MEMORANDUM

USE OF PLASTICS IN CHEMICAL PROCESS APPLICATIONS

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SUMMARY This memorandum summarizes in a brief and general manner the use of plastic materials of construction to date within the Chemicals Company. The use of resinous or plastic materials divides itself logically into six categories of product and these are discussed separately.

The Chemicals Company since 1935 has been one of the leading users of thin-film plastic coatings for chemical shipments to prevent contamination of the product. As coatings development produced more unique products, the Company has been particularly progressive in utilizing the high-build coatings to provide linings of higher integrity for corrosive applications. Once the use of reinforced coatings was made available in 1960, the Company was one of the first to use this type of application and has extensive applications made in all plants in the Company to date. The Company has been slow in using reinforced solid plastic construction, as compared with some other chemical and oil company operations, primarily because of the high solvent nature of our corrosive environments and the hazards involved in handling flammable materials in such a material of construction. A similar situation exists in the use of homogenous solid plastics, although our use of solid phenolics has been most extensive and successful in the past 25 years. The use of steel integrally lined with elastomers or plastics has a long history in the Company and has slowly increased over the years.

The aggressive pursuit of new materials by Materials of Construction personnel, the activity of these personnel in the National Association of Corrosion Engineers, and the excellent liaison established between these persons within the Company has not allowed new developments to arise in the marketplace without a thorough appraisal of their application to Company problems, an adequate evaluation of their economic potential, and an immediate feedback of new information to other persons in the Company interested in materials of construction selection.

INTRODUCTION The use of plastic materials of construction is increasing very rapidly in the Chemicals Company. As a means of initiating a program to evaluate the usefulness of the materials in the Plants, a survey was made in 1961 to determine the major installations of plastics in the operating Units. A later survey of these installations would then provide adequate feedback to reveal problems in the use of the materials, the mechanical and chemical stability of the plastics, and any significant differences in the products prepared by various vendors. This memorandum reports the results of the initial survey plus the additional information required to bring the data up-to-date.

A recent article by Mr. William Hall of Proctor and Gamble (1) regarding the use of plastics in the operations of that company aroused interest in this subject within our own Company. It is interesting to compare such information with that obtained from our operations.

The cooperation of other Materials of Construction personnel and Operating personnel in supplying the data is gratefully acknowledged.

DISCUSSION The use of resinous or plastic materials covers such a broad spectrum of products it becomes necessary to categorize the various uses in which these materials are employed. Whether a phenolic resin is formulated in an alcohol diluent to make a baking coating or is mixed with asbestos and cured under heat and pressure to a solid plastic product makes little difference when appraising the volume use of plastics in process operations. Consequently, rather than discussing types of resins used, the following categories of resins or plastics use within the Company is employed in this memorandum:

1. Thin coatings
2. Heavy coatings, films, toppings
3. Reinforced coatings
4. Reinforced solids
5. Homogenous solids
6. Lined steel

Thin coatings. The Chemicals Company was one of the first to use thin film linings to prevent contamination of their products. Since 1935, we have used baked phenolic resins on the interior of drums to provide our customers with a product free from contamination by the container. The success of this application led to the use of such linings, primarily phenolic, in tank cars, barge compartments, and in a host of field storage vessels. At the present time, we have 180 tank cars coated with six mils of phenolic resin used for the shipment of our refined products. The numbers of these cars increases yearly as customer requirements become more demanding and our range of products requires an even greater versatility in our container. Thousands of square feet of cylindrical tanks, spheres, pipelines, pumps, and portions of operating equipment are coated with this material to prevent contamination of the contents.

The reason for the extensive use of the phenolic coating within the Company is the excellent solvent resistance of this

(1) Anon., Pushing Plant Plastics, Chemical Week, March 23, 1963, p. 42.

material when baked. No other resinous product provides such durability when exposed to the wide range of organic solvents handled in our operations. Epoxy materials have been used in a similar manner but have been found to be more difficult in application and less versatile for general use. The vinyls and other solution coatings do not have adequate solvent resistance to compete with these two basic resins for Company uses.

In the evaluation of coating materials of all types, we initiated a continuous program of evaluation in 1955, and since that time have issued 82 reports describing the application properties, chemical resistance, and possible utility of a great number of coatings made available on the market.

No listing is given of the applications of thin film coatings within the Company because of the long history of use and the overwhelming number of applications made during the past thirty years.

