

**WYLE LABORATORIES**  
SCIENTIFIC SERVICES AND SYSTEMS GROUP

ANALYSIS OF THE DECOMPOSITION EFFECTS OF  
VINYLCEL INSULATION IN A DESIGN BASIS ACCIDENT

# NEQ NUCLEAR ENVIRONMENTAL QUALIFICATION

# REPORT

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# WYLE LABORATORIES

SCIENTIFIC SERVICES AND SYSTEMS GROUP  
HUNTSVILLE, ALABAMA

Rochester Gas and Electric Corporation  
89 East Avenue  
Rochester, New York 14649

REPORT NO. 17490-1  
WYLE JOB NO. 17490  
YOUR P.O. NO. N-BU-17089  
DATE September 28, 1981

## ANALYSIS OF THE DECOMPOSITION EFFECTS OF VINYLCEL INSULATION IN A DESIGN BASIS ACCIDENT

by

J.F. Gleason, M. Bruce, R. Thome

STATE OF ALABAMA }  
COUNTY OF MADISON }

ss. California Professional  
Engineering Reg. No. 2635

James F. Gleason

being duly sworn,  
deposes and says: The information contained in this report is the result of complete and  
carefully conducted analyses and is to the best of his knowledge true and correct in all  
respects.

SUBSCRIBED and sworn to before me this 1st day of OCT, 19 81

Thomas H. Stinson  
Notary Public in and for the State of Alabama at large.

My commission expires May 3, 19 83

Wyle shall have no liability for damages of any kind to person or property, including special or  
consequential damages, resulting from Wyle's providing the services covered by this report.

PREPARED BY J.F. Gleason, M. Bruce, R. Thome

WYLE Q.A.: Murvin J. Kimbrell DATE: 10/1/81

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TABLE OF CONTENTS

	<u>Page Number</u>
1.0 PURPOSE	1
2.0 SCOPE	1
3.0 APPLICABLE VINYLCEL TEST REPORTS	1
4.0 TEST RESULTS	1
4.1 Water Vapor Permeability and Humid Aging	1
4.2 Effects of Heat and Pressure	2
4.3 Resistance to Flame Exposure	2
4.4 Thermogravimetric Analysis	2
4.5 Radiation	2
5.0 ANALYSIS	3
5.1 Analysis Including Data for Similar Materials	3
5.2 Determination of Radiation Sensitivity	3
6.0 EVALUATION OF GINNA ACCIDENT CONDITIONS	3
7.0 CALCULATIONS	5
8.0 CORROSIVE EFFECTS	6
8.1 Effects on RHR Components	6
8.2 Effects on Carbon Steel Panel Liner	7
8.3 Effects on the 19-Mil Stainless Steel Insulation Facing Panels	8
9.0 CONCLUSIONS	8
10.0 REFERENCES	9
11.0 APPENDIX	12



## 1.0 PURPOSE

This analysis was prepared by Wyle Laboratories for Rochester Gas and Electric Company. The purpose of this report is to provide answers to the following NRC questions:

1. Estimate of the amounts of each gas, such as hydrogen, organic gases, and hydrogen chloride, which would be produced by radiation from the decomposition of the foam during a DBA.
2. The results of an analysis of the effect of the hydrogen chloride generated during a DBA, including corrosion of components in the containment building.

## 2.0 SCOPE

The scope of this investigation includes literature search and analysis of applicable data for Johns-Manville Vinylcel insulation. Test data for Vinylcel, and for a number of similar polyvinyl chloride materials is considered. The effects of the Robert E. Ginna plant normal and accident environments on Vinylcel are evaluated.

## 3.0 APPLICABLE VINYLCEL TEST REPORTS

- 3.1 Johns-Manville Research and Engineering Center, "Test Report Vinylcel (4PCF)-Water Vapor Permeability and Humid Aging Tests," Report No. E455-T-268, December 20, 1967
- 3.2 Johns-Manville Research and Engineering Center, "Test Report, Vinylcel (4PCF)-Effect of Heat and Pressure," Report No E455-T-266, November 3, 1967
- 3.3 Johns-Manville Research and Engineering Center, "Test Report, Vinylcel-Resistance to Flame Exposure", Report No. E455-T-258, September 21, 1967

## 4.0 TEST RESULTS

### 4.1 Water Vapor Permeability and Humid Aging

Per Report 3.1, Vinylcel with 4PCF nominal density was tested for water permeability at 90°F, for 50% relative humidity, and for dimensional changes at 120°F and 100% relative humidity. The results are as follows:

- o Results indicate that the water permeability of a 1-inch thick specimen was 0.06 perm-in.
- o After six (6) months at 120°F and 100% relative humidity, the volume change was only 1.2% and length and width changes only 0.3 %.

#### 4.0 TEST RESULTS (CONTINUED)

##### 4.2 Effect of Heat and Pressure

Per Report 3.2, Vinylcel of 4 PCF nominal density, 1-1/2 inches thick, was subjected to a combined heat and compression test to simulate an "incident" in a nuclear reactor containment vessel. The results are as follows:

The 30-minute test included a maximum temperature of 334°F at 90 PSI. Eighty six (86) percent of the test time was at a temperature greater than the 286°F maximum accident temperature at the Ginna plant. Maximum permanent loss of thickness was 29 percent. Weight loss was not measured so decomposition could not be evaluated.

##### 4.3 Resistance to Flame Exposure

Per Report 3.3, unfaced and metal-faced Vinylcel were subjected to a number of flame tests, including building tests, vertical panel test, tunnel test, and flame penetration. The metal-faced Vinylcel passed all tests, whereas, the unfaced performed satisfactorily in all but the flame penetration. Attempts were made to ignite the evolved gases. Only trace quantities of combustible gases (possibly H<sub>2</sub> or short chain hydrocarbons) were found.

##### 4.4 Thermogravimetric Analysis

The complete test report, Johns-Manville Test Report E455-T-142, was not available, but the test conditions and graphic results are provided in Report 3.3. The results are as follows:

The Vinylcel was subjected to a heating rate of 80°C per minute, and the air flow was 0.5 liters per minute. Initial weight loss occurred at 140°C (284°F), and rapid weight loss was observed at 225°C (437°F). A 38 percent weight loss was observed at 300°C (572°F). Decomposition was continued at a lower rate between 300° and 600°C (1112°F) to a 94.5 percent weight loss. No direct analysis of evolved gases was reported (see Figure 2).

##### 4.5 Radiation Exposure

Reference 8, notes "Radiation exposure of  $8 \times 10^6$  Roentgens within 6 hours will not change the physical properties of Vinylcel significantly but  $10^8$  Roentgens within 10 hours will cause some progressive deterioration." This radiation resistance was apparently based on generic data for PVC. No information on the radiation resistance of Vinylcel was located.

## 5.0 ANALYSIS

### 5.1 Analysis Including Data for Similar Materials

Since no specific data was available for irradiated Vinylcel, and since synergistic effects of temperature, radiation, and oxidizing conditions are known for some polyvinyl chloride-based materials, this analysis is based on data for generically similar materials. The following significant information is noted:

- o At temperatures below 200°C, the only volatile product from degradation of pure, unirradiated PVC is HCl; neither H<sub>2</sub> or Cl<sub>2</sub> has been detected, Reference 16.
- o For foamed or plasticized PVC based materials, HCl is the only volatile released in significant quantities. Reference 6 identifies products released in small quantities (less than 1% by weight) from three (3) PVC-based insulations at elevated temperatures in air. These constituents were CO<sub>2</sub>, CO, aldehydes, ammonia, cyanides and nitrogen oxides.
- o Irradiation also results in dehydrochlorination of PVC materials. This apparently occurs at doses as low as 5x10<sup>5</sup> rads for some PVC materials, Reference 12.

