SUMMARY REPORT

PHENOLIC PIPING

CHEMICAL RESISTANCE OF UCNC ASBESTOS-PHENOLIC PIPE

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SUMMARY Screening tests have been completed to determine the chemical resistance of three asbestos-resinous products prepared by the Union Carbide Nuclear Company. One of these products (No. 766-37) containing a phenolic binder exhibited excellent chemical resistance to a variety of organic and aqueous inorganic solutions. A commercial product based on this formulation should be superior to Johns-Manville Transite and should compare favorably with the J-M Chemtite (phenolic) chemical-resistant piping currently available. Additional laboratory tests and field installation of test sections of the No. 766 formulation will be made.

INTRODUCTION The Union Carbide Nuclear Company is interested in the development of commercial products which might utilize their asbestos product. One of these developments was the possible production of an asbestos-reinforced plastic pipe. Three separate samples of such pipe representing different resinous binders were submitted for evaluation. These had been made into flat stock 1/4" in thickness and were cut to appropriate size for mechanical testing by ASTM D-790 procedures. The three materials were designated as UCNC 465-15, UCNC 640-02, and UCNC 766-37. The resinous binder of the 766-37 was a phenolic resin. This composition has now been given a trade designation of F-100. The matrix of the other two compositions is unknown to the author.

This Department was requested to conduct standard chemical resistance tests of the three materials using the methods developed previously for the evaluation of rigid plastic materials. Test media were selected to represent a broad range of possible exposures with a particular emphasis on streams which might be encountered in waste disposal lines and other common commercial applications.

In order to obtain an adequate evaluation of the materials, a group of specimens was to be removed after 30, 90 and 180 days. Results of the tests concluded after 30 and 90 days have been reported previously (1). The data obtained by the previous exposures are not included in this report. Only the results of the tests concluded after 182 days of exposure are given in Tables I, II, III and IV.

DISCUSSION Two areas of use of plastic piping of the type developed from the asbestos material are envisioned. One of these is a general application where waste disposal lines, water distribution, hydrocarbon distribution, and other large volume but rather innocuous applications would be involved. These are areas of use where Johns-Manville Transite asbestos materials are currently used in large volume. Consequently, a comparison with the J-M Transite was made by exposure of all materials in dilute acids, alkalis, and certain organic chemicals to roughly approximate the worst conditions anticipated in general piping services.

The data for J-M Transite exposures are shown in Table I and reveal a substantial reduction in the properties of the material after exposure to most all of the test chemicals. In contrast, the No. 465 and 766 materials of the UCNC showed good resistance to essentially all of the chemicals. The 766 material was particularly outstanding in resistance to all test chemicals. The data leave no doubt that the 766 phenolic-asbestos material would be far superior to J-M Transite as a general service piping for miscellaneous service.

The No. 766 product (F-100) is composed of a phenolic matrix and evidenced the usual good chemical resistance of phenolic products. It is interesting to note the resistance of the 766 material to sodium hydroxide. The basic phenolic resin used in this formulation is not resistant to alkalis. The high percentage of asbestos present apparently acted as a sufficient shield to protect underlying layers of phenolic resin and prevented degradation of the product. The use of such a material in alkaline service should be carefully evaluated, however. Alternately, the poor resistance of the product in hydrochloric and sulfuric acid is probably caused by the presence of the asbestos. Chrysotile asbestos is not resistant to inorganic acids and the loss in modulus and other changes noted in the product are probably due to attack by the acids on the asbestos filler.

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(1) Letter of Cook, D. C., to N. J. Setter, Chemical Resistance of Rigid Asbestos, UCNC, March 26, 1963 (ML:500:51).

The No. 640 material had the poorest overall chemical resistance of the three products with the No. 766 being very definitely superior to all other materials tested.

As stated, the 766 material is superior to Transite as a general purpose piping product. In fact, the material compares most favorably with the present J-M Chemtite phenolic piping material currently offered by that company as a highly chemical resistant process piping. The 766 material has poorer mechanical properties, but the chemical resistance should be roughly the same. The J-M Chemtite contains crocidilite asbestos rather than the chrysotile, and consequently has better mineral acid resistance. However, as a piping material for process work, the 766 would be most attractive where the lower mechanical properties can be allowed.

The poorest property of the 766 (F-100) material is the poor impact resistance. Undoubtedly, the notch sensitivity is very high also. Longer asbestos fibers would be desirable to upgrade these properties,as well as the strength of the product. However, at the present time the F-100 product has strength and modulus in flexure very close to that of the Chemtite product.