Thick Coatings, Films, and Toppings. By 1950, coatings technology advanced to the point where very heavy, catalyzed coatings could be applied to metallic or non-metallic substrates. These products produced a coating with three distinctive advantages. For the first time a coating could be applied in the field which would be completely continuous for use in a truly corrosive environment. Secondly, cross-linking the resins in place by catalysis produced a film with reasonable solvent resistance without baking. Lastly, these materials could be used in many applications where it was impractical to attempt the baking of a resin to produce an adequate coating. Consequently, the application of these materials on steel and concrete began after an evaluation program in 1950, and the use of the materials has grown steadily since that time. Storage vessels, process vessels, and tank cars have been lined with these products with varying success but with a distinct economic savings realized. In this category, the epoxy resins have been the major component of the coating. In addition, we have available a number of phenolic catalyzed formulations which have proven to be most durable in our type of solvent exposure. These films average from 15 to 60 mils in thickness and are force-dried (not baked) when practical. Storage vessels, large-diameter pipelines, many concrete structures containing corrosive chemicals, and other items of process equipment have been coated with such materials.

Thin plastic films to be used as liners on the interior of small storage containers or, in the form of tape, as an exterior protective covering have received adequate attention over the years. We were the first persons to use polyethylene tape on the exterior of pipelines (1954), and the initial installation is still reported yearly throughout the country as an example of the effectiveness of polyethylene as a protective coating for underground structures.

Since the initial installation, hundreds of miles of Corporation pipeline have been laid with this type of coating on the exterior.

Meanwhile, the Republic Steel Corporation introduced their X-Tru-Coat polyethylene film blown over an asphaltic coating on steel as an external protection for steel pipe. This product can be purchased at less price than field application of the polyethylene tape and consequently is used whenever possible in the field. A considerable amount of this material has now been installed.

The use of polyethylene as a thin film layer on the interior of small storage vessels, drums, and smaller containers has been tried with varying success. In general, we have found the material to be less than adequate for applications other than use in 5-gallon cans. At the present time, only the latex materials are packaged in a 5-gallon container lined with a loose polyethylene bag, and we hope to eliminate this soon.

The protection of concrete floors in Unit areas has always been a problem, and over the years we have utilized epoxy, furane, polyester, and phenolic resin products to protect the concrete. The epoxy and polyester materials are commonly used today for this purpose and are widely used in the Chemicals Company and Plastics Company to provide abrasion resistant, chemically resistant surfaces on a concrete base.

Another large-volume use of coating material has been the coating of the interior of resin hopper cars. Some 221 of these have been coated in the past five years with an epoxy-phenolic coating to provide a maximum durability, excellent continuity over the steel, and good appearance for the transportation of vinyl and polyethylene resins. It is interesting to note that our selection of a coating material to use inside these cars was watched throughout the chemical industry and when our selection was made, orders by other chemical companies in the country were immediately placed utilizing the same coating.

Urethane resins have also been used in hopper car coatings in those areas where abrasion resistance of the coating was considered to be the most important property. Also, urethane varnishes have been used in the laboratory for similar applications where the excellent abrasion resistance imparted by this resin is desired.

Reinforced Coatings. With the advent of new thixotropic, catalyzed coating materials, a considerable attempt was made by the market to provide application equipment to obtain the maximum benefit from these products. Various unsuccessful models of spray equipment were offered with the culmination of the Rand gun in the late fifties. Initially the introduction of this gun stimulated the manufacture of boat hulls and other items by spray lay-up as opposed to conventional hand lay-up for the items. The lower cost of the construction was attractive, but it was soon found that only an artist could handle such an application with confidence. This item in itself had only limited use, but a few persons in the country saw the benefit of the design and have been able to utilize the principles of the Rand gun in producing reinforced resinous coatings of great thickness, comparable to solid reinforced plastic construction. In this type of operation, two separate resinous components are introduced simultaneously with chopped glass from a center head in the gun. This three-headed gun lays down a catalyzed, glass-reinforced, plastic lining of any thickness desired on any substrate.

