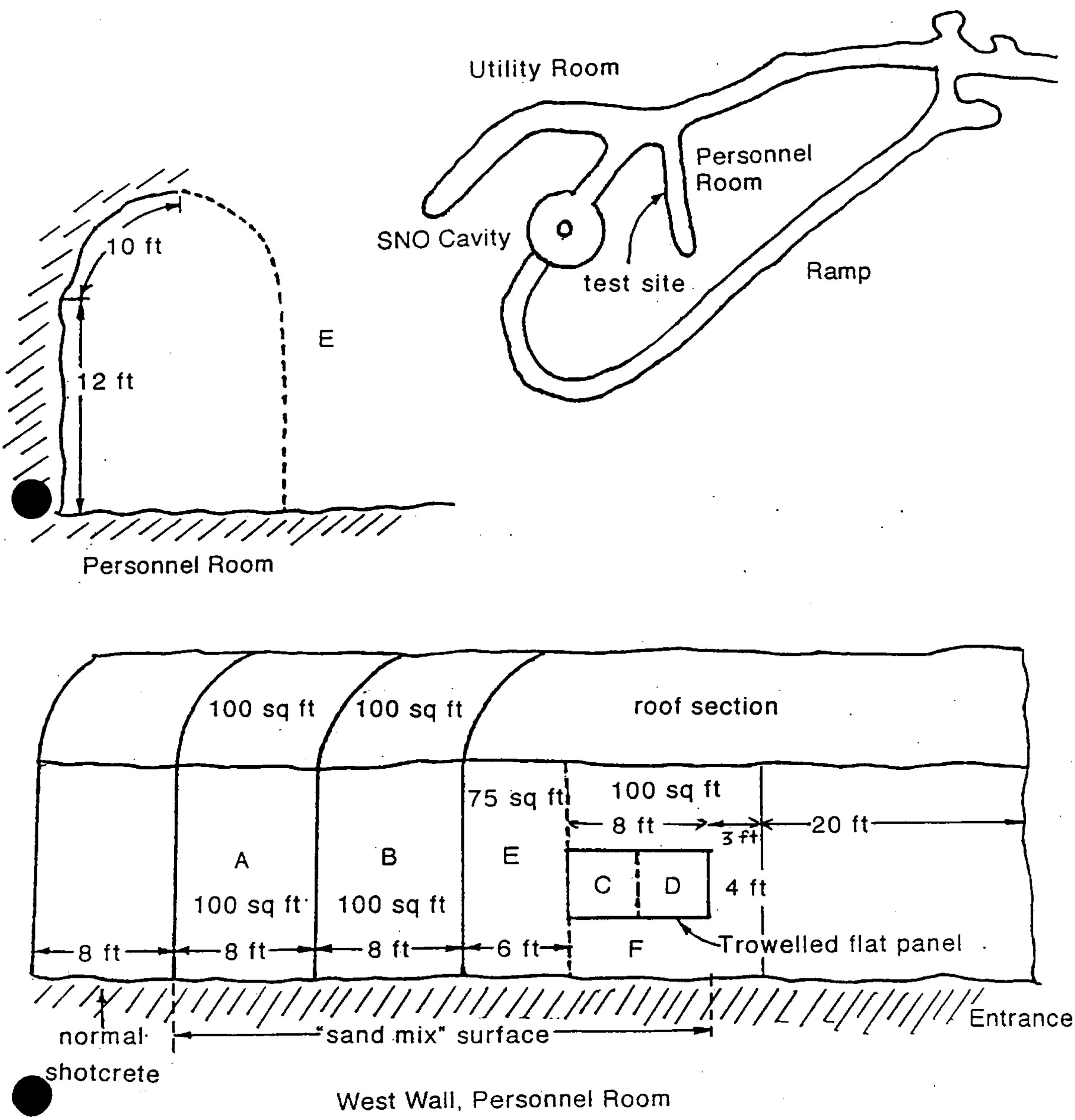
Based on Table 1, two 45 gal drums (A plus B component) will be available for each coating material. It is expected that the application of the coating will require one shift (6 hours) if set up times and delays are minimized. To check adhesion of overlap regions of successive layers, several top coats will be applied at the end of the shift, so that any effects of a delay of 6 hours between coating times can be observed. Humidity, air pressure, velocity and temperature, and dust levels will be monitored throughout the test. Concentrations of isocyanates in the air near the test site will be measured by SNO (1 monitor at the test site) and Inco (several sampling locations as outlined in the procedures report). Mask and breathing apparatus requirements for personnel present during the test are given in the Inco report. A clearance time for airborne chemicals following the end of spraying has been set at 40 minutes - after this time protective masks are not required.

