DEVELOPMENTS IN SPRAY APPLIED COATINGS FOR THE PROTECTION OF PROCESS VESSELS

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Protective Coatings

- Performance of Hand Applied Protective Coatings is well documented

- Used for the internal lining of process vessels Subject to erosion and corrosion from aggressive fluids.

HOWEVER -

- Internal linings are limited by their immersion temperature resistance

Alternative to Protective Coatings

Materials of Construction

- Stainless Steel
- Exotic Alloys
- Overlaid Carbon Steel
- Fusion Bonded alloys

Limitations

- Must be applied at Construction phase
- Can be expensive for marginal projects
- Difficult to maintain / repair on-site
- Can suffer galvanic effects

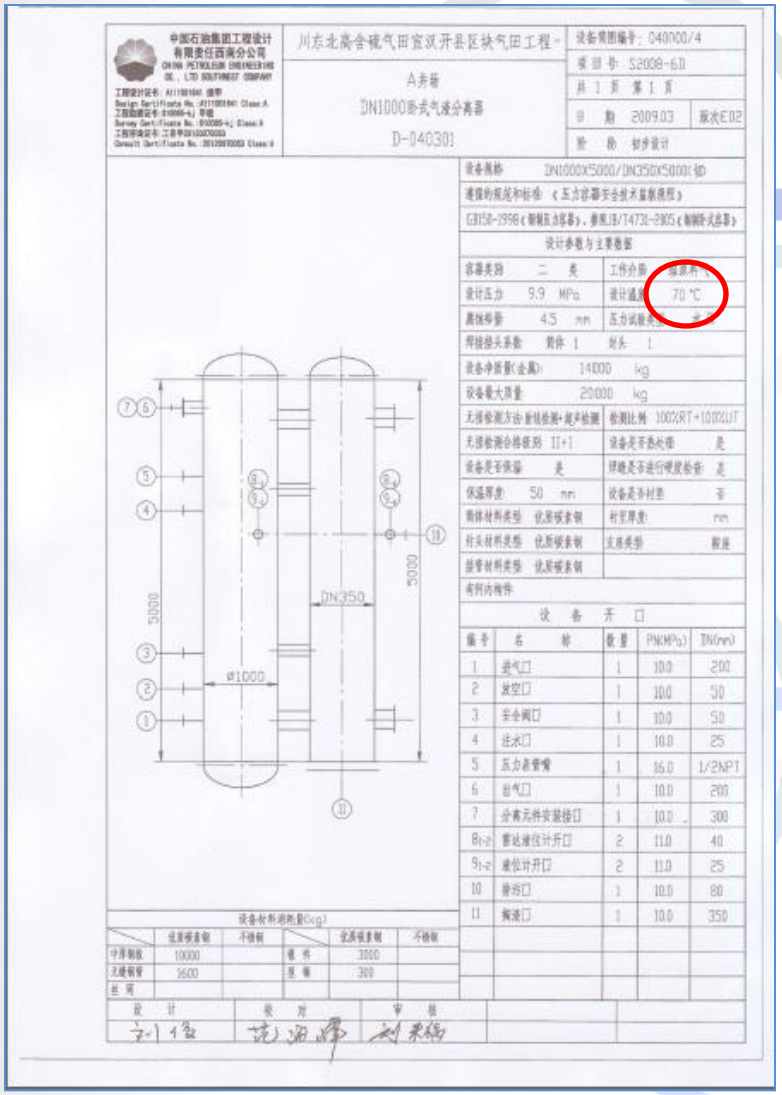
Protective Coating Selection Considerations

Equipment Operating Conditions

- Operating and design temperatures
- Operating and design pressures
- Process Fluids
- Solids entrainment

Shutdown / Maintenance Conditions

- Steam out conditions
- Chemical Cleaning
- Mechanical cleaning
- Hot work restrictions
- Turn-around times