The Matcote Company in Houston was one of the first to come up with a workable modification of the Rand gun for the application of the linings to process equipment. Consequently, we started using this product, when it was first offered, at our Texas City Plant and have rapidly expanded the use of this type of material during the past three years. Depending on the application, we specify from 1/16- to 3/16-inch of reinforced plastic for such applications. This type of application in essence provides a plastic tank within a steel vessel. With a tensile strength of some 5 to 8,000 psi in the plastic shell, it is presumed that the shell is self-supporting if of sufficient cross-section, and the steel backing is used merely as a container and fireproofing. Only epoxy and polyester resins are applied in this manner, although the number of resins so employed will undoubtedly increase in the future. Of these two, we use more polyester than the epoxy, primarily because of the better resistance of the polyester resin to organic acids. The epoxy material is used primarily for water service.

This type of coating is one often referred to in the literature as having reclaimed a steel tank or as a substitute for the purchase of stainless steel or other alloy construction. Indeed, steel tanks condemned for further service can be reclaimed by hand-patching holes in them and overlaying the entire interior with a heavy liner of the rigid plastic coating. When the Brownsville Plant was being renovated in preparation for the Butane Oxidation Process, this type of coating made it possible to use steel tanks for the storage of crude products. Otherwise, new steel tanks with a similar coating or stainless steel construction would have been required. Two of these vessels are of 214,000 gallons capacity each.

Unfortunately, the plants outside of the Texas area are handicapped in obtaining applications of this type at a reasonable price. Whereas, coating costs in the Texas area are $1.00 to $1.75 per square foot, the cost in the Kanawha Valley is $2.75 to $4.00 per square foot. Only four coating applicators in the country are currently offering this type of service, and of these, only one appears to really know how to perform the job (Matcote of Houston). The Brownsville, Seadrift, Texas City, Institute and South Charleston Plants have all recovered steel vessels and placed them in corrosive services by the application of this type of coating.

A similar coating application can be obtained by hand-lay-up of the resin and glass. Such applications are obviously more expensive and time-consuming.

A tabulation of the major applications of this type of coating are given in the Appendix. The author would conservatively estimate that for every square foot of this type of coating which Mr. Hall of Proctor and Gamble (1) has in service, we have at least 2,000 square feet.

Reinforced Solids. The Chemicals Company has not been in the forefront of those using reinforced solid plastic structures as chemical process equipment. This is due to two problems peculiar to our Company. One of these is the extreme solvent activity of our usual process streams, and the other is the usual flammability and hazard of the product being handled. We have installed short sections of line in hazardous solvent service as a test, but to date have not made an installation of any major pieces of equipment where the contained contents would constitute a hazard if discharged into the open. At the present time, we do not propose to change this practice.

Also, our strength in the use of coatings on steel has allowed us to resist the use of solid plastic equipment for some years at a savings in cost.

To better acquaint ourselves with the field of plastics and prepare for the obvious growth in the use of such materials of construction, a review of the available materials and the status of the market was made in 1956. A report was issued summarizing the status of the products at that time.

Working with plastic materials of construction is analogous to working with metals at very high temperatures. Creep data are the only true measure of the stability of a solid plastic in a given environment. Unfortunately, tests to measure creep are expensive, time-consuming, and require an inordinate amount of laboratory space to conduct. Also, when a reinforced plastic material is to be considered for a given application, sufficient time is not usually available to evaluate the plastic in that specific environment. Finally, it was apparent that no data were forthcoming from the fabricators or basic resin suppliers regarding the stability of the glass-reinforced plastics in chemicals of interest to our own Company. Because of these problems, a program was initiated in 1958 to establish the categorical resistance of available glass-reinforced resins in typical organic groupings. This extensive work was completed in 1960 and has provided us with an excellent base for recommendations of the use of these materials since that time. In conducting the tests, we desired to determine if there was a short method of establishing the stability of a plastic in a given environment. As a result of the program, we can now more accurately evaluate the stability of plastics in specific environments, and can do so after a test period of 60 to 100 days.

Unfortunately, the vendors of glass-reinforced plastic equipment have not established minimum standards for their industry, and the majority of the products being made are less than satisfactory. Efforts are currently being made by the industry to correct this situation. Meanwhile, the low bidder on such equipment usually provides an inadequate product. We are currently aiding in the writing of a specification for glass-reinforced plastic materials for the Chemicals Company. The first issue of this has been released, and will be expanded and improved as deficiencies are noted.

Our interest in the hazards associated with the use of these products required that we evaluate their fire resistance. Consequently, Mr. D. H. Way of the Fire Research Group conducted the most definitive tests made to date on these materials when exposed to fire. The results were far worse than anticipated. The materials simply have no fire resistance when exposed to a high-temperature flame.