### 5.2 Determination of Radiation Sensitivity

No data was found for exposure of Vinylcel to irradiation. Data available for exposure of other irradiated PVC materials was therefore considered.

The lowest radiation threshold value indicated in the referenced data for any PVC material was 5x10<sup>5</sup> rads (References 7 and 12). This value is 20 percent greater than the 3x10<sup>5</sup> rads requirement indicated for 40 years normal service at Ginna, Reference 14.

The normal radiation dose of 3x10<sup>5</sup> rads is, therefore, concluded to be insignificant.

## 6.0 EVALUATION OF GINNA ACCIDENT CONDITIONS

The Ginna accident condition is indicated as 286°F (141.11°C) and 60 psig for 2.8 hours, followed by 219°F (103.89°C) for up to 24 hours, and 152°F (66.67°C) for the remainder of 180 days.

From Reference 6, it was noted that none of the three PVC's tested evolved HCl until temperatures exceeded 160°C. The weight loss noted in all three samples ranged from 2.1 to 4% before HCl was detected. A comparison of TGA curves for those materials and Vinylcel indicates that Vinylcel has significantly better temperature resistance so the Ginna accident temperatures would not be expected to cause HCl evolution.



## 6.0

EVALUATION OF GINNA ACCIDENT CONDITIONS (CONTINUED)

Then for the Ginna accident scenario, the important parameter with regard to generation of HCl is the integrated radiation dose. The 180 day accident dose is  $2 \times 10^8$  rads. The accumulated radiation dose at the end of 2.8 hours will be less than  $2 \times 10^7$  rads per Regulatory Guide 1.89 Proposed Rev. 1, Appendix D. The 19-mil stainless steel facing will provide significant Beta shielding, stopping all Beta radiation with an energy less than approximately 1 MEV. Therefore, the radiation dose to the Vinylcel is calculated to be less than  $5 \times 10^6$  rads at the end of the initial 2.8 hour phase of the accident.

Reference 11 states that no HCl was found in mass spectrometer analysis of polyvinyl chloride irradiated to  $5 \times 10^6$  rads. It appears that the initial design basis event transient within the first 2.8 hours of high temperature regime would not generate HCl. This is further supported by data from Reference 3. Pure PVC resin irradiated to  $5.8 \times 10^6$  rads and exposed to  $150^\circ\text{C}$  in a pure oxygen atmosphere showed negligible weight loss after 3 hours.

Reference 3 demonstrated the well recognized fact that oxygen accelerates loss of HCl. It is also certain that elevated temperatures accelerate loss of HCl. It is apparent that the test conditions were more severe than the accident requirements at Ginna. Reference 24 states that pure PVC resins are not as resistant to dehydrochlorination as PVC based materials. Vinylcel may be significantly more resistant to loss of HCl than the material tested.

Reference 3 also provides useful data in determining a maximum rate at which decomposition might proceed. Samples of PVC irradiated to various doses in oxygen were exposed to  $150^\circ\text{C}$  for durations up to approximately 17 hours.

Figure 1 shows that after approximately 17 hours at  $150^\circ\text{C}$ , the weight loss of PVC was as follows :

<u>Radiation Dose (Rads)</u>	<u>Weight Loss at <math>150^\circ\text{C}</math> at 17 hours (%)</u>
0	2.5
$5.8 \times 10^6$	7
$17.4 \times 10^6$	11
$29 \times 10^6$	12
$52.2 \times 10^6$	14

## 6.0

EVALUATION OF GINNA ACCIDENT CONDITIONS (CONTINUED)

The rate of HCl evolution at Ginna accident temperatures should be slower than the values above. HCl could be neutralized by the containment spray system as it is released from the Vinylcel.

The total amount of HCl formed is also of concern. Reference 12, discusses total HCl generated from irradiation of PVC. The generation of HCl is defined by the chemical term of  $G_{HCl}$ , which is the number of HCl molecules produced per 100 electron volts of radiation absorbed by the PVC. Reference 12 notes a  $G_{HCl}$  of 22.6 at 160°F for PVC exposed to  $2 \times 10^7$  rads in vacuum.

A calculation assuming an absorbed dose to Vinylcel of  $2 \times 10^8$  rads (see appendix) indicates that Vinylcel would be required to have  $G_{HCl} = 75.65$  for total loss of HCl to occur. This is more than three (3) times the highest value found but since no value was found for a radiation dose of  $2 \times 10^8$  it was assumed that the calculated value was achievable. The following calculations and the evaluation of corrosive effects is based on the assumption that total decomposition occurs.

## 7.0

CALCULATIONS

Reference 13 provides an approximate structural formula for Vinylcel. The weight percent of the crosslinking agent was not identified, but since that agent would serve to reduce the percent chlorine it is adequate, for this treatment, to make the assumption that the material is PVC. From the empirical formula ( $CH_2 CH CL$ ) the material is 56.8 percent chlorine by weight.

For Ginna insulated wall, an area of 36,181 ft<sup>2</sup> of 1-1/4" (4 PCF) Vinylcel, the total material weight is approximately 6,838,000 gms, of which approximately 3,884,000 gms is chlorine.

The applicable parameters for Ginna, Reference 14, indicate that the total dehydrochlorination would release  $1.0956 \times 10^5$  moles of HCl.

If the HCl were uniformly distributed in the containment volume, the concentration would be  $4.22 \times 10^{-6}$  moles/cm<sup>3</sup>, as shown below:

$$\text{Concentration} = \text{Moles/volume} \quad (1)$$

$$\text{Concentration of HCl} = \frac{1.0956 \times 10^5 \text{ moles}}{\text{ft}^3 \times 28316.847 \text{ cm}^3/\text{ft}^3} \quad (2)$$

$$\text{Concentration of HCl} = 4.22 \times 10^{-6} \text{ moles/cm}^3 \quad (3)$$

The HCl will not remain in the atmosphere, but will be condensed and dissolved in the borated water solution recirculated through the Reactor Heat Removal (RHR) System.

## 7.0 CALCULATIONS (CONTINUED)

The total volume of solution available for dilution is 1,079,604 liters, as shown below:

### Spray System Tank

230,000 gal (2,000 ppm borated):	870.5 x 10 <sup>3</sup> liters
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### Reactor Flood Tanks

6,250 ft <sup>3</sup> (50-100 ppm borated):	176.95 x 10 <sup>3</sup> liters
1,134 ft <sup>3</sup> (2,000 ppm borated):	32.1 x 10 <sup>3</sup> liters

Total	1.08 x 10 <sup>6</sup> liters
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The final maximum concentration in the solution recirculated through the RHR System could be 0.105 molar in HCl. If unbuffered, the pH would be approximately 1. The solution is actually a dilute boric acid buffered with NaOH to a pH of 8.5-10.0. A 5,100-gallon tank of 30 percent NaOH is maintained on site with  $1.4476 \times 10^5$  moles of NaOH. The capability to monitor and adjust the pH of the solution is available after accident initiation. Since the HCl will be added gradually, the solution pH can be maintained in the required range of 8.5-10.0 by addition of NaOH solution.

The solution would become about 0.1 molar in NaCl. Corrosive effects for the RHR System would then be those of salt solutions.

The Vinylcel stainless steel facing and the carbon steel liner will be exposed to HCl as it evolves from the insulation. Some portion of this HCl will be absorbed by the insulation and remain in contact with the metal walls. Moisture may penetrate the insulation along the panel joints in the humid post-accident environment. This action would result in exposure of the carbon steel liner and the interior of the stainless steel facing to aqueous HCl. It is assumed that the stainless facing will be exposed to significant moisture; the carbon steel liner will be partially protected by the insulation.