In general, coatings would be applied starting with the HH453 material, in the areas described in Table 1. The recommended order for coating is: HH453 for areas A, C, floor panels 2,3a,3b, areas F, E. Secondly, the recommended order for coating with 201-25 is: areas A, B, C, D, floor panels 2,4,3a,3b, and areas F,E. In area E, a 0.075" layer of HH453 could be applied initially (optional). When the base coat is completed, the 201-25 material would be applied either as a base or top coat as indicated. In area E, a 0.075" second layer of 201-25 could be applied (optional). If time permits, when the coatings are complete, a 0.075" layer of HH453 could be applied in area E, followed by a similar top coat (0.075") of 201-25 material (if these material changes are feasible for the sprayer).

Several indicators of layer thickness (strips with nails mounted against the shotcrete) will be installed. In the test area C, the base and top coats will be applied, then a 1 ft x 1 ft x 2 " stainless steel box will be mounted against the coating and a 0.300" overcoat of 201-25 applied over the top of the box. Hopefully the box can be mounted during the lunch break. A 2 ft x 2 ft area in section E, typical of the shotcrete base finish will be covered with polyethylene and left uncoated, so that a wall finish sample is available. In section A, a 1 ft x 1 ft wall area will be coated with a release agent, so that the polyurethane can be easily removed later (marked with a strip at the boundary), to examine effects of surface roughness on polyurethane coating thickness. Finally, about six 6" x 6" acrylic plastic sheet squares will be mounted in a number of locations in sections A and F so that layer thickness measurements can be made later when these are cut out. The squares will be marked with a nail at the centre. Polyethylene sheeting will be used to mask edges of test sections, and under the test panels on the drift floor.

As indicated in the procedures report, all waste material will be removed from the test area by Urylon and SNO personnel for separate disposal. A report on the test procedures, the results of monitoring and details of the coating characteristics will be prepared by SNO/Urylon/Inco personnel, following the test.

Figure 1: Polyurethane Test Location - SNO Laboratory Test panel layouts



Appendix 2

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SNO

CONFERENCE NOTES

PROJECT: SNO
Miroc Polyurethane Tests

REF:

FILE:

BY: K. Langille

DATE OF CONFERENCE: January 15, 1993

LOCATION: Creighton Conference Room

PURPOSE: Review of Test Procedures

ATTENDING:

Laurentian
D. Hallman

Monenco
S. Snider

Inco
L. Beres
R. Caya
Y. Lachapelle
D. Brear
R. Coulter
K. Langille
D. O'Connor

DISTRIBUTION: Those listed plus;
A. McDonald
M. Sylvestre
G. Hodder

SNO PROJECT
CONFERENCE NOTES
January 15, 1993

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Miroc Polyurethane Tests
Review of Tests Procedures
and
FAILSAFE

1. Fit test for all personnel at the test site must be current. Non-Inco personnel must provide up to date certificates.

2. Twist lock plugs are required on all plug-in equipment provided by Urylon.

3. Urylon to provide list of equipment to be used for test.

4. Sizes of equipment and limitations for cage, rail car and vent door dimensions will be specified.

5. Electrical requirements to be specified by Urylon.

6. Process air requirements for Urylon to be specified, if required.

7. Breathing apparatus. Urylon to provide description of hose connections for connecting to the Inco Jumbo bottles to determine if they are compatible.