Table V shows the appraisal of the various materials tested as determined by an arbitrary limit on changes in weight, dimensions, hardness, strength, and modulus. These limits are entirely arbitrary but have been indicated by the testing of other materials to be significant as limiting changes in the material. No national recognition of these limits for rigid plastic materials is in effect but the values are believed to be accurate for an appraisal of screening tests for such products.

Many types of simple slip fittings may be used on piping made up for a general purpose system. However, when competing with piping materials for process applications, a secure, reproducible, reinforcing fitting must be provided to obtain optimum service from the material. Thus, it is imperative that an excellent fitting be found to join the F-100 piping before it is marketed for process applications. The current J-M molded phenolic fitting is an excellent product, and something of this type is necessary to provide the customer with a complete and usable package.

Additional tests are to be conducted using the F-100 (766) product. The stability of the plastic in a wide variety of organic chemicals will be determined in the manner previously employed for the evaluation of reinforced plastic materials (2). These data should be available by March, 1964. In addition, various test sections of the piping will be exposed in a variety of plant environments.

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(2) VanDelinder, L. S. and Cook, D. C., Materials of Construction: Evaluation of Rigid Plastics for Organic Chemical Service, February 8, 1962, (ML:500:69-F1).

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Notebook Reference: 3JCC

ATTACHMENTS
5 Tables

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CHEMICAL RESISTANCE OF J-M TRANSITE

Test Conditions: Ambient Temperature; Static Conditions; 182 days

Test Media	Spec. No.	% Wt. Chg.	% Dim. Chg.	ASTM D-785-51 Rockwell Hardness "R" Scale	ASTM D-790-58T Flexural Strength, PSI	ASTM D-790-58T Modulus in Flexure, PSI X 10^6	Remarks
Control	1	---	---	114.0	8,300	3.01	Unexposed
	2	---	---	100.0	7,890	2.98	"
	3	---	---	95.0	7,090	2.71	"
2% Hydrochloric Acid	1	+ 8.86	- 1.29	66.5	3,980	2.41	Yellow adherent coating
	2	+ 9.61	+ 0.42	59.0	4,495	2.50	
	3	+10.48	nil	68.0	3,765	2.08	
2% Sulfuric Acid	1	+21.92	+12.05	63.5	4,830	2.23	Loss of binder
	2(1)	---	---	---	---	---	
	3	+16.95	+11.15	72.5	3,995	2.12	
2% Nitric Acid	1	+14.00	nil	74.0	2,995	3.14	Adherent coating
	2	+14.10	+ 0.81	89.5	4,645	2.52	
	3	+13.02	- 0.40	95.0	3,835	2.08	
2-1/2% Sodium Hypochlorite	1	+15.36	nil	92.0	4,210	2.34	No apparent change
	2	+14.22	+ 0.41	102.0	4,155	2.30	"
	3	+ 8.79	+ 0.79	110.5	4,650	3.27	"
5% Acetic Acid	1	+ 3.11	nil	49.5	3,715	1.95	"
	2(1)	---	---	---	---	---	
	3	+ 6.67	nil	62.0	2,970	1.60	"
Ethyl Acetate	1	+ 4.52	+ 0.41	101.0	4,265	1.89	"
	2	+ 4.13	+ 0.41	90.0	4,460	2.40	"
	3	+ 1.57	- 0.81	113.0	5,480	3.25	"
2% Sodium Hydroxide	1	+15.77	- 0.42	96.0	4,450	2.47	"
	2	+15.45	- 1.22	94.5	5,110	3.10	"
	3	+15.80	+ 1.66	96.5	4,295	2.38	"
2% Ammonium Hydroxide	1	+14.30	- 0.40	101.5	5,210	2.77	"
	2	+15.33	+ 0.42	101.0	4,865	3.02	"
	3	+ 9.88	- 0.40	111.5	4,850	2.87	"
Kerosene	1	+11.35	nil	96.0	4,420	2.73	No apparent change
	2	+11.10	+ 0.43	99.5	4,535	2.83	"
	3	+11.22	+ 0.41	78.0	3,170	1.74	"
Methyl Isobutyl Ketone	1	+ 3.95	- 1.19	112.0	5,130	2.70	"
	2	+ 4.78	nil	82.5	3,015	2.49	"
	3	+ 4.57	nil	98.5	4,250	2.25	"
Ethylene Dichloride	1	+ 6.51	nil	94.0	4,625	2.57	"
	2	+ 6.98	nil	91.0	4,125	2.28	"
	3	+ 5.25	+ 1.21	106.5	4,835	2.61	"

(1) Specimens used for earlier demonstration and photographs.