## 8.0 CORROSION EFFECTS

Effects are considered separately for the RHR System components, the carbon steel liner of the insulation, and the 19 mil stainless insulation facing since they will be exposed to different environments, as noted in Paragraph 7.0.

### 8.1 Effects For RHR Components

As indicated in the preceding section, these components may be exposed to a 0.1 molar salt solution (approximately 0.6 percent salt). The corrosive effects should be similar to those of sea water and the data for sea water will be assumed applicable. Components in the system are all stainless steel or stainless steel clad.

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## 8.0 CORROSION EFFECTS (CONTINUED)

### 8.1 Effects For RHR Components (Continued)

Reference 20 indicates that a maximum rate for general corrosion of 316 stainless steel by sea water is 0.00063 inch per year. Low carbon and copper-bearing steels show higher corrosion rates of 0.004-0.005 inch per year. These low values indicate that significant corrosion should not occur in the 180-day post-accident period. Reference 19 indicated that sea water induced pitting and crevice corrosion can occur for stainless steels, but these actions would not become significant in less than 1.5-2 years.

### 8.2 Effects For Carbon Steel Panel Liner

The entire carbon steel liner (both insulated and non insulated surfaces) is protected from direct contact with the environment by a Carbo Zinc-11/Phenoline 305 coating system. This would retard or prevent direct contact between HCl and the carbon steel. Phenoline 305 is indicated by the manufacturer as having "very good" resistance to acid splashes and spills and Carbo Zinc-11 is rated "good". Reference 19 indicates good acid resistance for phenolic coatings at temperatures up to 300°F. If the top coat is penetrated the zinc based primer (approximately 86% zinc) provides an additional physical barrier and may be preferentially attacked by the HCl if it is penetrated. Though the effect may be reversed under some environmental conditions, temperatures below 140°F and the presence of Cl<sup>-</sup> ions would probably cause the zinc to act as a sacrificial anode (Reference 20) providing further protection of the steel liner.

Since no test data was available to determine the amount of protection provided (or whether zinc would act as a sacrificial anode at the Ginna specified 152°F ambient) the effects of direct HCl/carbon steel contact will be considered.

If moisture does not penetrate the insulation and the liner so that the carbon steel is exposed only to dry HCl gas, the corrosion effects would not be significant. Reference 21 indicates a corrosion rate of 0.00003 inch per year for carbon steel exposed to dry HCl at 500°F.

Carbon steel is, however, sensitive to aqueous HCl in air environments. If moisture penetrates the degraded insulation, or passes through joints between panels, corrosion would occur. Reference 20 indicates corrosion rates for mild steel (carbon steel) exposed to 0.4 percent and 4.0 percent HCl in air at room temperatures. These rates were 0.39 inch and 0.48 inch per year, respectively. Higher temperatures would also accelerate corrosion.

As indicated in Reference 19, corrosion rates greater than 0.05 inch per year, result in short service life for the specified material.

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## 8.0 CORROSION EFFECTS (CONTINUED)

### 8.3 Effects for the 19-Mil Stainless Steel Insulation Facing Panels

While more resistant than carbon steel, all stainless steels have poor resistance to aqueous HCl. Also direct aqueous HCl/stainless steel contact is more probable; moisture may not penetrate the insulation per paragraph 3.1 or the Carbo Zinc-11/Phenoline 305 but could penetrate along panel joints and around retaining bolts. Corrosion could occur along panel joints and around retaining bolts.

## 9.0 CONCLUSIONS

### 9.1 In response to NRC letter dated 1-17-81, Question No. 2:

#### Question

An estimate of the amounts of each gas as hydrogen, organic gases and hydrogen chloride, which would be provided by radiation from the decomposition of the foam during DBA.

#### Answer

The only gas produced in more than trace quantities would be HCl. No HCl gas would be expected until the radiation level exceeds  $5 \times 10^6$  rads. The postulated peak temperature during the DBA of  $286^\circ\text{F}$  occurring within the first 2.8 hours would probably not produce and HCl as long as the radiation level did not exceed  $5 \times 10^6$  rads during this time.

The postulated total integrated dose of  $2 \times 10^8$  rads would result in generation of HCl. The total amount generated is uncertain. A worst case of total dehydrochlorination is assumed although the actual loss is likely to be significantly less.

### 9.2 In response to NRC letter dated 1-17-81, Question No. 5:

#### Question

The results of an analysis of the effect of the hydrogen chloride generated during a DBA including corrosion of components in the containment building.

#### Answer

The HCl gases which would be released into the containment would become neutralized by the chemical spray. Minor corrosion to the reactor heat removed system may result.

The corrosion effects of dry HCl gas are insignificant.

9.0 CONCLUSIONS (CONTINUED)9.2 Answer (Continued)

Corrosion of the carbon steel liner could occur if aqueous HCl contacts its surface. This contact will be delayed and may not occur at all. The Vinylcel provides protection from the moist containment atmosphere. The Carbo Zinc 11/Phenoline 305 coating system is a barrier to direct HCl/Carbon Steel Contact. If penetrated, the Carbo Zinc 11 may act as a sacrificial anode further protecting the carbon steel.

Corrosion of the 19-mil facing is expected along panel joints and around retaining bolts.

10.0 REFERENCES

1. Letter from V. S. Noonan, Assistant Director for Material and Qualification, Division of Engineering, U. S. Nuclear Regulatory Commission, Subject: Ginna SEP on Organic Materials, January 17, 1981 (Enclosed)
2. "The Use of Plastics and Elastomers," W. W. Parkinson and O. Sisman, Nuclear Engineering and Design, Vol. 17 (1971), pp. 247-280, Wyle Library Code 438-81
3. "Thermal Analysis of Polyvinyl Chloride," R. Salovey and R. G. Badger, Journal of Applied Polymer Science, Vol. 16 (1972), Wyle Library Code 430-81
4. "Radiation Resistance of Cable-Insulating Material for Nuclear Power Generating Stations," S. Kawata, J. Ogura, K. Kasai, and T. Onishi, IEEE Transaction, Electrical Insulation, Vol. EI-13, No. 3, pp. 164-171, June, 1978, Wyle Library Code 214-79
5. "Effects of Radiation on Electrical Insulating Materials," C. L. Hanks and D. J. Hammon, REIC Report No. 46, Wyle Library Code 299-80
6. "Test Report, Thermal Decomposition Products and Burning Characteristics of Some Synthetic Low-Density Cellular Material," Bureau of Mines Investigation #4777, January, 1951
7. "Gamma Ray Dosimetry with Polyvinyl Chloride Films," Ernest J. Henley and Arthur Miller, Nucleonics, Vol. 9, No. 6, pp. 62-66, December, 1951
8. Letter from C. E. Ernst, Chief Engineer, Johns-Manville Industrial Insulations Division, to Gilbert Associates, Inc., Reading, Pennsylvania, Subject: BM Containment Insulation, SP-5290 Ginna Plant, December 22, 1967 (Enclosed)