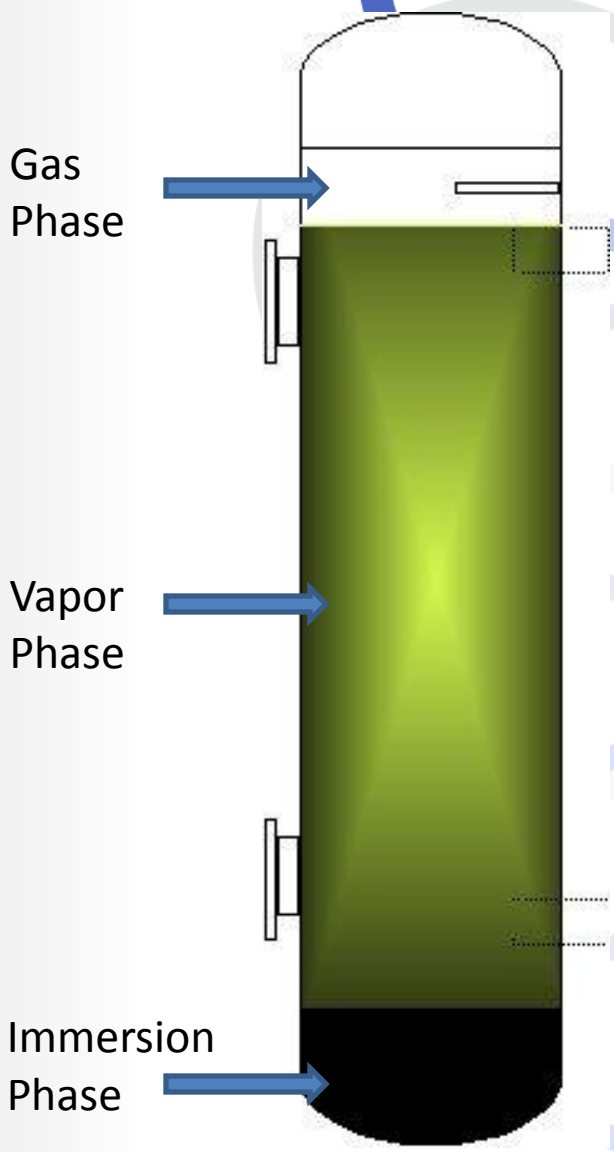
Protective Coating Selection Considerations

Ensure Coating is Suitable for Operating Conditions

- Analyze equipment operating modes
- Select coating based on most aggressive operating condition :

  - Dry Heat (Gas Phase)
  - Wet Heat (Vapor Phase)
  - ✓ - Immersion (Immersion Phase)

- Check Coating Manufacturers Data to ensure correct coating selection

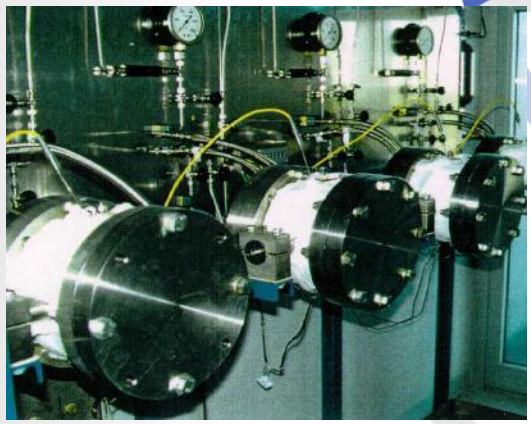


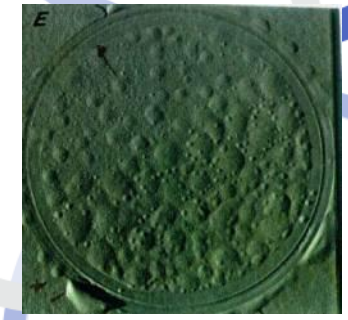
Protective Coating Selection Considerations

Consider Other operating Factors

- Operating and Design Pressure

  - Pressure vessels can be subject to sudden depressurization resulting in coating failure.





- Decontamination procedures

  - Steam out at elevated temperature
  - Chemical cleaning

Protective Coating Selection Considerations

Consider Other operating Factors

- Erosion from Entrained Solids

  - Process vessels can have entrained solids present either by design or changes to original operating parameters.

- Attack from Chemicals

  - Process vessels may in may situations require or produce chemical reactions that can cause deterioration in protective coatings e.g. :

    - Corrosion Inhibitors
    - Amine Solutions (MEA / MDEA …)
    - High levels of CO_2 / H_2S

Protective Coating Selection Considerations

Consider all factors before making your coating selection OR discounting the use of a Coating Solution

- Operating and Design Temperatures
- Operating and Design Pressures
- Vessel Operating Phases
- Shutdown conditions
- Erosion from entrained solids
- Chemical attack
- Application characteristics
- “ Repairability “
- Cost effectiveness

Hand Applied Protective Coatings

Phase 1 - Completed in 1994 utilizing modified Phenol Epoxy Novolac technology to design a product to withstand immersion temperatures in aqueous / hydrocarbon fluids up to 120 C.