8. Urylon to provide testing instruments.

9. Urylon to specify electrical heating requirements for the drums.

10. Urylon to advise what time is required for heating the barrels of material.

11. The Urylon drums must be palletized and strapped by the supplier.

12. The equipment and material should arrive at Inco on the Thursday prior to the test.

13. The orientation will take place on the Friday prior to the test.

14. Fire extinguishers will be provided by Inco.

15. Urylon to provide clean-up kit consisting of spare barrels, pallets, rags and sta-dry.

16. Some additional points discussed:
    - All humidity tests, temperature measurements and dust sampling will be done by SNO.
    - Additional monitoring for isocyanates should be carried out by SNO.
    - SNO to provide the pans required for the test panels.
    - Updated MSD Sheets to be provided.
    - Detailed scopes of work describing the actual tests to be provided for crew orientation.
    - A crew meeting will be held on the Friday preceding the test.

17. Non-Inco employees will obtain fit test at a certified station.

18. **Ventilation**

    Inco technician will:

    (a) Measure total ventilation air flow.
    (b) Check flows provided to the personnel drift.
    (c) Measure temperatures.
    (d) Measure humidity.
    (e) Measure isocyanate levels in drifts at various locations.

19. Only two Urylon personnel and scissor lift operator will be at the face during the spraying operation.

20. Failsafe Actions - Reference attached Specific Hazards Worksheet - Pages 1 and 2 dated January 15, 1993 for actions resulting from the failsafe meeting.

Appendix 3

INCO LIMITED

Ontario Division

TO: R. Coulter

DATE: January 25, 1993

FROM: K. Langille

SUBJECT: **Miroc Polyurethane Test**

Attached are the specific hazards worksheets that resulted from the failsafe of the procedures for the Miroc Polyurethane test.

KRL:kp
Attachment

xc:
M. Sylvestre
G. Hodder
A. McDonald
F. Stanford
H. Parsons
S. Snider
D. Hallman
L. Beres (4 copies)
D. O'Connor (2 copies)
R. Brewer - Monenco
L. Moriarty

CREIGHTON NO. 9 - 6800L

SPECIFIC HAZARDS WORKSHEET

PROJECT: SNO CAVITY LINER
SECTION: MIROC POLYURETHANE TEST APPLICATION

FAILSAFE MEETING NO: 1
DATE: January 15, 1993

REF	HAZARD	CONSEQUENCE	SEVERITY Major/Minor	EXISTING PROTECTION	RECOMMENDATION	ACTION BY	STATUS
1.	Isocyanate Vapors	Possible sensitization Refer MSDS sheets	Major	Full face positive Breathing Apparatus	To be worn by all personnel within 200 ft. of spray area during test.	R. Coulter	Jan 30/93
2.	Isocyanate Vapors	Possible sensitization Refer MSDS sheets	Minor	Half Face Respirators with organic vapor and charcoal cartridge	To be worn by all personnel greater than 200 ft. downstream of spray test area.	R. Coulter	Jan 30/93
3.	Fire at Test Site	Oxides of carbon nitrogen and traces of hydrogen cyanide	Major	Water hoses & dry chemical extinguishers	Ensure sprayers Scissor lift and forklift operators are familiar with use of extinguishers & hoses.	R. Coulter	Jan 28/93
4.	Jumbo air bottles empty	Personnel switch to SCBA Respirators	Minor	Spare bottles available	Check conditions of bottles before starting test.	D. O'Connor	Jan 28/93
5.	Air fan - Power interruption	Lack of ventilation air to Room 07	Minor		All personnel leave test at room 07 until fan power restored.	R. Coulter	As Required
6.	Main Vent fan at return air raise shut down.	Lack of ventilation air at Neutrino site.	Major	Electrician at test site.	All personnel proceed to 6800L Refuge Station.	Electrician	As Required
7.	Polyurethane drums ruptured during transportation	Material spilled in drift	Minor	Clean up kit carried on tram.	Review clean up procedures with tramming crew.	R. Coulter	Jan 29/93

