FINISH COATS FOR THE NEW MILLENNIUM

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SUMMARY: Some interim data is reported on new developments in VOC compliant 2K NISO and Polysiloxane chemistries (1K and 2K). These new coatings are being developed for the heavy duty pre-construction market but with other markets such as the architectural extrusion market in mind. This research paper tabulates the hardness and air drying characteristics of these new coatings chemistries and details some mechanical property attributes.

Keywords: Polysiloxane, VOC, NISO

1. INTRODUCTION

Technology drivers for the ongoing development of coatings in the future will depend upon two predominant factors:

a) The ability of new technologies to satisfy more demanding consumer expectations w.r.t. coatings technology i.e. enhanced application tolerances, improved durability, more cost effective formulations and so on. (In these instances the consumer is defined as either the applicator or the ultimate customer of the manufactured goods).

b) The ability of coatings suppliers to produce formulations which will conform to stringent regulatory requirements e.g. E.P.A., HASNO, HASE, COSHH.

Clearly, one of the biggest challenges which all coatings manufacturers are faced with are the permissible levels of solvents which are allowable in all formulations under new VOC laws[1]. Some of the strategies which are being employed to deal with VOC limits are:

a) Incineration or other methods of solvent emission abatement.

b) Various new technologies which are inherently low in solvent e.g. waterborne, UV, powder, hot melt or high solids.

c) Use of novel application techniques e.g. super critical CO_2.

The heavy duty pre-construction market, for example, is demanding coating systems which are easily applied, rapidly overcoated, handled and transported. Extremely good corrosion performance aligned with long term aesthetic properties (gloss retention, colour shift) are necessary requirements for this market sector. In addition the health and safety aspects of these coatings cannot be overlooked[2] as health and safety legislation is placing real fiscal responsibility for employee safety, welfare and long term health directly in the hands of employers.

This paper will focus upon the ongoing developments and properties of NISO and Polysiloxane topcoat chemistries designed in the main for the heavy duty pre-construction market.

2. COATING REQUIREMENTS FOR THE PRECONSTRUCTION MARKET

2.1 Three Coat System, 2 pack epoxy zinc, epoxy MIO, NISO Topcoat

2.1.1 Overview

Two pack epoxy coatings (crosslinked with active amine hydrogen crosslinkers) can be formulated to afford:

- High crosslink density with excellent chemical resistance.
- Good abrasion resistance and adhesion attributes.
- Good long term corrosion performance.

As such, epoxy primers are the most widely utilised primer for the marine and protective coatings market sectors. However, epoxy coatings do have an inherent weakness in that they undergo photolytically initiated chemical degradation (chalking) when exposed to UV radiation. As such these coatings are not recommended for applications where aesthetic appearance is critical. Industry practice therefore dictates that when an epoxy zinc rich primer / epoxy MIO system is used then it must be overcoated with a 2 pack NISO or polyurethane coating.

The handleability and recoat window of these coatings, designed for this market, are well known and relies upon the applicator being able to apply the three coat system in one working day (even under adverse environmental conditions such as low temp (ca. 5^{o}C) and high relative humidity). The focus of this presentation is not on primer chemistries, however for completeness, table one details typical coating parameters of rapid recoat zinc rich epoxy and MIO epoxy coatings designed for the pre-construction market. This presentation will not deal with compliant fast cure 250 g/L epoxy primer formulations even though such systems are available and are used in Europe.

2.1.2 2K NISO Coatings

2K NISO topcoats have been used for the pre-construction market because:

1. Unlike 2K polyurethane systems no monomeric isocyanate respiratory sensitisers are present e.g. TDI, HDI, IPDI.
2. 2K NISO topcoats can be formulated to afford excellent lacquer dry properties with rapid development of hardness, mechanical and handleability properties.
3. 2K NISO topcoats (generally based upon acrylic componentry) can be formulated to afford excellent resistance to either thermal and / or photochemical polymer degradation.

Many research initiatives have focused upon developing high solids NISO coatings; some of the more common crosslinking chemistries which have been exploited are Michael addition chemistry, free radical initiated polymerisation, carbodiimide, aziridine plus a range of nucleophillic ring opening reactions involving epoxy and anhydride functionality. Polysiloxane chemistry is a relatively new NISO chemistry, however it has achieved widespread market acceptance (refer later).