Coating Properties :

Type	: Two Component binary reacting Modified Epoxy Novalac System containing abrasive fillers to enhance abrasion and erosion resistance.
Immersion Temperature Resistance	: 120 C
Steam-Out Temperature Resistance	: 210C
Explosive Decompression Resistance	: 100 bar (limit of testing to date)

Hand Applied Protective Coatings

Phase 2 - Further developments using enhanced resins and chemically bonded fillers to increase immersion temperature resistance up to 180 C.
In-house and Independent testing was completed to confirm performance

Coating Properties :

Type (1591) : Two Component binary reacting silicone Modified Epoxy Novalac System containing abrasive fillers to enhance abrasion and erosion resistance.

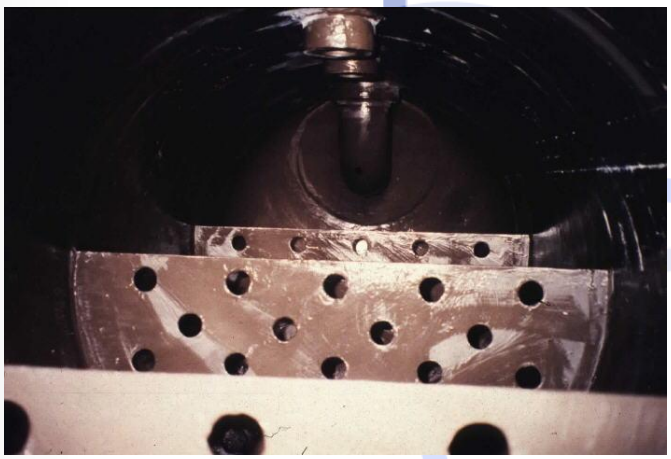
Immersion Temperature Resistance : 180 C

Steam-Out Temperature Resistance : 210C +

Explosive Decompression Resistance : 80 bar (limit of testing to date)

Hand Applied Coatings – Application Histories

Equipment	- Existing Oil and Gas Test Separators
Material of Construction	- Carbon Steel
Location	- Global Locations
Service Conditions	- Variable depending on well conditions between 80 and 155 C and pressures up to 100 bar.
Coating System	- 1591
Application Date	- 1997 to date
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 800microns

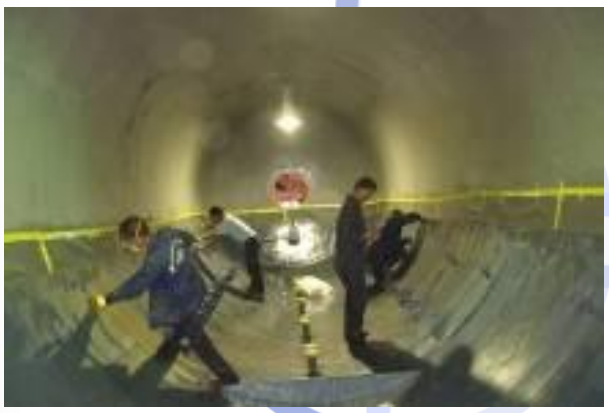


Hand Applied Coatings – Application Histories

Equipment	- Process vessels for new Major Offshore Platform
Location	- Singapore
Material of Construction	- Carbon Steel
Service Conditions	- Variable depending on well conditions between 60 and 110 C and pressures up to 75 bar.
Coating System	- 1391
Application Date	- 2004
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 1000microns

Hand Applied Coatings – Application Histories

Equipment	- Mercury Extraction vessels for New Major Offshore installation
Location	- Malaysia
Material of Construction	- Carbon Steel
Service Conditions	- Variable depending on well conditions between 60 and 105 C and pressures up to 40 bar.
Coating System	- 1391
Application Date	- 2006
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 1000microns



Hand Applied Coatings – Application Histories

Equipment	- Distilled water production unit in Refinery
Location	- Thailand
Material of Construction	- Stainless Steel
Service Conditions	- Operating condition of 97C
Coating System	- 1391
Application Date	- 1999
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 1000microns

Hand Applied Coatings – Application Histories

Equipment	- Sour Water Stripper in Refinery
Location	- Australia
Material of Construction	- Carbon steel
Service Conditions	- Operating condition of 70 – 105C
Coating System	- 1391
Application Date	- 2004
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 1000microns