10.0 REFERENCES (Continued)

9. Letter from Jack Miner, Manager, Engineering and Technical Services, Johns-Manville Sales Corporation, Denver, Colorado, Subject: Vinylcel Physical Properties and Radiation Resistance, April 7, 1981
10. Contact Reports, Ray Thome to J. Richardson, Johns-Manville Product Coordinator, dated July 31, 1981, Subject: Vinylcel Insulation Technical Data and Reports (Enclosed)
11. "Effects of Radiation on Material and Components," J. F. Kircher and R. E. Bowman, Reinhold Publishing Corporation
12. Radiation Chemistry of Polymeric Systems, A. Chapiro, John Wiley & Sons, Chapter 7
13. "Rigid PVC Foam Process Attracts Phillips," Article from International, not dated (Enclosed)
14. Contact Report, M. Bruce to G. Wrobel, Rochester Gas & Electric Corporation, dated August 7, 1981, Subject: Obtain Containment Information (Enclosed)
15. Contact Report, Ray Thome to G. Eichele, Johns-Manville Sales Coordinator, dated July 30, 1981, Subject: Vinylcel Insulation (Enclosed)
16. "Mechanism of PVC Degradation," W. C. Giddes, Rubber Chemistry and Technology, 164, pp. 177-216
17. "Thermal Decomposition of Poly (Vinyl Chloride)," R. Stromberg; S. Straus, and B. G. Achkammer, Journal of Polymer Science, Vol. 35, pp. 355-368 (1959)
18. "Vinylcel Structural Core Rigid Crosslinked PVC Foam Physical Properties (Average Values)," Johns-Manville (Enclosed)
19. NACE Basic Corrosion Course, National Association of Corrosion Engineers, Houston, Texas, Eighth Printing, 1977
20. Corrosion and Corrosion Control, H. H. Unlig, John Wiley & Sons, Inc., Second Edition, 1971
21. "Properties and Selection of Metals," Metals Handbook, American Society for Metals, 8th Edition, Vol. I, 1961
22. Radiological Health Handbook, U. S. Department of Health, Education, and Welfare, Rockville, Maryland, Revised Edition, p. 122, January, 1970

10.0

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23. Carboline Product Data Sheets, Carboline Company, St. Louis, Missouri (Enclosed)
24. "Determination of the Stability of PVC Compounds Against High Temperature", J. Novak, American Chemistry Series, Advances in Chemistry, Vol 85, pp 45-46.



11.0

APPENDIX

The theoretical yield of HCl is 56.8% by weight or  $1.5583 \times 10^{-2}$  moles/gm PVC substituting this value in the equation below and solving for  $G_{HCL}$  identifies the G value required for total dehydrochlorination.

$$\text{Moles HCl} = \frac{G \text{ moles HCl/100 eV} \times 2 \times 10^{10} \text{ ergs/gm PVC} \times 6.2 \times 10^{11} \text{ eV/erg} \times 1 \text{ mole HCl/} 6.02 \times 10^{23} \text{ molecules}}{6.2 \times 10^{11} \text{ eV/erg} \times 1 \text{ mole HCl/} 6.02 \times 10^{23} \text{ molecules}}$$

Therefore,

$$G = 1.5583 \times 10^{-2} \times 100 \times \frac{1}{2 \times 10^{10}} \times \frac{1}{6.2 \times 10^{11} \times 6.02 \times 10^{23}}$$

$$G = 75.65.$$

Where,

$$G = \text{molecule HCl/100 eV}$$

$$\text{Radiation Dose} = 2 \times 10^8 \text{ rads or } 2 \times 10^{10} \text{ ergs/gm PVC}$$

$$1 \text{ erg} = 6.2 \times 10^{11} \text{ eV}$$

$$\text{Avogadro Constant} = 6.02 \times 10^{23} \text{ molecules/mole}$$

IRRADIATED POLY(VINYL CHLORIDE)

3267

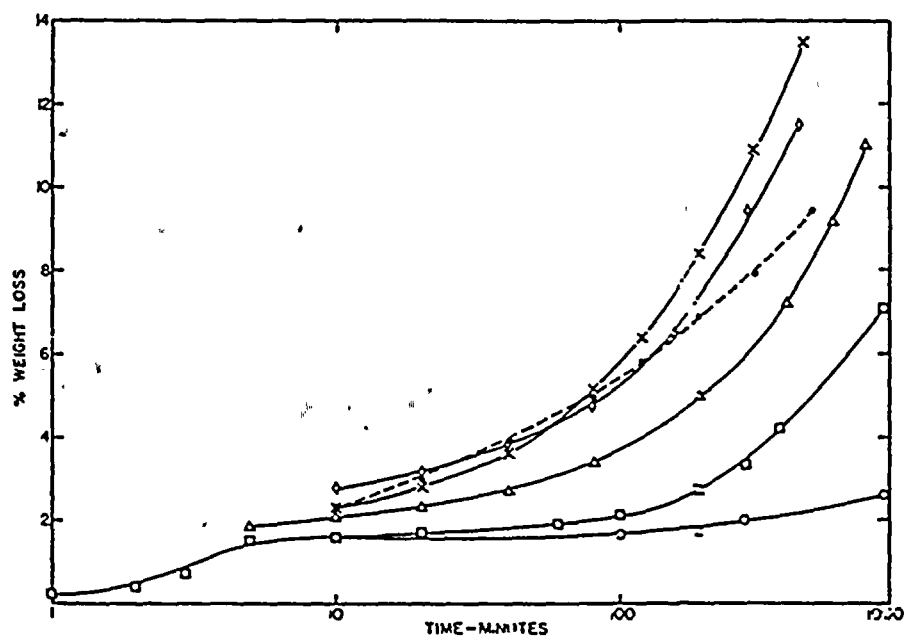


FIGURE 1. ISOTHERMAL THERMOGRAVIMETRY OF IRRADIATED PVC -  
150°C OXYGEN ATMOSPHERE: (O) CONTROL; (□) 5.8  
M RADS; (Δ) 17.4 M RADS; (◇) 29.0 M RADS; (X)  
52.2 M RADS; (—●—) 52.2 M RADS IN NITROGEN