In most cases, however these chemistries are based upon relatively solvent rich, high VOC formulations. Modification of these base formulations to achieve lower VOC limits can retard mechanical property development and handleability characteristics.

The overall properties of some new VOC compliant NISO chemistries which are under investigation by Ameron are detailed in Table Two. (VOC compliant topcoats for metal end use are defined under EPA legislation). Sward Rocker hardness development and BK recorder results are detailed in Figures One and Two. The most interesting feature of the Rocker / Dry time data presented in Figures One and Two is the similarity of the data for the 420 g/L (HIS) and the conventional NISO (540 g/L) coating. The conventional NISO coating is a proven workhorse in many markets and has outstanding lacquer dry, hardness and mechanical property development attributes. Our expectation is that the new 420 g/L coating will have superior exterior exposure performance cf. the conventional solids coating. Comparative exterior exposure data from severe UV exposure sites in New Zealand and Australia is being compiled for these coatings.

TABLE ONE

TYPICAL COATING PARAMETERS OF RAPID EPOXY RECOAT PRIMER / INTERMEDIATE

	TEST METHOD	ZINC RICH PRIMER	MIO INTERMEDIATE
VOC (mixed/thinned) g/L	ASTM D3960	90 – 340	320 - 370
Volume Solids	ASTM D2697	69 ± 3	70 ± 3
Max Recoat Window	In House	1 month	1 month
Recoat @ 5°C	In House	3 hours	3 hours
Resistance to Carbamation @ 5°C / >90% Relative Humidity	In House	Good	Good

TABLE TWO

COATING PARAMETERS OF VOC COMPLIANT COATINGS CF CONVENTIONAL NISO TOPCOATS*

Property	Test Method	Conventional Solids NISO	High Solids NISO (1)	High Solids NISO (2)
VOC (g/L)	ASTM D3960	540	420	420
Weight Solids	AS1580.30 1.1 - 1992	55	66	66
Volume Solids	ASTM D2697	39%	52%	52%
Pot Life	In House	8 hours	8 hours	8 hours
Gloss (60°)	AS1580 602.2	90 +	90 +	90 +
QUV Performance	B Lamp	Excellent	Not available	Excellent
Impact Resistance Reverse	ASTM D2794-93	10J pass	10J pass	10J pass