The recent design of two new aqueous-solution processes for the production of a glyoxal and the latexes allowed us to use plastic construction on a major scale for the first time. Consequently, a significant number of vessels and over 5,000 feet of plastic piping will be used in the construction of these two units. These items of equipment along with others used in the past are tabulated in the Appendix.

We are on committees of the National Association of Corrosion Engineers, ASTM, and the Manufacturing Chemists Association concerned with plastic materials of construction. The activities of these organizations are being followed and the information used in our Company operations.

Homogenous Solids. The use of homogenous, solid plastics dates back considerably farther than the use of glass-reinforced materials. We have used solid polyvinyl chloride (PVC) and polyethylene tubing and piping on numerous occasions dating back to at least 1956. The PVC material is probably the most successful and widely used of the plastic materials marketed in the past. Unfortunately, we cannot use the product in any but water or mineral acid service, and even then process upsets contaminate the streams with solvents at times and completely destroy the plastic. Consequently, no great amount of it has been used as piping in any one installation within the Company. The solvent resistance is extremely poor. However, for a chloralkali plant or other facility handling inorganic chemicals, this material is truly an outstanding and most useful product.

Polyethylene piping and tubing has been used in many small installations within the Company, but in no major design. This is because of the poor strength of the material and the difficulty in obtaining an adequate, durable fitting. Again, the use of the material is restricted to an essentially aqueous system. As you possibly know, the laboratories in Building 770 of the Technical Center have polyethylene drain lines, PVC distilled-water lines, and polyester ductwork for the fume hoods in many of the rooms.

One area where we are going to use significant quantities of high-density polyethylene is in shipping containers. After a three-year program of evaluating available plastic shipping containers in the small sizes, we made recommendations for a complete conversion of our oblong tin can to polyethylene jugs in 1962. Unfortunately, difficulty developed with the cap used on the jug, but after some delay, we are now ready to make the complete conversion to plastic containers in all sizes from 4-ounce through 1-gallon in size. In the 5- and 55-gallon container category, we have used a polyethylene drum insert since its introduction on the market in 1959. A good quantity of these are still used today. Meanwhile, we have been cooperating with the Plastics Company in developing the use of small containers (4-ounce to 55-gallon) made from polyethylene, particularly a high-density drum insert as an improvement over the older, slush-molded, porous, low-density material.

We have attempted to specify large bag inserts inside steel or other tanks to contain liquid systems or powdered resins. Again, however, since we cannot use the vinyl materials exposed to our solvents, it was necessary to restrict the appraisal to the use of polyethylene, and we have been unable to see the practicality of this type of construction.

The use of asbestos-reinforced phenolic materials dates back to the thirties. We have used a considerable amount of Haveg piping in the Ethanol Acid Unit and various other small pieces of equipment constructed from this material in other acid exposures over the years. Also, the Marietta Plastics Company Plant used a significant amount of this material for the Raschig Phenol Process. More recently, we installed a number of solid-phenolic sieve trays in the hydrogen cyanide stripping still at the Institute Plant. We have been unable to find a metal at a reasonable cost to resist this particular environment.

We aided Johns-Manville in the marketing of their new Chemtite phenolic and epoxy piping by the laboratory evaluation of the product and the installation of experimental sections in a wide variety of environments. Our data were most helpful to them in marketing the product and provided us with significant information on the use of this type of material. Meanwhile, the Nuclear Company was attempting to exploit their asbestos acquisitions in California by making this into some form of usable piping material. We have cooperated with this Division of the Corporation in evaluating various asbestos-reinforced phenolic formulations. Their final product, termed F-100, appears to be the equivalent of the Johns-Manville Chemtite piping, and we look forward to using a significant amount of this material in the future.

A number of installations employing solid plastic construction are listed in the Appendix.

Lined Steel. One method of utilizing plastic materials of construction in a safe manner when flammable materials are present is by lining the interior of steel with the plastic. We have used Saran-lined pipe in the Chlorohydrin Units since the early forties, and as other types of integrally lined pipe have been offered, these have been evaluated and placed in service where applicable. One of the finest products of this type available today is Teflon-lined pipe of the Resistoflex Corporation. We have not experienced a failure in this material in a wide variety of extremely aggressive environments up to 250°C. The material is expensive and not too versatile in field design work, but when purchased and installed one can be sure the installation is permanent. We have attempted to make thin polyethylene inserts in steel piping. The results have been unsatisfactory. PVC-lined piping is of no great interest to us, as discussed above. However, in 1958 a wooden condensate cooling tower at the Texas City Plant was lined with PVC to contain demineralized water for the Vinylite process. This plastic construction and the associated piping are still in service.