CREIGHTON NO. 9 - 6800L

ECIFIC HAZARDS
ORKSHEET

PROJECT: SNO CAVITY LINER
SECTION: MIROC POLYURETHANE TEST APPLICATION

FAILSAFE MEETING NO: 1
DATE: January 15, 1993

REF	HAZARD	CONSEQUENCE	SEVERITY Major/Minor	EXISTING PROTECTION	RECOMMENDATION	ACTION BY	STATUS
8.	Fire during tramming of drums	Vapors from polyurethane	Major	Extinguisher on locomotive and flat car	Install new extinguisher on locomotive	R. Coulter	Jan 30/93
9.	Chemical Splash in eyes	Burnt eyes	Major	Full face piece and glasses	Review correct handling procedures and install emergency eye wash facility	R. Coulter	Jan 29/93

Present:

Inco Operations
L. Beres
R. Caya
Y. Lachapelle

Maintenance
D. Brear

Mines Engineering
R. Coulter

General Engineering
K. Langille

Ventilation
D. O'Connor

Laurentian
D. Hallman

Monenco
S. Snider

URYLON™ PLASTICS INC.

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GUELPH, ONTARIO
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16

February 2, 1993

Dr. Doug Hallman
SNO Institute
Laurentian University
Sudbury, ON
P3E 2C6

Dear Doug:

I wish to express my thanks to you and all others involved in the Urylon spray trials this past weekend at the SNO underground site.

Overall I was very pleased with the results.

I will give a brief summary of the trial:

The relative humidity during spraying ranged from 58% at the beginning of the spraying to 52% at the end. The temperature was a fairly constant 29°C.

The Mineguard 453 was sprayed in the desired areas as instructed. At the beginning the technician sprayed 10 passes and upon measuring, the thickness was found to be 500 mils; double the intended thickness. The technician subsequently adjusted the number of passes to 6 which was found to result in a thickness range of 250 - 320 mils. This is likely as accurate as can be expected in the cavity.

The 201-25 was sprayed over all the Mineguard 453 at a target thickness of 50 mils. The sprayer accomplished this in 2 quick passes. Upon measurement the thickness range was found to be between 51 and 75 mils. While this is a large range I believe it could be narrowed down to between 50 and 60 mils with experience. In other areas a target of 300 mils of 201-25 was sprayed. The actual thickness measured was found to be between 280 and 380 mils. The bond between the separate layers of the Mineguard 453, 201-25 and the Mineguard 453/201-25 interface were all found to be extremely well bonded with no evidence of delamination.

The 2 colours used to ensure uniform coverage worked well and would help in controlling thickness if each series of passes used an alternate colour.

The 201-25 showed no signs of foaming due to excess moisture present. If the relative humidity is kept in the same range as for this trial and all surfaces are as dry as they were for this trial, 201-25 would be adequate to be used alone if desired.

(cont'd . . . .)

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(cont'd . . .)

This trial amplified the importance of proper surface preparation. In all areas where shotcreting had taken place with no post treatment (trowelling when wet or bricking when dry) the coverage was poor and unacceptable. The areas that were trowelled or bricked were acceptable. Until proven otherwise all shotcreted surfaces must be either trowelled or bricked prior to any Urylon coatings being applied. All surfaces were blown down with compressed air 24 hours prior to spraying. There was a large amount of dust present on all surfaces and if this had not been conducted I would have expected inferior bonding between the coating and the shotcrete. While blowing off worked well in this small area I believe it would generate too much airborne dust in the cavity and this dust would settle out on all surfaces. Therefore I recommend all surfaces are either hosed down with water 48-72 hours prior to spraying or vacuumed within 72 hours of spraying.

The test results on the combination panel sprayed underground indicates the materials are within spec and the results follow:

		Standard Deviation
Tensile	2408 psi	102
Elongation	104.8%	10.7
Young's Modules	22810	716

If you require more information please contact me.

Sincerely,
URYLON PLASTICS INC.

Patrick Diebel, P. Eng.
Technical Director

PD/la

cc-Ken Langille, Inco
Bob Coulter, Inco
Bob Brewer, Monenco
Barry Robertson, Queen's Univ.