** Figures relate to a White topcoat at identical PVC's.*

Figure One

COMPARISON OF DRYING TIMES FOR SOME DEVELOPMENTAL COMPLIANT TOPCOATS

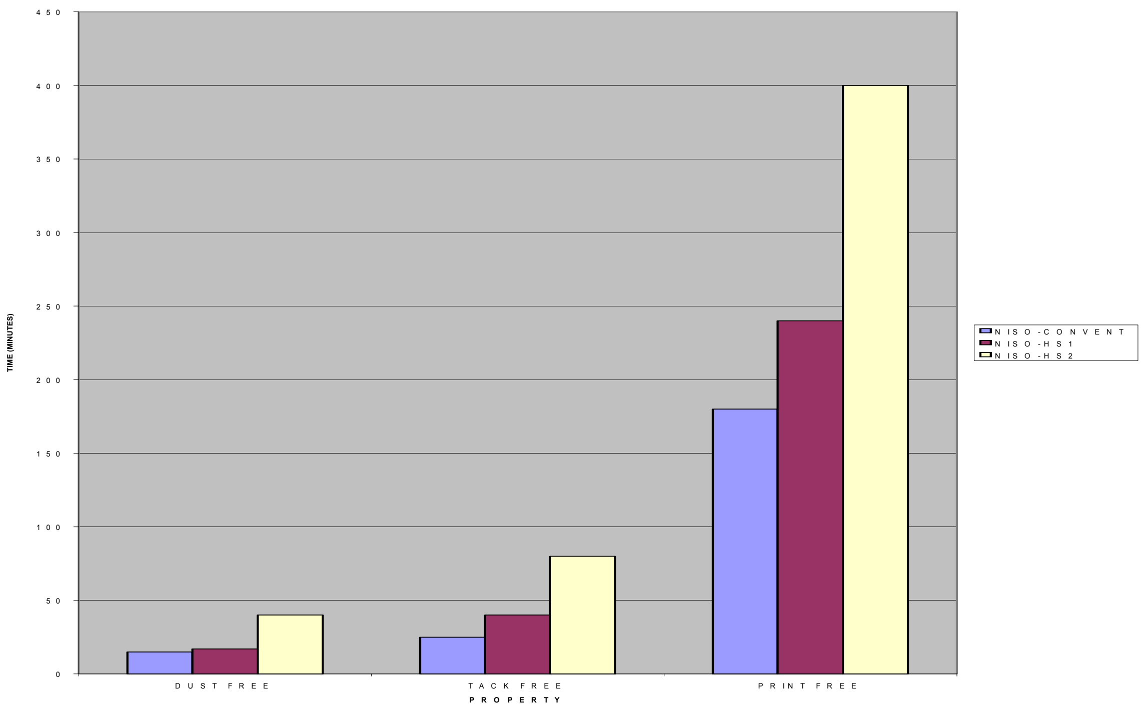

Figure Two

NISO SWARD HARDNESS DEVELOPMENT

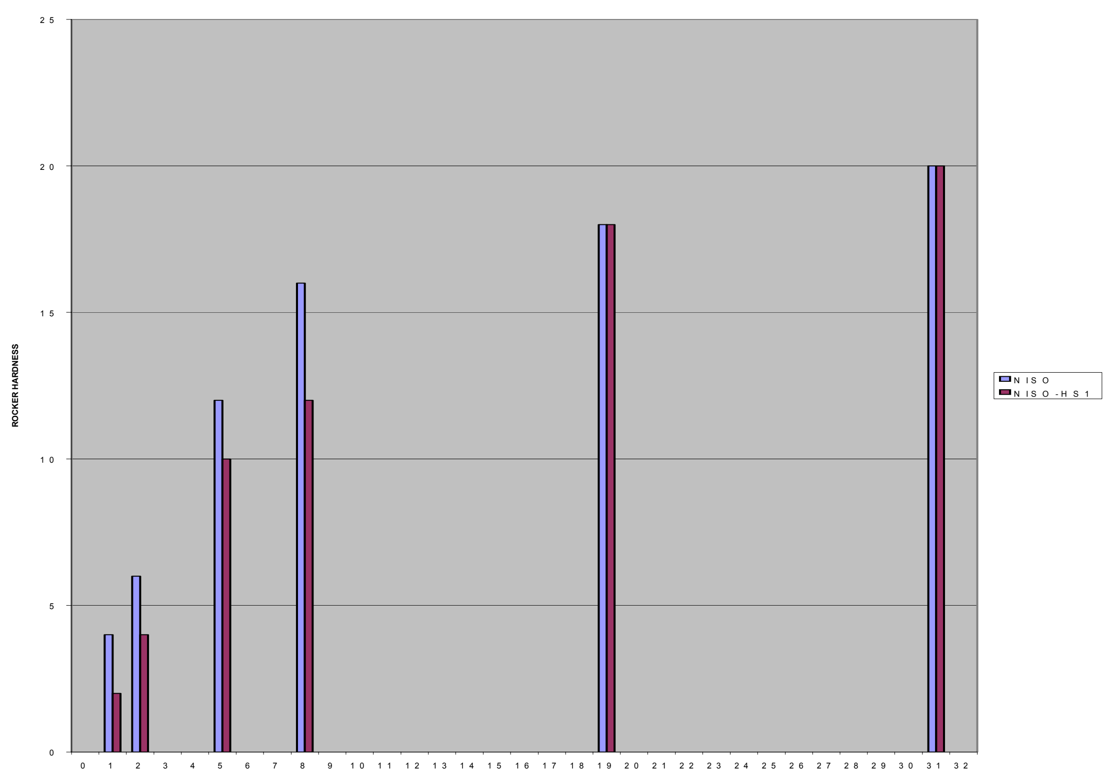

TABLE THREE

PERFORMANCE TEST RESULTS – PSX700

TEST	METHOD	TYPICAL RESULTS
Abrasion	ASTM D4060 - Abrasion resistance of organic coatings by Taber Abraser (one coat at 150µm DFT over carbon steel) Surface preparation, SSPC SP-10, near white metal blast	No more than 53 mgs average less after 1000 cycles CS-17 wheels and 1000g load
Adhesion	ASTM D4541 pull off. Strength of coatings using portable adhesion testers (one coat at 150µm DFT over carbon steel). Surface preparation SSPC-SP-10, near white metal blast.	No less than 2000 psi (Elcometer Adhesion).
Cleveland Humidity	ASTM D2257 – Testing water resistance of coatings in 100% relative humidity. (One coat at 150µm DFT over carbon steel). Surface preparation SSPC-SP-10 near white metal blast.	No blistering, cracking or delamination after 5500 hours of exposure.
Exterior Severe Weathering	South Florida marine exposure, 45^{o} facing east (one coat 150µm DFT). Surface preparation SSPC-SP-10 near white metal blast.	No blistering, cracking or delamination of film. 90% gloss retention after 18 months weathering.
Flame Spread	ASTM E84-84 – Standard method for test of surface burning characteristics of building materials. (One coat 375 - 500µm DFT over 11 gauge CRS). Surface preparation SSPC-SP-10 near white blast.	Flame spread 10 Smoke developed 16 NFPA Class A
Impact Resistance	ASTM D2794 – Resistance of organic coatings to effects of rapid reformation (impact). (One coat @ 150µm DFT over 11 gauge carbon steel). Surface preparation SSPC-SP-10 near white blast.	Direct 38 inch / lb Reverse 8 inch / lb
Pencil Hardness	ASTM D3363 – Film hardness by pencil test (one coat at 150µm DFT). Surface – clean, phosphated CRS.	H pencil
QUV Weathering	Accelerated ultraviolet cyclic weathering test (one coat 150µm DFT over CRS). Surface clean / dry.	Typically no blistering, cracking or delamination of film after 15 weeks exposure. 50% gloss retention after 15 weeks.
Salt Spray	ASTM B117 – Salt spray (fog) testing (one coat 150µm DFT over carbon steel). Surface preparation SSPC-SP-10 near white metal blast	No blistering, cracking, softening or delamination of film. No more than 1mm rust creep at scribe and no more than 1% rusting of edges after 5500 hours.

2.3 Polysiloxane Chemistry

2.3.1 Introduction