Hundreds of feet of Penton (chlorinated polyether) lined pipe have been used at the Texas City and Whiting Plants in the weak-acid isopropanol process. This is used where lead-lined steel was previously installed with troublesome results.

Future Work. We believe an aggressive program of evaluating and utilizing plastic materials of construction has been in effect in the Chemicals Company. We propose to continue this program in the future with particular attention to the following:

(1) Continued appraisals of coatings and plastics for possible use in process equipment. Modifications of testing techniques and the extrapolation of the data to field use will be employed as indicated by a comparison of the laboratory data with field experience.

(2) Continued activity in technical organizations having strong interest in the use of these types of materials. Information gained regarding successful and unsuccessful applications of plastic materials can be applied to our own plant problems.

(3) Continued application of economic comparisons between plastic and alloy construction for proposed installations. Mr. C. P. Dillon of this Group has provided, to personnel who specify materials of construction, the most rapid and usable method of comparing economic alternatives in materials selection. Using this method, it is very easy to make sensible appraisals of alternate materials.

(4) Continued effort to educate operating personnel in the use of these materials, both to make their use more successful and to overcome the initial resistance to the use of such products.

(5) Continued creep testing of those plastics of greatest interest. Only this property of the plastic, when exposed to a given environment, has application to design work. With this information, we should be able to prepare better specifications for future purchases.

(6) Continued search for the proper utilization of furane plastic construction. The furanes offer the optimum chemical resistance for our exposures but have certain qualities which are difficult to reconcile with reinforced plastic construction. Attempts are being made in the industry to correct these deficiencies and this work must be followed closely.

(7) Continued testing of the vinylidene fluoride materials. This plastic has shown truly excellent resistance to our type of exposures. Preliminary screening tests have been conducted and this must be followed by an appraisal of techniques of applying the material to steel or in its use as an homogenous solid.

(8) Continued evaluation of the various polyethylene coatings. Ultimately, it is anticipated that this resin will be used in a coating applied in such a manner that it will be useful for a drum lining or storage tank application.

(9) The expanded use of polypropylene-lined steel pipe is indicated on the basis of initial cost of this product. The installed cost compared with other materials will be obtained to determine the area of use for this product.

LSVanDelinder

L. S. VanDelinder

Attachment

Appendix

APPENDIX

USE OF PLASTICS IN CHEMICAL PROCESS EQUIPMENT

Thin film coatings (6 mils)

Innumerable applications. No listing.

Heavy coatings (10 to 60 mils)

Numerous applications. No complete listing.

Reinforced coatings (1/16" to 3/16")

Plant 526, Butane Oxidation Unit. Two 214,000-gallon steel tanks were lined with reinforced Atlac polyester in original construction (1960) to contain crude product from the reaction area. Six other tanks of approximately 1000-gallon capacity similarly coated.

Plant 515. The first application of glass-reinforced coating systems was made in the Texas City Plant. The Matcote Company applied an epoxy (ERL 2795) on a column section in March, 1960. Since that time the following equipment has been lined with reinforced epoxy or polyester at that Plant.

(1) Building 57: 6'-Diameter x 20'-long column section (epoxy), 1960.

(2) Building 9: Four Catexer (ion exchange bed tanks) 7'-diameter x 16'-long with epoxy, 1960-1961.

(3) Tanks 9207 and 9111 for crude Oxo product with epoxy, 1960.

(4) Six acid-cleaning buggy tanks with epoxy, 1960.

(5) Tanks 9010, 9103, 9105, 9109, and 9111 for crude Oxo products. These 48'-vessels, coated with polyester on bottom and partially on sides to combat water-layer corrosion in bottom (1960-1961).

(6) Building 75: Sodium sulfite solution tank coated with epoxy, 1960.

(7) Buildings 7 and 158: Concrete pits for condensate storage coated with epoxy, 1960-1961.

(8) Building 119: Twelve autoclave jackets coated over entire exterior with epoxy, 1961.