Hand Applied Coatings – Summary

- Temperature range up to 180C immersion resistance
- Pressure let-down resistance up to 100Bar
- Excellent erosion resistance
- Good application characteristics
- Solvent free
- Excellent resistance to hydrocarbons , amines and aqueous solutions
- Short cure times / fast return to service
- Repairable on-site
- Proven track record
- Available globally

Spray Applied Coatings Development

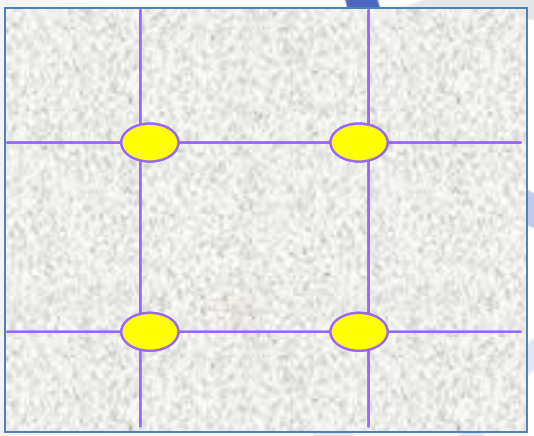
Sprayable Coating Design Considerations

- To be based on proven hand applied coating resin and filler technology
- Use minimum level of resin modifier to achieve spray viscosity
- Optimize the filler blend and filler level to minimize effect on viscosity
- Remove coarse silicon carbide filler which would cause severe wear on the spray equipment
- Target immersion temperature resistance at minimum 120°C (248°F)

Spray Applied Coatings Development

Functionality and Cross Linked Density

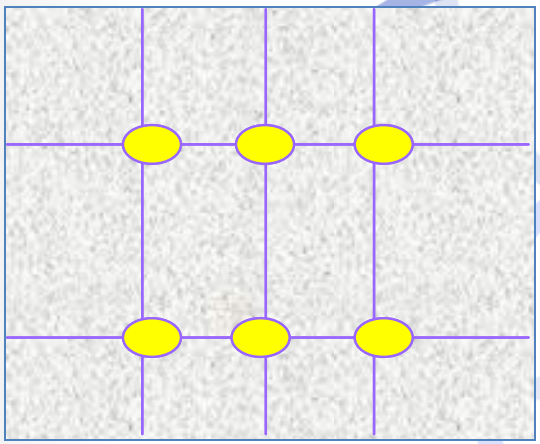
Cross link density is the number of reactive chemical sites within a given volume of Polymer material and the higher the cross linked density , the higher the polymer becomes to permeation.



Conventional

Higher Cross linked density results in :

- Increased glass transition/heat distortion temperature
- Higher resistance to water & gas permeation
- Higher resistance to explosive decompression



Modified

Spray Applied Coatings Development

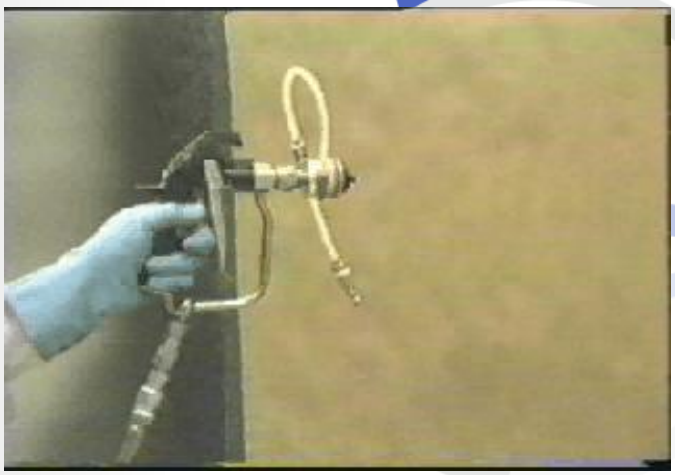
The development therefore of the sprayable high temperature resistant coating systems has revolved around increasing the number of reactive sites within the matrix using known polymer technology based on the hand applied systems BUT reducing the viscosity of the resins systems to enable them to be sprayed.