The chemistry and features of both single pack and 2 pack variants of patented Polysiloxane chemistry have been well documented in the scientific literature.[3-8] Some of the typical performance attributes of the inorganic / organic hybrid coating are described in Table Three. A general description of the chemistry is detailed in Scheme One. The high volume solids and low VOC of these coatings makes them attractive to specifiers who require long term corrosion performance without the need for continual maintenance.

Indeed the combination of coating attributes such as corrosion performance, adhesion, weatherabiliity, gloss retention and abrasion resistance coupled with its superb heat resistance have opened up many market sectors to this unique chemistry. For example the refurbishment and coating of navy vessels, railway coaches, hopper cars, offshore structures and bridges have all been success stories for Polysiloxane chemistry. The purpose of this section was to briefly recap the typical properties of this chemistry prior to discussing newer areas of Polysiloxane development.

2.3.2 New Areas of Development within Polysiloxane Chemistry

Research initiatives in our Australasian Technical Centre are aimed towards moulding Polysiloxane chemistry to new end uses including the architectural and commercial industrial market sectors. The architectural aluminium extrusion sector, for example, utilises some very demanding specifications like AAMA 605.2 and AAMA 2605-98 to filter out coatings which only have premium durability and corrosion performance with excellent mechanical properties. With these objectives in mind new Polysiloxane chemistry is being investigated. Our primary objectives have been to accelerate the cure chemistry whilst still maintaining the performance attributes of 2K Polysiloxanes as detailed in Table Three.

Comparative data for some developmental single and two pack Polysiloxane formulations can be found in Figures Three and Four and Table Four. The developmental Polysiloxane data tabulated in both Figures Three and Four clearly shows that the attributes of handleability, cure and mechanical properties can be accelerated via the use of newly defined Polysiloxane formulation coating principles. VOC's and volume solids have not changed considerably. However, in the cases of formulations P/Silox-4 and P/Silox-5 be mixed coating potlives have decreased dramatically. This may or may not be an issue for the applicator as plural components spray equipment is now a readily accessible technology.