TGA Curve of VINYLCEL

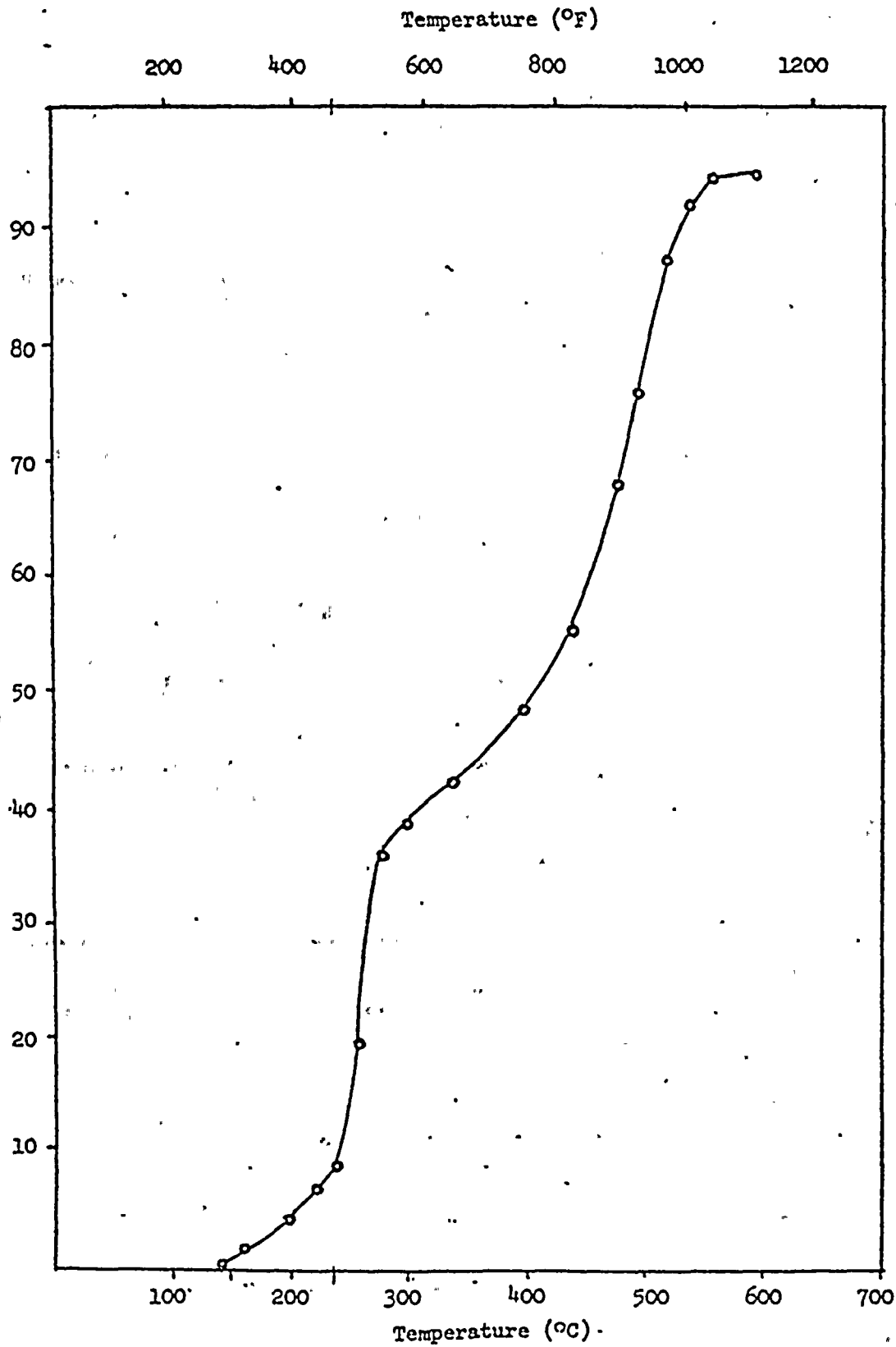


FIGURE 2



JAN 17 1981

1/26/81

GEORGE,

MEMORANDUM FOR: Gus C. Laines, Assistant Director  
for Safety Assessment  
Division of Licensing

PLEASE CALL ME  
(301-497-7816) RE:  
CONFERENCE CALL ON  
THIS TOPIC.

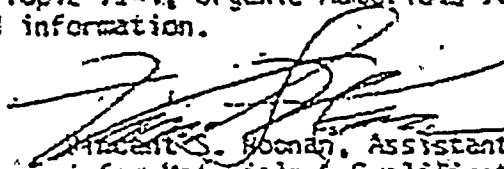
FROM: Vincent S. Noonan, Assistant Director  
for Materials & Qualifications Engineering  
Division of Engineering

SUBJECT: GINNA SEP ON ORGANIC MATERIALS

Under the Systematic Evaluation Program, we are reviewing Topic VI-1 "Organic Materials" for the Ginna Plant. This plant has the unique feature that the inner surface of the containment building is insulated with  $\frac{3}{4}$  in. thick sheets of Vinylcell foam encapsulated in 0.019 in. stainless steel. To complete our review, we need the following information:

1. The total weight of insulating foam in the containment building.
2. An estimate of the amounts of each gas, such as hydrogen, organic gases and hydrogen chloride, which would be produced by radiation from the decomposition of the foam during a DSA.
3. Paths, if any, by which these gases might escape from the stainless steel boxes and enter the containment under accident conditions.
4. The results of an analysis of the contribution of hydrogen and other gases generated from the foam to the amounts of combustible gases produced from other sources during a DSA.
5. The results of an analysis of the effect of the hydrogen chloride generated during a DSA, including corrosion of components in the containment building.

We can complete our review of Topic VI-1, Organic Materials four weeks after we receive the requested information.

  
Vincent S. Noonan, Assistant Director  
for Materials & Qualifications Engineering  
Division of Engineering

cc: Next page

EXHIBIT A

# JOHNS-MANVILLE

SALES CORPORATION

## INDUSTRIAL INSULATIONS DIVISION

22 EAST 40th STREET • NEW YORK, N. Y. 10016 • TELEPHONE: 532-7600 • AREA CODE 212



December 22, 1967

Gilbert Associates, Inc.  
525 Lancaster Avenue  
Reading, Pa. 19603

Attention: Mr. K. T. Momose

Re: BM Containment Insulation  
SP-5290 Ginna Plant

Dear Mr. Momose:

On November 29, at your request Mr. E. D. Cox sent to your attention the following reports:

Report E 455-T-258 Vinylcel - Resistance to Flame Exposure

Report E 455-T-266 Vinylcel (4pcf) Effect of Heat and Pressure

Subsequent to this you requested engineering data on the 4 pcf Vinylcel similar to that previously furnished for 6 pcf Vinylcel. This is as follows:

2:07.2 Based on pressure cycling tests of nominal 6 pcf Vinylcel (Report E 455-T-238) and the relative elastic moduli of 6 pcf and 4 pcf Vinylcel, we estimate the maximum deflection of 4 pcf Vinylcel to be 2.8% and the residual deformation to be 0.8%.

3:01.2

a. Thermal conductivity (BTU/hr sq ft/F/in) per ASTM C-518 Heat Flow Meter calibrated per ASTM C-177 Guarded Hot Plate.

Mean Temperature, F.	75	100	125	150
BTU-in	0.22	0.23	0.25	0.27

b. Compressive yield strength per ASTM D1621 --- 140 psi at the 0.2 percent point on stress-strain curve.

c. Maximum operating temperature for continuous service - 175F, but may vary with specific application requirements.

d. Maximum allowable temperature for specified time interval... See attached Report No. E455-T-266, Appendix I, Compression Under Combined Heat and Pressure Test.

- 2 -

e. Moisture vapor permeability per ASTM C-355. See attached Report No. E455-T-268, Appendix I, Table 3.

f. Shear strength per ASTM C-273 - 68 psi ultimate.

g. Shear modulus per ASTM C-273 - 3510 psi.

h. Compressive modulus per ASTM D-1621 - 2300 psi.

i. Density per ASTM D-1622 - 4.0 lbs/cu ft. nominal, 3.7 lbs/cu ft. minimum.

j. Average coefficient of linear expansion -  $9.4 \times 10^{-6}$  in/in/F.

k. Curves for the Case III showing temperature before and after accident plotted against time. See Report No. E 455-T-266, Analogue Study of Vinylcel used as Containment Insulation.

l. Test results of permeability tests per ASTM C-355. See attached Report E 455-T-268,

Predicted curve for 6 month test as required under 2:07.9. See attached Report No. E455-T-268. Dimensional rather than weight change is given as explained under Humid Aging (Results) of the report.

m. Radiation exposure of  $8 \times 10^6$  roentgens within 6 hours will not change the physical properties of Vinylcel significantly but  $10^8$  roentgens within 10 hours will cause some progressive deterioration.

The 4 pf Vinylcel will be supplied 44" x 84" x 1-1/4" thick. Length and width tolerance will be  $\pm 1/32$ ".

Very truly yours,

C. E. ERNST  
- Chief-Engineer

CBE/ca

P.S. As I advised your secretary on Wednesday, Research is sending 6 copies of report E455-T-238 directly to you.