(9) Building 79: Crude Oxo product receiver coated with epoxy, 1961.

(10) Building 54: Ten-foot section of a caustic scrubber column coated with polyester, 1961.

(11) Building 112: No. 3 Dichloride reactor base (15') coated with polyester, 1961.

(12) Building 9A: Eighteen troughs on six water filters coated with epoxy, 1961.

(13) Four large aluminum and steel tanks coated with epoxy on exterior of bottom and sides to stop leaks.

(14) Building 11: All of bottom and part of sides of a 60'-diameter water tank for return condensate storage coated with epoxy, 1960.

(15) Building 79: Double compartment tank for crude Oxo product storage fully coated with polyester, 1962.

(16) During 1962 one additional water filter and seven more storage vessels (average 2000-gallon capacity) coated with reinforced epoxy or polyester.

Plant 510: Three tanks coated with reinforced resins. Two tanks (approx. 4000-gallon size) coated with polyester to resist hydrochloric acid in process solution. One tank (approx. 15,000-gallon) coated with epoxy for condensate storage.

Plant 512, Acrylic Acid Unit: 3/16"-Reinforced polyester on steel applied July, 1961 on 10,000-gallon tank for acrylic acid service. Inspected January, 1963. Few soft areas but in good condition in general.

Plant 512, Utilities: Coal shutes at Powerhouse with 3/16" reinforced polyester by General Fire and Rustproofing, April, 1962. Failure.

Plant 512, Acrylic Esters Unit: 3/16"-Reinforced polyester on old lead-lined tank to salvage tank and use in $(NH_4)_2SO_4$-H_2SO_4 storage, February, 1963.

Plant 514, Vinyon N Unit: Dynel bag house (previously coated) - 3/16" (requested) Atlac 382, May, 1962, by Porter Paint. Failed in six months - no reinforcement in resin. Resin varied greatly in thickness. To reapply by hand, probably using an epoxy.

Plant 514, Waste Treatment Unit: Clarifiers and aero-accelators (4) lined with Coroline (epoxy). All steel internals coated with 1/32" Phenoline 302 (phenolic). Polyethylene piping used for sample lines, drain lines, etc. All effluent piping from Plant 514 coated with Phenoline 302. Island sump entirely coated with Phenoline 300 in 1954 (excellent condition in 1962).

Plant 526, Butane Oxidation Unit: Some of distillation columns (copper) in recovery area have been patched so many times with reinforced polyester to stop leaks that the columns now look more like reinforced-plastic structures.

Plant 513, Ethylene Oxide Unit: Base of water scrubber being lined with reinforced polyester in place of lining with stainless steel.

Reinforced solids

Plants 510 and 515: Approximately 200 feet of Fibercast glass-reinforced epoxy piping installed for condensate water transfer at both Plants. Installation date unknown.

Plant 512, Waste Treatment Unit: Approximately 7000 feet of glass-reinforced polyester pipe ranging in size from 6 to 30 inches installed to convey waste streams from the plant (1962).

Plant 514, Sorbic Acid Unit: Five glass-reinforced Atlac polyester tanks will be purchased for installation in this Unit to handle process streams.

Technical Center, Building 770: A number of hood ducts were constructed of polyester reinforced plastic in original construction to combat attack by mineral acid condensation. These run from individual rooms to roof of building.

Plant 512, Phthalic Anhydride Unit: Polyester (red color) scrubber installed in original equipment of the Phthalic Anhydride Unit. Scrubs last bit of phthalic from blow-off air (1962).

Maintenance: Polyester channels over pipe rack supports installed September 13, 1961, as a test.

Plant 512, Styrene I: Fibercast 90° ell installed November, 1960 in the ethylation product line handling benzene, ethylbenzene $AlCl_3$, HCl at 50-60°C. Removed after definite softening of the epoxy resin. Flange cracked during reinstallation. A test section of Chemtite Type PW pipe was then provided for this line.

Plant 512, Styrene II: A Haveg 7710 reinforced (Atlac 382 polyester) water scrubber, 12"-diameter x 12'-high, was installed May, 1961 to remove HCl from the unit vent gases. The scrubber operates at ambient temperatures and pressures. Fibercast pipe was used in the installation - approximately 30 feet of 4" pipe for the gas streams and 60 feet of 2" for the water streams. The scrubber cost approximately $500 compared to $6000 - $8000 for the equivalent item fabricated from a HASTELLOY alloy.

