BULLETIN

MADISON CHEMICAL INDUSTRIES INC.

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Use Madison's Coatings to Solve Chemical Resistance Problems

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Madison Chemical Industries Inc.
"The World Leader For Infrastructural Coatings"™
490 McGeachie Drive Milton, Ontario, Canada L9T 3Y5
Phone (905) 878-8863 Fax (905) 878-1449
Email: sales@madisonchemical.com Web Site: www.madisonchemical.com

1. INTRODUCTION

Protective coatings or linings are unique specialty products which represent the most commonly used method of corrosion control. They are used to give long term protection under a broad range of corrosive conditions, extending from atmospheric exposure to full immersion in strongly corrosive chemical solutions. There are various protective coatings/linings available in the market, and each of these coatings/linings has a characteristic combination of capabilities and limitations. A careful analysis of the problem, therefore, is required in order to choose the coating/lining which would be the most effective and economical.

Since 1973 Madison Chemical has developed a variety of high solids, high performance polyurethane coatings. Madison technology has been used to coat or line over 350,000 underground and aboveground steel tanks registered and installed in North America. Continual product and market development has also seen Madison technology used for applications involving oil & gas piping, water and wastewater tank internals and municipal piping. There have been ***zero failures*** associated with Madison's coatings on these applications. An educated customer, however, is always regarded as Madison's most important product.

2. THE FUNCTION OF A CHEMICAL RESISTANT COATING/LINING

Chemical resistance is the ability of a coating/lining to resist breakdown of a structure by action of chemicals to which it is exposed. The protective coating/lining in itself provides little or no structural strength, yet it protects other materials so that the strength and integrity of the structure can be maintained. The function of the protective coating or lining is to separate two highly reactive materials; i.e., to prevent strongly corrosive industrial fumes, chemical liquid solutions, solids, or gases from contacting the reactive underlying substrate of the structure. The fact that coatings are usually a relatively thin film separating the two reactive materials indicates the vital importance of the coating. The concept is to attain a corrosion-free structure protected by the coating as a barrier.

In order to fulfill its function, according to this concept, a coating must be a completely continuous film. Any imperfection becomes a focal point for the attack of chemicals and the breakdown of the structure. Good adhesion to the substrate is also the key requirement for the chemical resistant coating/lining, particularly in long-term immersion service. It is thus expected that the chemical resistance of the coating/lining will basically depend on the following two factors:

a. the nature of the coating/lining;
b. the application of the coating/lining.

3. THE CHEMICAL RESISTANCE OF MADISON'S POLYURETHANE COATINGS

There are a variety of methods and standards available for determining the chemical resistance of coatings. Because chemical resistance is an important property of coatings, one would think that the measurement of chemical/corrosion resistance would be a well-developed science. Unfortunately, this is not the case. This is because the coatings, most of them being polymeric materials, interact with chemicals in many different ways. A common mechanism is absorption into the coating, which increases weight and volume (swelling). Another mechanism may be the leaching of a component in the coating. Seldom is a polymeric coating attacked only on its surface. Therefore, chemical testing of polymeric coatings has not been as codified as testing for metals, as the metals corrode primarily from their surfaces and their corrosion rates are usually fairly constant.

In evaluating chemical resistance, especially for immersion service, many coating manufacturers would: apply a coating to one or both sides of the carbon steel panels; conduct immersion of one-half to two-thirds of the total panel surface area in specified chemicals; and then visually examine the appearance of the coating surfaces. Quite often, the chemical resistance data provided by your coating manufacturer does not contain the following information: how thick the tested coating is; how good the surface preparation is; what types of failures are included; and finally what criteria they used to determine "pass" or "failure". Thus, words such as "excellent", "good", "fair", and "failure" actually have no meaning to you. One should, therefore, carefully identify and examine the test data from your coatings manufacturers.

Madison uses a revised testing method of ASTM D543 (Standard Test Method for Resistance of Plastics to Chemical Regents) for evaluating the chemical resistance of all Madison polyurethane coatings. Instead of coated steel panels, "free films" of the coating are used and totally immersed in specified chemicals. The recommended coating thickness for each individual product is used as the actual testing thickness of these free films, which normally are within the range of 20 mils. These arrangements provide the most severe corrosive conditions to get fast and accurate indications of the coatings long term chemical resistance performance. After immersion of the chemical, the percentage increase or decrease in weight, length, width, and thickness is calculated. The criterion we use to determine a "pass" or "failure" is 3%. The general appearance of the specimen after immersion is also evaluated. The criteria for "pass" are: no blistering, no cracking, no significant color change, and no significant softening.