Appendix 5

To: K. Langille

From: L. Burford

Subject: Polyurethane Test Monitoring

February 22, 1993 18

On Saturday, January 30, 1993, the ventilation department conducted air quality tests for triethanolamine and isocyanates during the spraying of polyurethane coatings in the control room drift of the **SUDBURY NEUTRINO OBSERVATORY**, 6800 level, Creighton Mine.

At the beginning of the shift all the vent doors were checked to ensure they were closed and the fans above the doors were turned on; volumes were taken at the Neutrino intake fan (35000 cfm), the 6800 level main return (68500 cfm), and the access drift leading out of the neutrino area (35000 cfm); airflow direction was verified as moving westward from the top sill to the return air raises and the 6900 level exhaust fan was running. Following the completion of the tests, a volume was taken at the end of the vent duct leading into the control room drift (8200 cfm). At some time during the test the 6900 level exhaust fan stopped, however, air continued to exhaust 6900 level and flow toward the return.

The tests were conducted using eight Gilian HiFlow Samplers set at a flow rate of 1 L/min. Four samplers were connected with single impingers to test for TRIETHANOLAMINE; four samplers were connected with duel impingers to test for ISOCYANATES. Two pumps, a single and a double, were set up in each of the four stations located at and downwind of the test location. (See attached print for station locations.) Temperatures and humidities were taken hourly and recorded. Prior to the tests commencing, volumes and airflow directions measured, noted and then verified at the end of the test.

The pumps were turned on at 9:30am and turned off at 1:20pm upon completion of the spraying. The samplers connected with duel impingers were turned off approximately one hundred and twenty minutes into the test due to the evaporation of the solution in the impingers.

L. Burford

xc: D. O'Connor

M. Carey

B. Coulter

SUDBURY NEUTRINO OBSERVATORY POLYURETHANE TEST ENVIRONMENTAL MONITORING JANUARY 30, 1993

STATION	TIME	WET BULB	DRY BULB	HUMIDITY
A FILTERS 5009; 5007/5008	10:00 10:56 12.59	72.5 72.0 73.0	82.5 81.0 83.5	61% 63% 60%
B FILTERS 5012; 5001/5002	10:08 11:00 13:02	72.0 72.0 72.0	82.0 82.0 82.0	60% 60% 60%
C FILTERS 5011; 5003/5004	10:10 11:03 13:04	72.5 73.0 73.0	83.0 83.5 83.5	59% 60% 60%
D FILTERS 5010; 5005/5006	10:12 11:06 13:06	73.5 74.0 74.0	84.5 84.5 84.0	59% 60.5% 61%

LOCATION	VOLUME	TEMP	HUMIDITY	DESCRIPTION
intake fan	35000 cfm	66/71.5	74.5%	Drawn into fan.
SNO exit	35000 cfm			From SNO toward return
control room	8200 cfm			velocity is 30.2'/min. exiting control room drift.
return air	68500 cfm	76/83	72%	

EXPOSURE DATA BY DATE
WORKROOM STATION DUMP FROM THE OEMP FILE
FOR DIVISION 1 PLANT 17 AND BUILDING 57 AND STATION 00
FOR THE PERIOD 93/01/30 TO 93/01/30

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
93/01/30	1	1-17-5001	ISOPHORANE DIISOCYANATE	0.0008	0.0050	PPM	16.0
			METHYLENE BISPHENYL ISOCYANATE	0.0008	0.0050	PPM	16.0
			TOLUENE-2,4-DIISOCYANATE	0.0010	0.0000	PPM	0.0

URYLON 201-25 PART A & B
6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT
SPRAYING POLYURETHANE COATING ON THE WALL.
STATION B OPPOSITE CONTROL ROOM DRIFT ENTRANCE

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
93/01/30	1	1-17-5002	ISOPHORANE DIISOCYANATE	0.0008	0.0050	PPM	16.0
			METHYLENE BISPHENYL ISOCYANATE	0.0008	0.0050	PPM	16.0
			TOLUENE-2,4-DIISOCYANATE	0.0010	0.0000	PPM	0.0

URYLON 201-25 PART A & B
6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT
SPRAYING POLYURETHANE COATING ON THE WALL.
STATION B OPPOSITE CONTROL ROOM DRIFT ENTRANCE