## VENDOR CONTACT REPORT

REFERENCE 10

Contact Report Of: RAY ThomeTelephone ☒Date of Contact: 7-31-81

Follow Up Date: \_\_\_\_\_

Agency Or Company and Address	JOHN-MANVILLE RESEARCH & ENGR CENTER DENVER, Colo.			
Phone	303-979-1000 EXT 4804			
Person(s) Contacted and Title	Jean Richardson, Product Coordinator			
Item(s) and Part Number(s)	Vinylcel Insulation		Rochester G+E JOB NO 17490	
Information needed	<input type="checkbox"/> Temperature Limits <input type="checkbox"/> Time/Temperature Data <input type="checkbox"/> Catalogue <input type="checkbox"/> Life Cycles <input type="checkbox"/> Reliability Data (MIL Spec) <input checked="" type="checkbox"/> Radiation <input type="checkbox"/> Material <input checked="" type="checkbox"/> Other <u>General</u>			
Discussion	<p>Ms. Richardson indicated that Mr. C.E. Ernet, Chief Engineer had retired from the company and would check on the following items:</p> <ol style="list-style-type: none"> <li>1. Availability of a Report NO. E 455-T-238</li> <li>2. A substitute material for <u>Vinylcel</u> since it has not been manufactured for years.</li> <li>3. Determine the type of radiation studies performed since Mr Ernet retirement.</li> </ol>			
Action	No further action until the Research Center indicates availability of information.			
Copies To	J. GLEASON, D. STINSON, M. Bruce, & VCR FILE <u>transmission Hand</u>			

# Rigid PVC foam process attracts Phillips

Minority interest in French plastics firm gives it a captive outlet for joint venture's resin production

Phillips Petroleum doesn't produce polyvinyl chloride in the U.S., but in western Europe, the company shows keen interest in that large-volume plastic. Earlier this year, Phillips teamed up with West Germany's BASF to form Badische Phillips Petroleum, N.V. (Badiphil), in Antwerp in its first venture to make PVC resins (C&EN, June 20, page 23). It followed that move last month by acquiring a 35% interest in the Paris-based

plastic fabricator Kléber-Colombes Plastiques, S.A.

The minority holding in Kléber-Colombes Plastiques gives Phillips a captive outlet for Badiphil's PVC. Kléber-Colombes Plastiques has a particularly strong position in rigid PVC foams. Its process for producing a cross-linked PVC foam has been licensed by 14 companies in 12 countries (including B. F. Goodrich and Johns-Manville in the U.S.).

At the same time that Phillips bought 35% of Kléber-Colombes Plastiques, the West German firm, Renolit-Werke, GmbH, Worms, acquired 14%. This left a 51% interest in the hands of the parent tire and rubber goods manufacturer, Kléber-Colombes, S.A.

Phillips and Renolit are linked in the U.S. With National Distillers they own American Renolit, which produces PVC calendered goods.

Kléber-Colombes Plastiques will post sales of about \$15 million this year. Rigid PVC foam has been one of its major products for 15 years. But the cross-linked material, Klegecell G 300, has only been offered for about a year and a half. Kléber-Colombes Plastiques pins its hopes for increased sales on better dimensional stability at temperatures to 120° C. and higher mechanical strengths for the cross-linked foams.

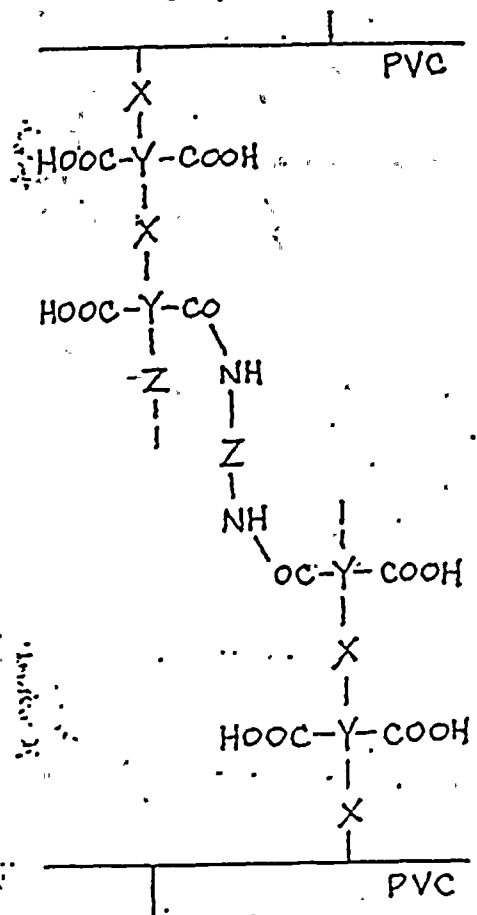
In its older process (U.S. Patent 2,576,749), Kléber-Colombes used a two-step process, in which the reaction of water with a diisocyanate produced carbon dioxide to give a hardened, cellular structure. This product has two relatively serious drawbacks, according to Dr. Yvan Landler, manager of the Paris research center of Kléber-Colombes. It costs too much, since the process can't produce foams with densities below 2.5 pounds per cu. ft. Secondly, it has poor thermal dimensional stability. At 90° C. the foam shrinks about 40%. At 150° to 160° C., these foams collapse.

Cross-linking, however, makes possible a foam which has a density of 1.5 pounds per cu. ft. with correspondingly lower costs. Also, temperature stability is improved. At 90° C., shrinkage is only 5%. At 150° to 160° C., cross-linked foams retain their cellular structure. In addition, me-



Kléber-Colombes' Landler  
14 licensees, 12 countries

Kléber-Colombes pictures bridges of amide groups between chains



X is segment of vinylidene monomer in the laterally grafted chain

Y (with two carboxyl groups) is segment of ethylenic anhydride after hydrolysis in the laterally grafted chain

Z is carrier grouping of isocyanate functions in di- or polyisocyanate used

Source: U.S. Patent 3,200,089

chanical strengths and solvent resistance are improved.

The new process (U.S. Patent 3,200,089), issued to Dr. Landler and Pierre Lebel, also has two steps. Addition of a vinylidene monomer, an ethylenic anhydride, and a free-radical catalyst to PVC resin and isocyanate is the first or molding step. In the second step, a reaction with water produces the finished cross-linked foam.

Dr. Landler proposes a mechanism to explain the formation of the cross-linked foam (see drawing). He describes the process as one in which amide groups from the isocyanate bridge grafted PVC macromolecules. In the heat and pressure of molding in the first step, the ethylenic anhydride and vinylidene monomer copolymerize. The copolymer then grafts onto the PVC molecule. In the second step, the anhydride units on the graft hydrolyze to acids and react with isocyanate molecules to cross-link the PVC.

Solubility studies bear out this hypothesis. According to Dr. Landler's U.S. patent, the Kléber-Colombes products are insoluble in dimethylformamide, which can dissolve other types of PVC-based cellular materials. The conclusion is that the Kléber-Colombes products are distinctly different and may have a reticulated structure with a tridimensional network.



Contact Report Of: M. Bruce

REFERENCE 14  
Telephone ☒ Visit ☐  
Page 1 of 3

Date Of Contact: 8-7-81

Follow Up Date: \_\_\_\_\_

Agency Or Company and Address	Rochester GAS & ELECTRIC
Phone	(716) 546-2700
Person(s) Contacted and Title	George Wrobel
Purpose	OBTAIN INFORMATION REQUIRED FOR JOB #17490
Discussion	<p>Mr. Wrobel indicated the following:</p> <ol style="list-style-type: none"><li>1. Containment volume (free space) is <math>917,000 \text{ ft}^3</math> (Conservative treatment - Actual volume is <math>\sim 970,000 \text{ ft}^3</math>)</li><li>2. They have both insulated and non-insulated surface area. Assuming <u>all</u> insulated surface area is <math>36,181 \text{ ft}^2</math>, insulation thickness <math>1\frac{1}{4}'' + \frac{1}{32}''</math>. Density is 4 PCF.</li><li>3. They are interested in the HCl effects on their RHR System - stainless steel or stainless clad. Normal radiation dose over the plant life is <math>3 \times 10^5 \text{ rads}</math> (approximate max.).</li><li>4. Their accident condition is <math>286^\circ\text{F}</math> max for 28 hours, <math>219^\circ\text{F}</math> for up to 24 hours after accident initiation, and <math>152^\circ\text{F}</math> for remainder of 180 days.</li></ol>
Action	Prepare Analysis Report
Copies To:	J. GLEASON, D STINSON, R. Thome & BCR File