To conduct the modified ASTM D543 test, at least 3 coating free films are weighed, size measured, and then immersed into a chemical solution for at least 7 days at ambient temperature. After the immersion time, they are dried, weighed again and combined with the evaluation of other properties (e.g. size change, general appearance, etc.). Coatings that have passed all the above-mentioned criteria are *recommended* for continuous immersion at ambient temperature. Coatings that have passed the criteria for general appearance but have failed in the percentage of dimensional or weight change are *limited resistance* (they are not recommended for continuous immersion but are suitable for situations involving spillage, splashing, fumes and intermittent exposure at ambient temperature). Coatings that have failed one or more of the appearance criteria are *not recommended* for any service involving the chemicals.

We believe these self-imposed criteria are the toughest in the industry. Often a competitive product will seem to have good chemical resistance in a certain area but be unsuitable for any exposure other than casual contact. If the coating manufacturer neglects to provide exact details of the test methodology and the pass-fail criteria being used, insist that they do so.

Results of actual long-term chemical immersion tests have been very consistent with those obtained with the modified ASTM D543 method. For example CorroCote II/CorroPipe II UltraLiner have shown almost zero percent of weight and size changes after over 1 year continuous immersion in a saturated sodium hydroxide solution, with no effects on their general appearance.

4. APPLYING MADISON'S POLYURETHANE COATINGS

Selecting a proper coating for your application is the first step toward your chemical resistance application. In order to fulfill this function, one should obtain the following information: (1) type of service (continuous immersion or spillage, splashing, intermittent exposure); (2) concentration of each ingredient in the chemical solution for your application; (3) pH value; (4) long-term service temperature and intermittent exposure temperature; (5) type of substrate you want to coat; (5) your surface preparation ability (e.g., the ability to sand-blast); (6), the type of coating application methods you want to use (brush, airless spray or plural component spray); and (7) the type of handling characteristics you want (e.g., cold temperature cure, one coat capability etc.)

As indicated in the above chemical resistance table, many of Madison's polyurethane coatings are recommended for continuous immersion service involving aggressive chemicals. Some are also suitable for splashing, spillage and incidental contact with extremely aggressive chemicals. For your particular application, at least one or two coatings may be suited. Examples are:

> CorroCote "S" and CorroPipe "S" are 72% solids coatings which can be applied by brush, roller or single component spray equipment. A trained applicator may be able to build 10 or more dry mils in a single coat. They are well suited for situations such as sewage treatment, oil water separators, and chemical plant maintenance.
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> CorroCote II PW and CorroPipe II PW are NSF approved, two-component, instant setting, solvent free, 100% solids coatings. Not only are these two

coatings very suitable for protecting potable water tanks/pipes from internal corrosion and abrasion, but also, offer excellent resistance to various chemicals.

Flexcel II coating is like a very tough layer of rubber fused to the surface of the structure. Flexcel II has remarkable impact and abrasion resistance and it also has a good resistance to certain chemicals.

CorroCote II Ultraliner and CorroPipe II Ultraliner are two-component rigid coatings, which have the best all-around chemical resistance among all of Madison's polyurethane coatings.

The proper application of polyurethane coatings play an important role in the chemical resistance of the system: Firstly, the structure to which the coating is to be applied must be designed in such a way that it can easily accept the coating and provide a proper base for it. There are many types of difficult-to-coat areas commonly involved in today's construction and structures. Sharp edges, corners, crevices, rough welds, etc., are normally the problem areas which should be eliminated. Secondly, contaminated substrates should be avoided because they usually prevent the coating from developing its full properties of adhesion and resistance. Thirdly, application of coatings must be done in the best possible manner with excellent surface preparation. Sand or metallic grit blast is normally a necessity for the surface preparation of a steel substrate before applying a coating on it. Near White Blast (NACE, NO.2 blast or SSPC-SP10 blast) with a minimum 2.5 mils (63 microns) profile is normally required for submersion service. In some cases involving immersion in very aggressive chemicals, a minimum 3.0 mils (75 microns) profile is necessary.

Finally, coatings should be properly applied onto the substrate so that a continuous and uniform film can be achieved. Particular attention should be paid to all these difficult-to-coat areas to ensure that they are properly protected.

Each of these factors involves considerable knowledge and experience on the part of the applicator. Careful selection of the applicator is critical.

5. SUMMARY

For chemical and related processors, unique concerns require a broad range of multi-purpose coatings to handle a wide range of acids, alkalines, salts and solvents. Madison's leading edge in polyurethane technology offers a full line of high performance, corrosion resistant coatings for your chemical resistance application.