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
93/01/30	1	1-17-5003	ISOPHORANE DIISOCYANATE	0.0007	0.0050	PPM	14.0
			METHYLENE BISPHENYL ISOCYANATE	0.0016	0.0050	PPM	32.0
			TOLUENE-2,4-DIISOCYANATE	0.0010	0.0000	PPM	0.0

URYLON 201-25 PART A & B
6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT
SPRAYING POLYURETHANE COATING ON THE WALL.
STATION C DOWN WIND OF CONTROL ROOM

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
93/01/30	1	1-17-5004	ISOPHORANE DIISOCYANATE	0.0007	0.0050	PPM	14.0
			METHYLENE BISPHENYL ISOCYANATE	0.0008	0.0050	PPM	16.0
			TOLUENE-2,4-DIISOCYANATE	0.0010	0.0000	PPM	0.0

URYLON 201-25 PART A & B
6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT
SPRAYING POLYURETHANE COATING ON THE WALL.
STATION C DOWN WIND OF CONTROL ROOM DRIFT

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
93/01/30	1	1-17-5006	ISOPHORANE DIISOCYANATE	0.0008	0.0050	PPM	16.0
			METHYLENE BISPHENYL ISOCYANATE	0.0008	0.0050	PPM	16.0
			TOLUENE-2,4-DIISOCYANATE	0.0010	0.0000	PPM	0.0

URYLON 201-25 PART A & B
6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT
SPRAYING POLYURETHANE COATING ON THE WALL.
STATION D DOWN WIND OF CONTROL ROOM DRIFT
PAST DOWN RAMP

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
93/01/30	1	1-17-5008	ISOPHORANE DIISOCYANATE	0.0008	0.0050	PPM	16.0
			METHYLENE BISPHENYL ISOCYANATE	0.0008	0.0050	PPM	16.0
			TOLUENE-2,4-DIISOCYANATE	0.0011	0.0000	PPM	0.0

URYLON 201-25 PART A & B
6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT
SPRAYING POLYURETHANE COATING ON THE WALL.

EXPOSURE DATA BY DATE
WORKROOM STATION DUMP FROM THE OEMP FILE
FOR DIVISION 1 PLANT 17 AND BUILDING 57 AND STATION 00
FOR THE PERIOD 93/01/30 TO 93/01/30

SAMPLE DATE	SHIFT	SAMPLE NUMBER	CONTAMINANTS	VALUE	TWAEV	UNITS	PCT-TWAEV
	STATION A LOCATED IN CONTROL ROOM DRIFT						
93/01/30	1	1-17-5009	TRIETHANOLAMINE	0.0212	0.5000	PPM	4.2
	URYLON 201-25 PART A & B						
	6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT						
	SPRAYING POLYURETHANE COATING ON THE WALL.						
	STATION A LOCATED IN CONTROL ROOM DRIFT						
93/01/30	1	1-17-5010	TRIETHANOLAMINE	0.0209	0.5000	PPM	4.2
	URYLON 201-25 PART A & B						
	6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT						
	SPRAYING POLYURETHANE COATING ON THE WALL.						
	STATION D DOWN WIND OF CONTROL ROOM DRIFT						
	PAST DOWN RAMP						
93/01/30	1	1-17-5011	TRIETHANOLAMINE	0.0208	0.5000	PPM	4.2
	URYLON 201-25 PART A & B						
	6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT						
	SPRAYING POLYURETHANE COATING ON THE WALL.						
	STATION C DOWN WIND OF CONTROL ROOM DRIFT						
93/01/30	1	1-17-5012	TRIETHANOLAMINE	0.0207	0.5000	PPM	4.1
	URYLON 201-25 PART A & B						
	6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT						
	SPRAYING POLYURETHANE COATING ON THE WALL.						
	STATION B OPPOSITE CONTROL ROOM DRIFT ENTRANCE						
93/01/30	1	1-17-5005	ISOPHORANE DIISOCYANATE	0.0008	0.0050	PPM	16.0
			METHYLENE BISPHENYL ISOCYANATE	0.0065	0.0050	PPM	130.0
			TOLUENE-2,4-DIISOCYANATE	0.0010	0.0000	PPM	0.0
	6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT						
	SPRAYING POLYURETHANE COATING ON THE WALL.						
	STATION D DOWN WIND OF CONTROL ROOM DRIFT						
	PAST DOWN RAMP. VENTILATION INTO CONTROL ROOM						
	DRIFT 8,200 CFM AND 35,600 CFM IN MAINLINE						
	ALL WORKERS IN AREA WEARING SCBA'S						
93/01/30	1	1-17-5007	ISOPHORANE DIISOCYANATE	0.0008	0.0050	PPM	16.0
			METHYLENE BISPHENYL ISOCYANATE	0.0141	0.0050	PPM	282.0
			TOLUENE-2,4-DIISOCYANATE	0.0011	0.0000	PPM	0.0
	6800 LEVEL NEUTRINO PROJECT CONTROL ROOM DRIFT						
	SPRAYING POLYURETHANE COATING ON THE WALL.						
	STATION A LOCATED IN CONTROL ROOM DRIFT						
	VENTILATION INTO CONTROL ROOM DRIFT 8,200 CFM						
	AND 35,600 CFM IN MAINLINE						
	ALL WORKERS IN AREA WEARING SCBA'S						