Plant 514, Fine Chemicals: Installed a reinforced polyester scrubber on the Ethyl Silicate Unit blow-off system (HCl, ethanol, H_2O) about 1957. Removed during renovation.

Plant 514, Fine Chemicals: Reinforced polyester laminate (green) barometric condenser installed on 5601 system (HCl and steam) in October, 1961.

Many Flexitallic gaskets used with Teflon filler at high temperatures or for extreme solvent exposures.

Plant 515: 500 Feet of 3", 4", and 6" Bondstrand filament-wound epoxy piping installed for demineralized water service in 1961.

<u>Homogenous solid</u>

Plant 526, Butane Oxidation Unit: Approximately 2000 feet of 4" Chemtite PW piping was installed in the initial construction as an acid-waste line from the Unit to the disposal area (1960).

Plant 514, Latex Unit:
Plant 514, Glyoxal 40% Unit: Over 5000 feet of 4" Chemtite PB piping is being installed on these two jobs in conjunction with the use of 11 glass-reinforced Atlac polyester tanks to contain process solutions and refined products. In addition, 4 filament-wound, glass-reinforced, epoxy tanks are installed in the Glyoxal Unit.

Plant 514, Gas Department: Piston rings made of phenolic resin varying from 37" to 43-1/2" are used in propane compressors. Last 4 to 5 years. Also used in Compressor Stations. Also, compressor valve plates of phenolic construction used (good for 6 years).

Plant 514, Vinylite A: Hard rubber and Saran tubing used at ambient temperature in chlorine and hypochlorite service for many years.

Plant 514, Butanol: One-inch PVC piping used to handle H_3PO_4 at ambient temperatures.

Plant 514, Acetaldehyde: Phenolic tube inserts are used in a copper-tubed heat exchanger carrying acetaldehyde and hydrogen at 90-120°C. Inserts used to prevent erosion of tube ends. Successful.

Plant 514, Limestone: Polyethylene piping (solid) used to convey waste lime and abrasives from Unit for 5 years without difficulties. Saran-lined piping used in chlorohydrin solutions (2% HCl) at 40°C; OK. Saran and Kel-F diaphragms used on valves in HCl and lime service. Satisfactory.

Technical Center, Building 770: All laboratory run-out drains made of solid polyethylene pipe and fittings in initial installation. All distilled water piping throughout building made of PVC.

Plant 512, HCN Unit: Installed 3" Chemtite EW piping (epoxy with Fibercast flanges) in HCN waste stream containing NaOH, NaOCl, ethanol, sulfates, etc. at 35°C on August 10, 1961.

Plant 512, Filament T: A test section of Chemtite Type PW (phenolic) has been in service on the acetonitrile wash baths since 1959 for handling a 4-5 per cent solution of acetonitrile in water at 30-60°C. This section is still performing satisfactorily.

Plant 512, HCN: Haveg 41 (phenolic) trays and supports in HCN stripping still, February, 1963.

Plant 514: Installed polyethylene water line on pipe-rack about 1956. Removed when expansion and contraction moved the line all over the rack.

Cliffside: Installed polyvinyl chloride (PVC) piping at Cliffside for water-treating facilities, about 1954. No problems.

Solid Teflon expansion joints are popular at all locations (particularly Fine Chemicals, UCPC, Marietta, and miscellaneous distillation departments). No trouble if molded bellows are used.

Literally miles of polyethylene instrument tubing is used in all of the plants.

PVC, solid polyethylene, or PE-coated conduit used extensively in all plants.

Plant 515, Vinylite Unit: Water cooling tower constructed of wood (10' x 10' x 15') lined with sheet PVC in 1958 to handle condensate for Vinylite process water. Still in good condition.

Plant 514, Vinylite: Glass-impregnated Teflon bearings used on Vinylite autoclaves (suspension), Building 176 in June, 1961. Partially successful.

Lined Steel

Plant 514, Chlorohydrin: Saran-lined pipe has been used for 15 years in seven different applications to carry chlorinated hydrocarbons and HCl at temperatures up to 50°C. Teflon bellows and plug valves used. Polyethylene tubing (sample lines) and sheeting (blank covers) used in similar streams.

Plant 517, Isopropanol Unit: All lead-lined steel piping replaced with Penton-lined steel in 1961. Penton-coated, lined or solid valves used in piping.

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