CHEMICAL RESISTANCE CHART – 7 DAYS

Salt Solution	CC II	TX15	CC+	OMNI	CP PW	CC II PW	CLD	UL	CC-S	MG120	FLX
Aluminum Sulfate (28%)	R	R	R	R	R	R	R	LR	R	R	LR
Calcium Chloride (50%)	R	R	R	R	R	R	R	R	R	R	R
Ferrous Chloride (17.7%)	R	R	R	R	R	R	R	R	LR	R	LR
Potassium Chloride (35.95)	R	R	R	R	R	R	R	R	R	R	R
Sodium Chloride (26%)	R	R	R	R	R	R	R	R	R	R	R
Sodium Dichomate (10%)	R	R	R	R	R	R	R	R	R	R	LR
Sodium Sulphate (10%)	R	R	R	R	R	R	R	R	R	R	LR
Sodium Sulphate (25%)	R	R	R	R	R	R	R	R	R	R	LR
Solvent Solution	**CC II**	**TX15**	**CC+**	**OMNI**	**CP PW**	**CC II PW**	**CLD**	**UL**	**CC-S**	**MG120**	**FLX**
Aliphatic Naphtha	R	R	R	R	R	R	R	R	R	R	NR
Aliphatic Naphtha (Light)	R	R	R	R	R	R	R	R	R	R	R
Cyclosol 63	NR	NR	NR	R	R	R	R	R	LR	R	NR
Ethylene Glycol	R	R	R	R	R	R	R	R	R	R	R
Gasoline	N	NR	R	R	LR	R	R	R	NR	R	NR
Kerosene	R	R	R	R	R	R	R	R	LR	R	NR
2,2,4-Triethyl Pentane	R	R	LR	R	R	R	R	R	R	R	R
Triethylene Glycol	R	R	R	R	R	LR	LR	LR	NR	R	NR
Varsol	R	R	R	R	R	R	R	R	R	R	NR
Acid Solution	**CC II**	**TX15**	**CC+**	**OMNI**	**CP PW**	**CC II PW**	**CLD**	**UL**	**CC-S**	**MG120**	**FLX**
Boric Acid (6%)	R	R	R	R	R	R	R	LR	R	R	NR
Oleic Acid	R	R	R	R	R	R	R	R	R	R	NR
Sulphuric Acid (10%)	NR	NR	NR	NR	NR	NR	R	R	NR	NR	NR

Alkalis Solution	CC II	TX15	CC+	OMNI	CP II PW	CC II PW	CLD	UL	CC-S	MG120	FLX
Calcium Hydroxide (10%)	R	R	R	R	R	R	R	R	R	R	NR
Chromium Trioxide (10%)	R	R	NR	R	R	R	R	R	R	R	LR
Chromium Trioxide (25%)	R	R	NR	R	R	NR	NR	NR	R	R	LR
Hydrogen Peroxide (3%)	R	R	R	R	R	LR	LR	LR	NR	R	NR
Hydrogen Peroxide (30%)	R	NR	NR	NR	NR	NR	NR	NR	NR	R	NR
Potassium Hydroxide (10%)	R	R	R	R	R	R	R	LR	R	LR	LR
Potassium Acetate (20%)	R	R	R	R	R	R	R	R	NR	R	R
Sodium Hydroxide (30%)	R	R	R	R	R	R	R	R	R	R	LR
Sodium Hypochlorite (10.8%)	R	R	R	R	R	R	R	R	R	R	R
Other Solutions	**CC II**	**TX15**	**CC+**	**OMNI**	**CP II PW**	**CC II PW**	**CLD**	**UL**	**CC-S**	**MG120**	**FLX**
Anti-freeze	R	R	R	R	R	R	R	R	R	R	R
Corn Syrup	R	R	R	R	R	R	R	R	R	R	R
Diesel Fuel	R	R	R	R	R	R	R	R	R	R	LR
Distilled Water	R	R	R	R	R	R	R	R	LR	R	NR
Furnace Oil	R	R	R	R	R	R	R	R	R	R	R
Fuel oil #2	R	R	R	R	R	R	R	R	R	R	R
Molasses	R	R	R	R	R	R	R	R	LR	R	R
Tap water	R	R	R	R	R	R	R	LR	NR	R	NR
Jet Fuel A	R	R	R	R	R	R	R	R	R	R	R
Jet Fuel A1	R	R	R	R	R	R	R	R	R	R	LR
Avgas	R	R	R	R	R	R	R	R	R	R	R
LL 100 Avgas	R	R	R	R	R	R	R	R	R	R	NR

Code: R=Recommended (<3%); NR = Not Recommended(>5%); LR = Limited Resistance(>3%,<5%); NA = Not Available; CC II = CorroCote II Classic; TX15 = CorroPipe TX-15; CC+ = CorroCote Plus/CorroPipe Omni; CC-S = CorroCote/CorroPipe S; PW = CorroCote/CorroPipe PW; CLD = CorroClad 2000; UL = CorroCote/CorroPipe UltraLiner; FLX = Flexcel II/CorroPipe II High Abrasion* = Chemical resistance data for common epoxy amine cured coatings are taken from 1993 NACE Course 50: Protective Coatings and Linings

This chart is offered to our customers as an aid in using our product. The information is based on laboratory work with and does not necessarily indicate end product performance This chart is general in nature and is not intended to apply to a specific situation. The prospective user must determine the application of our product in an environment based upon individual characteristics. Madison Chemicals offers no guarantee or warranty as to the applicability of this chart for any particular situation as actual conditions of use are beyond our control.