Appendix 6

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DEPARTMENT OF MINING ENGINEERING
GOODWIN HALL

Queen's University
Kingston, Canada
K7L 3N6
Tel 613 545-2230
Fax 613 545-6597

March 9, 1993

Mr. E. D. Hallman
Sudbury Neutrino Observatory Office
Fraser Science and Engineering Building
Laurentian University
Ramsey Lake Road
Sudbury, Ontario
P3E 2C6

Dear Doug:

Please be advised that technical staff of this Department travelled to the Creighton Mine during the period March 7-8 for the purpose of conducting adhesion pull tests of the installed Mineguard™ layer materials. Two tests were successfully completed and adhesion failure conditions (load-deformation response curves) are presently being assessed for these two trials.

Enclosed please find a travel expense summary detailing costs incurred by Mr. Peter Lausch in completing these tests. I would appreciate it if reimbursement could be made directly to Peter at the Queen's Mining Engineering Departmental address shown on the letterhead of this page.

Details of the adhesion strength data will be sent to you by FAX as soon as we are able to complete data reduction. At this time it would appear that the HH453 material (on shotcrete) exhibits similar or better adhesion response to our previous test material installations upon cast concrete slabs. It was noted by Peter, however, that the spray installation and plate bonding process was not optimal (ie.- (a) incomplete base bonds were achieved beneath both plates; that is, not all of the basal areas of these plate were seen to be covered by the Mineguard™ and in direct contact with the rock surfaces, and (b) varying layer thicknesses had been applied over the test sites, indicating some inability of the sprayer to consistently coat the rock.) In any event, I will forward the completed data as soon as possible.

Best regards,

J. F. Archibald

J. F. Archibald

Queen's University
Department of Mining Engineering
Kingston, Ontario K7L 3N6

Fax: (613) 545-6597
Telephone: (613) 545-2230

FACSIMILE TRANSMISSION

COMPANY: SUDBURY NEUTRINO OBSERVATORY OFFICE

TO: DOUG HALLMAN

FAX NO.: (705) - 673 - 6532

FROM: J.F. ARCHIBALD

NUMBER OF PAGES: 3 (including this one)

DATE: MARCH 9/93

RE: NEUTRINO PULL TEST RESULTS ON MINEGUARD™

MESSAGE: – RESULTS OF SINGLE TEST, SHOWING:
a) LOAD/DEFORMATION RESPONSE OF TEST ON THICK COATING ADHESION TEST vs. LAB RESULTS ON 4000 psi CONCRETE SLABS
b) PEAK ADHESION STRESS OF PULL TEST vs. % R.H. FOR THIS TEST (compared to previous lab test results); * – incomplete base bond (≈ 40% max.) achieved.