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CHEMICAL RESISTANCE OF UCNC 465-15

Test Conditions: Ambient Temperature; Static Conditions; 182 days

Test Media	Spec. No.	% Wt. Chg.	% Dim. Chg.	ASTM D-785-51 Rockwell Hardness "M" Scale	ASTM D-790-58T Flexural Strength, PSI	ASTM D-790-58T Modulus in Flexure, PSI X 10^6	Remarks
Control	1	---	---	102.0	8,730	2.50	Unexposed
	2	---	---	102.0	10,925	2.50	"
	3	---	---	103.0	10,475	2.40	"
2% Hydrochloric Acid	1	- 1.89	+ 0.43	89.0	6,750	1.72	No apparent change
	2	- 1.43	+ 0.42	92.5	8,090	1.81	"
	3	- 1.54	+ 0.85	93.0	6,910	1.60	"
2% Sulfuric Acid	1	- 2.64	+ 0.85	86.5	5,890	1.62	"
	2	- 2.02	+ 0.42	88.5	6,210	1.63	"
	3	- 3.53	+ 0.85	90.5	6,230	1.25	"
2% Nitric Acid	1	+ 0.69	+ 0.86	96.0	7,410	2.18	"
	2	+ 1.08	+ 0.42	98.0	7,140	1.91	"
	3	+ 0.48	+ 0.42	100.5	6,310	1.53	"
2-1/2% Sodium Hypochlorite	1	- 0.46	nil	96.5	7,840	2.14	"
	2	- 0.36	+ 0.43	97.0	7,850	2.56	"
	3	- 0.53	+ 0.43	95.5	6,820	2.14	"
5% Acetic Acid	1	nil	+ 0.89	77.0	6,600	1.50	"
	2	+ 0.10	+ 0.42	74.5	6,450	1.48	"
	3	- 0.39	+ 0.89	73.0	7,040	1.38	"
Ethyl Acetate	1	+ 4.03	+ 1.28	106.0	4,140	2.15	"
	2	+ 3.82	+ 1.27	98.0	5,250	2.86	"
	3	+ 3.92	+ 1.27	104.5	3,705	2.87	"
2% Sodium Hydroxide	1	+ 5.29	+ 1.27	86.5	6,700	2.22	"
	2	+ 5.30	+ 0.85	89.0	6,710	1.93	"
	3	+ 5.10	+ 2.14	89.0	6,470	1.95	"
2% Ammonium Hydroxide	1	+ 4.09	+ 0.85	99.0	7,020	3.17	"
	2	+ 3.98	+ 0.85	100.0	7,190	3.13	"
	3	+ 4.04	+ 1.28	99.0	7,310	2.66	"
Kerosene	1	+ 0.70	nil	103.5	8,190	3.20	"
	2	+ 0.67	nil	104.0	7,640	3.25	"
	3	+ 0.70	+ 0.43	102.5	8,530	2.60	"
Methyl Isobutyl Ketone	1	+ 1.29	nil	101.0	6,830	3.26	"
	2	+ 1.74	nil	102.5	7,300	2.57	"
	3	+ 0.59	nil	105.0	9,170	2.46	"
Ethylene Dichloride	1	+ 4.88	+ 1.28	103.0	3,920	2.78	"
	2	+ 4.64	+ 0.43	106.5	5,340	2.88	"
	3	+ 4.61	+ 0.43	105.5	5,120	2.70	"