Page No. 21

REFERENCE 14

Page 2 of 3

Telephone ☒ Visit ☐Contact Report Of: M. BruceDate Of Contact: 8-7-81

Follow Up Date: \_\_\_\_\_

Agency Or Company and Address	Rochester Gas & Electric
Phone	(716) 546-2700
Person(s) Contacted and Title	George Wrobel
Purpose	OBTAIN INFORMATION REQUIRED FOR JOB #17490
Discussion	<p>5. Air flow is not severely restricted. They have difficulty in performing their routine pressure testing due to the extra time required to achieve complete stabilization of pressure in the insulated sections.</p> <p><b>SPRAY REQUIREMENT:</b> The following solutions will be released in the containment:</p> <ul style="list-style-type: none"><li>a. 230,000 gal. tank @ 1200 GPM (minimum 30 minutes) partly through the low head injector &amp; partly through the high head injector (This is buffered to a pH of 8.5-10.0 with 5100 gallon of 30% NaOH).</li><li>b. In addition, the reactor flood-tank has 6250 ft<sup>3</sup> of 50-100 ppm borated water, and two accumulators contain 1,134 ft<sup>3</sup> of 2000 ppm borated water.</li><li>c. The total solution will be recirculated through PWR heat exchanger where the pH can be checked and adjusted in emergency.</li></ul>
Action.	See sheet 1.
Copies To:	J. Gleason, D. Stinson, R. Thome & CR File

Contact Report Of: M. Bruce

REFERENCE 14  
Page 3 of 3  
Telephone ☒ Visit ☐

Date Of Contact: 8-14-81

Follow Up Date: \_\_\_\_\_

Agency Or Company and Address	Rochester GAS AND ELECTRIC
Phone	(716) 546-2700
Person(s) Contacted and Title	George Wrobel
Purpose	VINYLCEL INSULATION JOB NO 17490
Discussion	George Wrobel supplied other INFORMATION AS FOLLOWS: The carbon steel liner - all surface area (insulated & UNINSULATED) is covered with Carbo Zinc II primer and Phenoline 305 topcoat from Carboline Co, St. Louis, MO. (Ph 314-644-1000). They have chemical spray tests, but no acid test data.
Action	A follow-up call to Carboline verified that no directly applicable test data is available. They are forwarding product data sheets on Carbo Zinc II and Phenoline 305.
Copies To:	J. Gleason, D. Sturain, R. Thome, CR File

Report No. 17490-1  
Page No. 23  
VENDOR CONTACT REPORT

REFERENCE 15

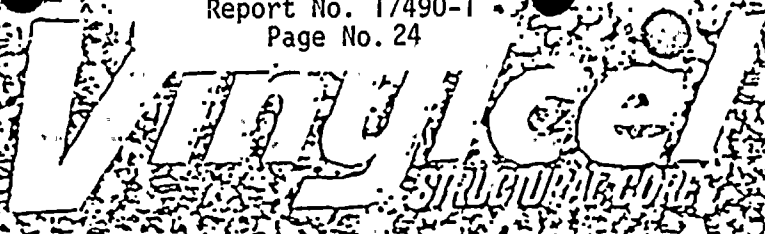
Contact Report Of: RAY Thome

Telephone ☒ Visi

Date of Contact: 7-30-81

Follow Up Date: \_\_\_\_\_

Agency Or Company and Address	John Manville INDUSTRIAL INSULATION DIV. New York, N.Y.		
Phone	212-532-7600		
Person(s) Contacted and Title	GLORIA Eichele, Sales Coordinator		
Item(s) and Part Number(s)	VINYLCEL INSULATION Rochester G+E JOB NO 17490		
Information needed	<input type="checkbox"/> Temperature Limits <input type="checkbox"/> Time/Temperature Data <input type="checkbox"/> Catalogue <input type="checkbox"/> Life Cycles <input type="checkbox"/> Reliability Data (MU Spec) <input checked="" type="checkbox"/> Radiation <input type="checkbox"/> Material <input type="checkbox"/> Other _____		
Discussion	<p>To establish the physical properties when Vinylcel has been exposed to high gamma radiation.</p> <p>The coordinator indicated the company stopped manufacturing this insulation sometime during 1967-1970 and did not possess any additional information.</p> <p>The chief engineer listed in our copies of correspondence was not listed in her phone directory.</p>		
Action	<p>Suggested I contact the Atlanta office for engineering support.</p> <p>Atlanta office, in turn, recommended the Denver Product Information Center.</p>		
Copies To	J. GLEASON, D. STINSON, H. Bruce & VCR File, <sup>Foundry</sup> <sup>Denver</sup>		



# RIGID CROSS-LINKED PVC FOAM

## VINYLCEL

### PHYSICAL PROPERTIES\* (average values)

PROPERTY	TEST METHOD	NOMINAL DENSITY, PCF		
		2	4	6
Compressive Strength (ultimate), psi	ASTM D1621-64			
at 70F		45	158	265
at 175F		38	113	185
at 212F		33	106	175
Laminar Tensile Strength, psi	ASTM C297-61	50	165	285
Shear Strength (ultimate), psi	ASTM C273-61	30	75	123
Flexural Strength	ASTM C203-58			
Modulus of Rupture, psi		70	190	310
Modulus of Elasticity, psi		3000	7000	9000
Coefficient of Linear Expansion in/in/F x 10 <sup>-6</sup> (up to 110F)		8	10	10
Linear Shrinkage, %				
100 days 175F dry soaking heat		2%	1.7%	0.5%
100 days 158F, 100% RH		3%	2%	0.5%
63 days 120F, 100% RH		<1%	<1%	<1%
Water Vapor Permeability, perm-inch	ASTM C355-64	0.1	0.04	0.001
Water Absorption, % volume 48 hrs at 10' head	HH I-524	2%	3%	2%
Flammability, 1" thick	ASTM E84-61			
Tunnel Flame Spread		20	NA	36 (3/4" tk.)
Smoke Developed		80-100	NA	>200
Thermal Conductivity (Btu in. per sq ft per F per hr)	ASTM C518-63T			
75F mean		.20	.22	.23
OF mean		.16	.18	.19

\* Test Data values shown are averages as tested by standard methods. These values are provided as guides for product evaluation and are given without liability to Johns-Manville.

**carboline**

**CARBO ZINC® 11** REFERENCE 23  
Page 1 of 2

350 HANLEY INDUSTRIAL COURT • ST. LOUIS, MO. 63144 • 314-644-1000

### SELECTION DATA

**GENERIC TYPE:** Self curing, inorganic zinc primer. The coating consists of a basic zinc silicate complex. Base and zinc filler mixed prior to application.

**GENERAL PROPERTIES:** An inorganic zinc base coat that protects steel galvanically, eliminating sub-film corrosion. Has outstanding application properties. Can be applied at the recommended thickness in one coat.

**RECOMMENDED USES:** Carbo Zinc 11 (the first self-curing inorganic zinc primer) is used as a single coat protection of steel structures in weathering exposure and as a base coat for organic and inorganic topcoats in more severe services. Excellent for the interiors and exteriors of storage tanks containing fuels and organic solvents. Has many uses as a maintenance primer, with or without topcoats, depending on exposure. Used widely in chemical plants, paper mills, refineries and coastal or salt atmospheres including offshore structures. Carbo Zinc 11 meets the stringent performance requirements of the American National Standards Institute, ANSI N101.2-1972 and ANSI N5.12-1974.