IF YOU DID NOT RECEIVE THE NUMBER OF PAGES INDICATED ABOVE,

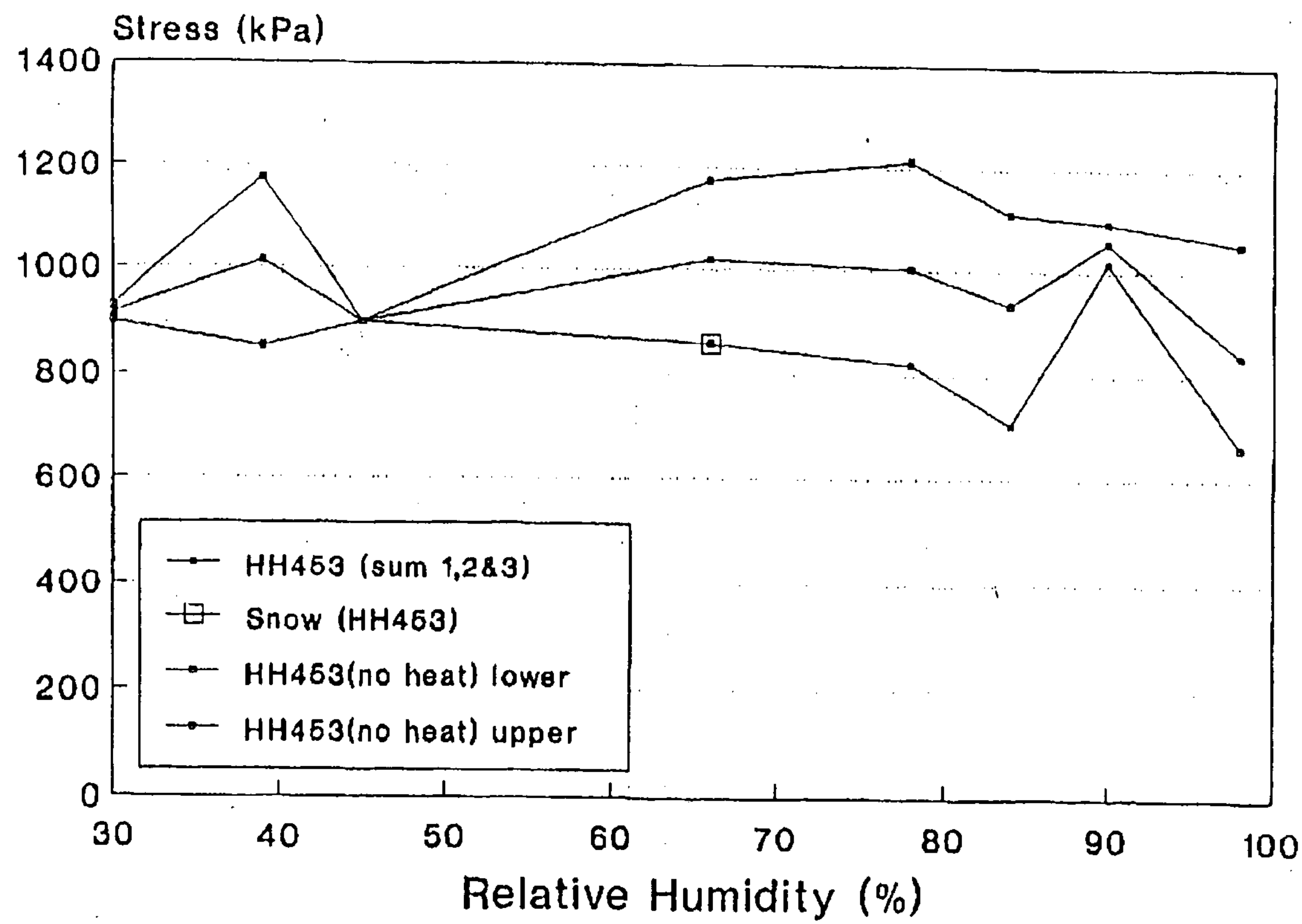
PLEASE CALL

QUEEN'S MINING IMMEDIATELY AT (613) 545-2230

REGARDS

J.F. Archibald

ADHESION vs HUMIDITY



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LOAD vs DEFORMATION