TABLE III

CHEMICAL RESISTANCE OF UCNC 640-02

Test Conditions: Ambient Temperature; Static Conditions; 182 days

Test Media	Spec. No.	% Wt. Chg.	% Dim. Chg.	ASTM D-785-51 Rockwell Hardness "R" Scale	ASTM D-790-58T Flexural Strength, PSI	ASTM D-790-58T Modulus in Flexure, PSI X 10^6	Remarks
Control	1	---	---	109.0	6,190	2.14	Unexposed
	2	---	---	109.5	6,480	2.30	"
	3	---	---	107.0	8,000	2.83	"
2% Hydrochloric Acid	1	+ 8.30	+ 0.40	- 17.0	2,095	1.35	Softened and Laminated
	2	+11.82	- 1.18	- 14.0	2,215	1.28	
	3	+ 7.08	- 2.40	- 16.0	2,688	1.44	"
2% Sulfuric Acid	1	+13.05	+ 8.39	15.0	2,880	1.54	"
	2	+14.07	+ 8.72	12.5	2,365	1.08	"
	3	+ 7.57	+ 3.96	14.0	2,745	1.45	"
2% Nitric Acid	1	+16.10	+ 1.98	85.0	2,400	1.75	"
	2	+16.95	+ 1.59	18.0	2,835	1.50	"
	3	+15.63	+ 1.98	- 1.0	2,645	1.56	"
2-1/2% Sodium Hypochlorite	1	+16.87	nil	85.0	3,680	2.06	No apparent change
	2	+17.30	nil	76.0	3,750	1.97	"
	3	+18.10	nil	65.0	2,535	1.48	"
5% Acetic Acid	1	+ 9.93	+ 3.98	46.0	1,048	0.507	Softened and Laminated
	2	+ 9.36	+ 3.58	54.0	1,512	0.751	
	3	+14.28	+ 1.60	87.0	1,812	1.54	"
Ethyl Acetate	1	+ 4.23	nil	75.0	2,665	1.77	No apparent change
	2	+ 5.08	nil	104.0	4,255	2.50	"
	3	+ 3.12	nil	102.0	4,855	2.53	"
2% Sodium Hydroxide	1	+10.85	+ 0.40	71.0	2,420	2.09	"
	2	+16.50	nil	90.0	3,780	1.99	"
	3	+14.50	+ 0.40	84.0	2,110	1.37	"
2% Ammonium Hydroxide	1	+21.82	+ 0.80	123.0	7,940	2.87	"
	2	+25.80	nil	122.0	6,550	2.38	"
	3	+24.95	+ 0.80	121.5	5,330	2.81	"
Kerosene	1	+13.10	+ 0.80	106.0	5,710	2.86	Saturated
	2	+13.65	nil	101.0	6,180	2.47	"
	3	+12.67	nil	93.0	5,710	2.53	"
Methyl Isobutyl Ketone	1	+ 9.73	nil	101.0	4,895	2.56	No apparent change
	2	+ 8.69	+ 0.40	101.0	5,370	2.56	"
	3	+ 5.34	nil	102.0	5,570	2.85	"
Ethylene Dichloride	1	+10.42	+ 0.40	96.0	4,750	2.46	"
	2	+ 8.06	nil	74.5	3,875	2.07	"
	3	+ 8.67	- 0.40	97.0	5,480	2.56	"

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CHEMICAL RESISTANCE OF UCNC 766-37

Test Conditions: Ambient Temperature; Static Conditions; 182 days

Test Media	Spec. No.	% Wt. Chg.	% Dim. Chg.	ASTM D-785-51 Rockwell Hardness "M" Scale	ASTM D-790-58T Flexural Strength, PSI	ASTM D-790-58T Modulus in Flexure, PSI X 10^6	Remarks
Control	1	---	---	103.5	11,600	1.98	Unexposed
	2	---	---	103.0	12,625	2.08	"
	3	---	---	105.5	10,100	2.18	"
2% Hydrochloric Acid	1	- 3.08	+ 0.84	98.0	10,525	1.30	Laminated
	2	- 2.66	+ 0.42	101.0	10,950	1.17	"
	3	- 3.13	+ 0.42	101.5	10,400	1.48	"
2% Sulfuric Acid	1(1)	---	---	---	---	---	---
	2	- 4.08	+ 1.27	98.5	9,860	1.53	Laminated
	3	- 4.29	+ 0.42	100.5	9,640	1.37	"
2% Nitric Acid	1	- 8.22	- 0.41	104.5	10,675	1.41	Slight lamination
	2	- 2.55	nil	104.0	11,650	1.94	"
	3	- 5.37	+ 0.41	103.0	11,660	1.70	"
2-1/2% Sodium Hypochlorite	1	- 0.11	nil	100.0	10,475	1.99	Slight discoloration
	2	+ 0.51	+ 0.41	100.5	9,800	1.74	"
	3	+ 0.34	nil	100.5	9,320	1.96	"
5% Acetic Acid	1	+ 1.17	+ 0.41	101.5	9,300	1.46	No apparent change
	2	+ 1.06	+ 0.84	102.0	11,225	1.64	"
	3	+ 1.29	+ 0.83	100.5	10,775	1.58	"
Ethyl Acetate	1	- 0.33	- 0.41	101.0	10,500	1.96	"
	2	- 0.34	nil	103.0	11,430	2.06	"
	3	- 0.38	nil	100.0	10,560	2.02	"
2% Sodium Hydroxide	1	+ 4.64	+ 1.67	95.0	9,190	1.66	Adherent film
	2	+ 4.16	+ 1.68	93.5	10,325	1.54	"
	3	+ 5.58	+ 1.24	92.5	8,470	1.43	"
2% Ammonium Hydroxide	1	+ 3.63	+ 0.83	105.0	8,130	2.26	No apparent change
	2	+ 3.60	+ 0.41	105.5	9,620	2.40	"
	3	+ 3.61	+ 0.83	105.0	9,950	2.39	"
Kerosene	1	- 0.14	- 0.41	104.5	9,900	2.53	"
	2	- 0.16	- 0.82	102.0	10,425	2.48	"
	3	- 0.16	nil	106.5	10,625	2.00	"
Methyl Isobutyl Ketone	1	- 0.43	- 0.41	102.5	11,775	1.99	"
	2	- 0.50	nil	103.0	11,220	2.02	"
	3	- 0.43	- 0.41	103.0	10,900	2.03	"
Ethylene Dichloride	1	- 0.29	+ 1.25	105.5	10,150	2.42	"
	2	- 0.41	nil	103.5	12,500	2.32	"
	3	- 0.27	nil	104.5	12,180	2.35	"