SCHEME ONE

PSX700 TECHNOLOGY BASED ON POLYSILOXANE TECHNOLOGY

Two distinct stages:

Stage One:

Chemical hybridisation of alkoxy functional silane with epoxy functionality.

Stage Two:

Hydrolytic polycondensation with formation of a Polysiloxane Inorganic Matrix.

Figure Three

COMPARISON OF B.K DRYING TIME FOR SOME DEVELOPMENTAL POLYSILOXANES

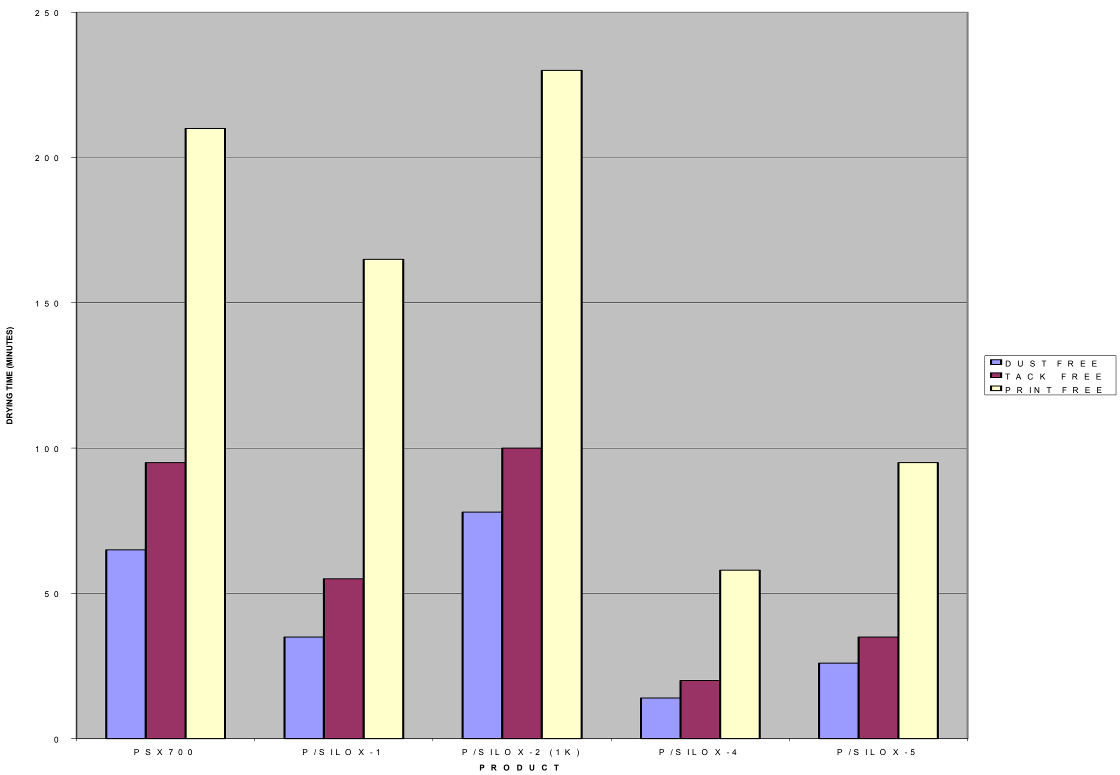

Figure Four

DEVELOPMENTAL POLYSILOXANES – SWARD ROCKER HARDNESS DEVELOPMENT

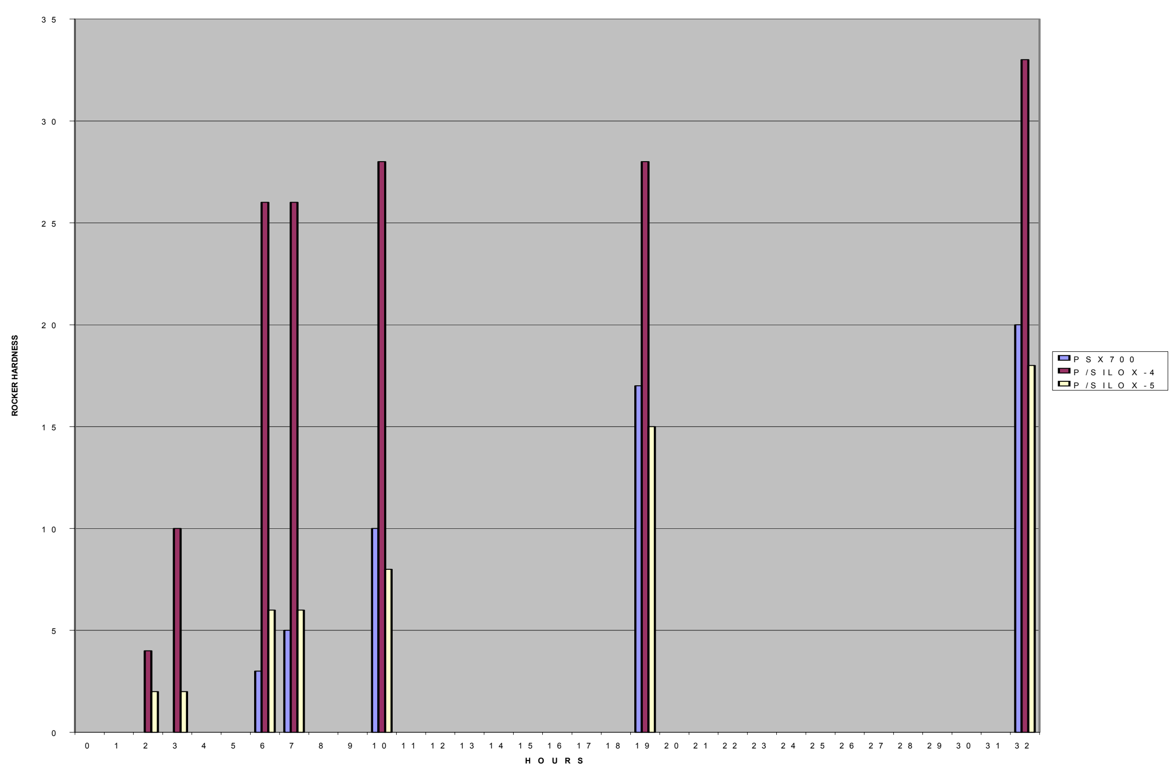

TABLE FOUR +

1K / 2K DEVELOPMENTAL POLYSILOXANE COATING ATTRIBUTES

Property	Test Method	PSX700	P/Silox-1	P/Silox-2 (1K)	P/Silox-4	P/Silox-5
Potlife (workable)	In House	4-8 hours	4-8 hours	> 24 hours	Plural component required	2 Hours
Impact Resistance: Direct Reverse	ASTM D2794	 5J 2J	 5J 2J	 5J 2J	 5J 2J	 5J 2J
Adhesion (Crosshatch)	In House	100%	100%	100%	100%	100%
Volume Solids	ASTM D2697	90 ± 3	90 ± 3	85 ± 3	90 ± 3	90 ± 3

+ VOC content for all formulations is approximately 115 g/L, all formulation details refer to a white, high gloss formulation at the same PVC. All properties evaluated SSPC-SP-10 near white blast steel substrate @ 120µm DFT.

3. SUMMARY

Research efforts are being directed towards developing new topcoat coatings chemistries for the pre-construction market, architectural and industrial markets in the areas of 2K NISO and Polysiloxane chemistries (1K and 2K). A key area of research has been to attempt to formulate compliant coatings with improved drying characteristics. Our initial results, as presented in this paper, have shown that it is possible to develop both Polysiloxane and 2K NISO (compliant) coatings to improve this critical attribute. Sward Hardness and BK recorder results demonstrate that the cure speed of Polysiloxane chemistry can be modified to achieve a more rapid cure. This feature is without doubt a critical coating attribute for many market sectors. Accelerated and natural weathering of these coatings is now underway to determine the longer term performance attributes of these coatings. VOC and H & S concerns coupled with enhanced consumer expectations for greater product performance will be key technology drivers for the future. This paper has briefly touched upon some of Ameron's research initiatives to develop new topcoat coating chemistries for the new millennium. These exciting new chemistries will be further reported upon as new data becomes available from our research laboratories which are centred in the USA, Holland and New Zealand.

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