**NOT RECOMMENDED FOR:** Immersion or indirect exposure to acids or alkalis without suitable topcoat.

**CHEMICAL RESISTANCE GUIDE:** (with proper topcoat)

Exposure	Immersion	Heavy Fumes or Light Splash and Spillage	Outside Weathering or Mild Fumes
Acids	NR	Very Good	Excellent
Alkalies	NR	Very Good	Excellent
Solvents	Excellent	Excellent	Excellent
Salt	Excellent	Excellent	Excellent
Water	Excellent	Excellent	Excellent

**TEMPERATURE RESISTANCE:** (non-immersion)

Continuous: 750° F (399° C)  
Non-continuous: 800° F (427° C)

**FLEXIBILITY:** Fair-Good **WEATHERING:** Excellent

**ABRASION RESISTANCE:** Excellent. Abrasion resistance increases with age.

**SUBSTRATES:** Apply over properly prepared steel, cast iron, or other surfaces as recommended.

**TOPCOAT REQUIRED:** May be topcoated with epoxies, phenolics, vinyls, acrylics, silicones, chlorinated rubbers or others as recommended.

**NOTE:** Under certain conditions a mist coat or tie coat may be desirable to prevent topcoat bubbling.

**COMPATIBILITY WITH OTHER COATINGS:** Apply directly over substrate, Carbo Weld® 11 or other inorganic zincs as recommended.

### SPECIFICATION DATA

**THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL:**

	By Weight
Carbo Zinc 11	79% ± 2%
Percent zinc in dry film	86%

**RECOMMENDED DRY FILM THICKNESS PER COAT:**  
2-3 mils (50 to 75 microns)

**THEORETICAL COVERAGE PER MIXED GALLON:\***  
1000 mil sq. ft. (24.5 sq.m/1 @ 25 microns)  
333 sq. ft. at 3 mils (8.2 sq.m/1 @ 75 microns)

\*NOTE: Material losses during mixing and application will vary and must be taken into consideration when estimating job requirements.

**SHELF LIFE:** Base: 12 months minimum  
Zinc Filler: 24 months minimum

**COLORS:** Gray or Green only.

**GLOSS:** Matte finish.

### ORDERING INFORMATION

Prices may be obtained from Carboline Sales Representative or Main Office. Terms — Net 30 days.

**SHIPPING WEIGHT:**

	1's	5's
Carbo Zinc 11	23 lbs. (10.4 kg)	113 lbs. (51.3 kg)
Carboline Thinner #33	9 lbs. (4.1 kg)	41 lbs. (18.6 kg)
Carboline Thinner #21	8 lbs. (3.6 kg)	36 lbs. (16.3 kg)

**FLASH POINT:** (Pensky-Martens Closed Cup)

Carbo Zinc 11 Base	56° F (13° C)
Carboline Thinner #33	101° F (38° C)
Carboline Thinner #21	53° F (12° C)

Feb. 81 Replaces Jan. 80

To the best of our knowledge the technical data contained herein are true and accurate at the date of issuance and are subject to change without prior notice. User must contact Carboline to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee our products to conform to Carboline quality control. We assume no responsibility for coverage, performance or injuries resulting from use. Liability, if any, is limited to replacement of products. Prices and cost data if shown, are subject to change without prior notice. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY THE SELLER, EXPRESS OR IMPLIED, STATUTORY, BY OPERATION OF LAW, OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

**carboline**

# PHENOLINE® 305 FINISH

350 HANLEY INDUSTRIAL COURT • ST. LOUIS, MO. 63144 • 314-644-1000

REFERENCE 23  
Page 2 of 2

## SELECTION DATA

**GENERIC TYPE:** Modified phenolic. Part A and Part B mixed prior to application.

**GENERAL PROPERTIES:** A heavy duty topcoat, Phenoline 305 Finish sets to a hard, tough, smooth finish having very good abrasion resistance. The surface is glossy and easily cleaned. Has excellent resistance to a wide range of solvents, caustics, cleaning solutions and acid entrained vapors of high concentration. Phenoline 305 Finish has outstanding chemical, physical and application properties. Phenoline 305 Finish is easily repaired, has excellent resistance to hydraulic fluids and meets the applicable performance criteria of the American National Standards Institute ANSI 101.2-1972 and ANSI N5. 12-1974. It has performed satisfactorily in radiation resistance and decontamination testing at Oak Ridge National Laboratory.

**RECOMMENDED USES:** Phenoline 305 Finish is an excellent coating for the protection of steel and concrete surfaces in nuclear power plants. Because of its glossy appearance and excellent physical properties, Phenoline 305 Finish is an excellent topcoat for use by manufacturers of industrial equipment and components. Also used in chemical processing plants, pulp and paper mills for the protection of structural steel and concrete against severe splash, spillage and fumes. Makes an excellent floor coating, addition of Special Silica #2 provides a non-skid surface.

**NOT RECOMMENDED FOR:** Immersion service or continuous spillage of hot or concentrated acids.

## CHEMICAL RESISTANCE GUIDE:

Exposure	Splash and Spillage	Fumes
Acids	Very good	Excellent
Alkalies	Excellent	Excellent
Solvents	Excellent	Excellent
Salt	Excellent	Excellent
Water	Excellent	Excellent

## TEMPERATURE RESISTANCE:

Continuous:	200°F (93.3°C)
Non-continuous:	250°F (121°C)

**FLEXIBILITY:** Fair

**WEATHERING:** Very good

**ABRASION RESISTANCE:** Very good

**SUBSTRATES:** Apply over suitably primed metal or cementitious surfaces. Surfacers normally required for poured vertical surfaces.

**TOPCOAT REQUIRED:** Normally none

**COMPATIBILITY WITH OTHER COATINGS:** May be applied over inorganic zincs, catalyzed epoxies, modified phenolics or others as recommended. Acceptable primers are Carbo Zinc® 11, Carbo Zinc 12, Carboline 195 Surfacers, Carboline 295 WB Surfacers, Phenoline 305 Primer, Phenoline 305 Concrete Primer, Phenoline 307 or others as recommended. A mist coat may be required when applied over inorganic zinc.

## SPECIFICATION DATA

**THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL:**

By Volume  
64 ± 2%

Phenoline 305 Finish

**RECOMMENDED DRY FILM THICKNESS PER COAT:**  
4-6 mils (100-150 microns)

**THEORETICAL COVERAGE PER MIXED KIT\*:**

1 gal. kit (yields 1.25 gal.)	
1283 mil sq. ft. (25.6 sq. m/l @ 25 microns)	320 sq. ft. at 4 mils (6.4 sq. m/l @ 100 microns)
5 gal. kit (yields 6.25 gal.)	
6416 mil sq. ft. (25.6 sq. m/l @ 25 microns)	1603 sq. ft. at 4 mils (6.4 sq. m/l @ 100 microns)

\*NOTE: Material losses during mixing and application will vary and must be taken into consideration when estimating job requirements.

**SHELF LIFE:** 2 years minimum

**COLORS:** Phenoline 305 Finish: Standard colors are White C800, Gray C705, Gray C703. Consult Carboline Color Chart.

**GLOSS:** Glossy

## ORDERING INFORMATION

Prices may be obtained from Carboline Sales Representative or Main Office. Terms — Net 30 days.

## SHIPPING WEIGHT:

	1 Gal. Kit (1.25 gal.)	5 Gal. Kit (6.25 gal.)
Phenoline 305 Finish	17 lbs. (7.7 kg)	80 lbs. (36.3 kg)
Phenoline Thinner	9 lbs. (4.1 kg)	45 lbs. (20.5 kg)
Carboline Thinner #2	9 lbs. (4.1 kg)	45 lbs. (20.5 kg)

**FLASH POINT:** (Pensky-Martens Closed Cup)

Phenoline 305 Finish Part A	68°F (20.0°C)
Phenoline 305 Finish Part B	60°F (15.6°C)
Phenoline Thinner	77°F (25°C)
Carboline Thinner #2	30°F (-1°C)

May 80 Replaces Jan. 80

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