(1) Specimen used for earlier demonstration and photographs.

TABLE V

APPRAISAL OF CHEMICAL RESISTANCE OF ASBESTOS MATERIALS

(Arbitrary limits of changes in mechanical properties are assigned as indicated in left column)(1)

Exposed: 182 days

Test Media	2% Hydrochloric Acid	2% Sulfuric Acid	2% Nitric Acid	2-1/2% Sodium Hypochlorite	5% Acetic Acid	Ethyl Acetate	2% Sodium Hydroxide	2% Ammonium Hydroxide	Kerosene	Methyl Isobutyl Ketone	Ethyle Dichlor
Transite											
5% Change in Weight	U	U	U	U	S	S	U	U	U	S	U
5% Change in Dimensions	S	U	S	S	S	S	S	S	S	S	S
30 Points Change in Hardness	U	U	S	S	U	S	S	S	S	S	S
25% Loss in Strength	U	U	U	U	U	U	U	S	U	U	U
25% Loss in Modulus	S	U	S	S	U	S	S	S	S	S	S
Disposition	U	U	U	U	U	U	U	S	U	U	U
UCNC 465-13											
5% Change in Weight	S	S	S	S	S	S	U	S	S	S	S
5% Change in Dimensions	S	S	S	S	S	S	S	S	S	S	S
30 Points Change in Hardness	S	S	S	S	S	S	S	S	S	S	S
25% Loss in Strength	U	U	U	S	U	U	U	U	S	S	U
25% Loss in Modulus	U	U	S	S	U	S	S	S	S	S	U
Disposition	U	U	U	S	U	U	U	U	S	S	U
UCNC C40-02											
5% Change in Weight	U	U	U	U	U	S	U	U	U	U	U
5% Change in Dimensions	S	U	S	S	S	S	S	S	S	S	S
30 Points Change in Hardness	U	U	U	S	U	S	S	S	S	S	S
25% Loss in Strength	U	U	U	U	U	U	U	S	S	S	U
25% Loss in Modulus	U	U	U	S	U	S	S	S	S	S	S
Disposition	U	U	U	U	U	U	U	S	S	S	U
UCNC 766-37											
5% Change in Weight	S	S	U	S	S	S	S	S	S	S	S
5% Change in Dimensions	S	S	S	S	S	S	S	S	S	S	S
30 Points Change in Hardness	S	S	S	S	S	S	S	S	S	S	S
25% Loss in Strength	S	S	S	S	S	S	S	S	S	S	S
25% Loss in Modulus	U	U	S	S	S	S	S	S	S	S	S
Disposition	S	S	S	S	S	S	S	S	S	S	S

S = Satisfactory
U = Unsatisfactory

(1) VanDelinder, L. S., and Cook, D. C., Materials of Construction – Evaluation of Rigid Plastics for Organic Chemical Service, February 8, 1962 (ML:500:69-F1)

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