Spray Applied Coatings Development

Sprayable Coating Testing Program

Sprayability :

The products were designed to be applied using either SINGLE component heated airless spray OR DUAL component heated airless spray



Immersion Temperature Resistance :

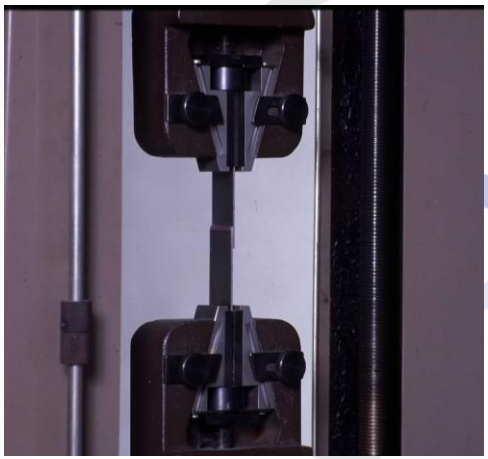
The products were designed to perform in immersion temperatures up to 150C in pressurized service – Hydrocarbon and Water mixtures

Spray Applied Coatings Development

Sprayable Coating Testing Program

Adhesion :

High levels of adhesion are required to resist the effects of osmosis a well as the forces exerted on the coating during decompression cycling.



Chemical Resistance at Elevated Temperatures :

The ability of the coatings to resist attack from the service liquids is important to ensure long term performance

Spray Applied Coatings Development

Summary

- Range of Coating systems available
- Sprayable using single or dual component heated airless spray
- Solvent free systems
- Immersion temperature resistance up to 150C and down to - 40C
- Resistant to explosive decompression
- Resistant to process fluids and well chemicals
- Suitable for sour gas service (H2S / CO2)

Independent Testing to Support Coating Performance

Solvent-free Ceramic filled Epoxy Phenol Novolac

Statoil	1 month	85˚C	1160psi
(Stabilised crude/produced water/methane/1% carbon dioxide)			
ELF	1200 hours	80˚C	435psi
(Water and Gas Mixture)			
Charter Coatings	1 month	98˚C	1305psi
(Gas condensate/methane/4% carbon dioxide/3% hydrogen sulphide)			
Advantica	300 hours	85˚C	435psi
(Stabilised crude/water/carbon dioxide)			

Independent Testing to Support Coating Performance

Intermolecularly bonded Epoxy Phenol Novolac Composite Coatings

NNC	6 months	130°C	435psi

(Stabilised crude/produced water /methane / 2% carbon dioxide 50ppm Hydrogen Sulphide)

SACMET	600 hours	160°C	145psi

(Water/steam cycling)

Advantica	300 hours	85°C	435psi

(Stabilised crude/water/carbon dioxide)

Spraying Capabilities and Specification

Typical Spray Set - Up

- Minimum 56:1 ratio pump
- Heated circulating water for spray lines at 60 - 70C
- Spray tip size 423-527
- Tip pressure 4300 psi
- Tip temperature approx 50C

Single Component Heated Airless Spray

Dual Component Heated Airless Spray

Spray Applied Coatings – Application Histories

Equipment	- New Construction Offshore Process Vessels
Location	- Middle East
Material of Construction	- Carbon Steel
Service Conditions	- 80 to 110 C and pressures up to 60 bar.
Coating System	- 1521
Application Date	- 2007
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 850 microns.

Spray Applied Coatings – Application Histories

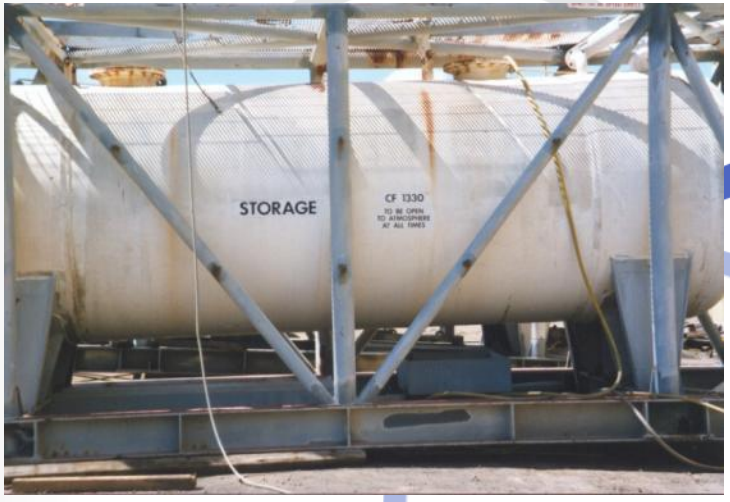
Equipment	- New Construction Offshore Process Vessels
Location	- Middle East
Material of Construction	- Carbon Steel
Service Conditions	- 95 to 115 C and pressures up to 55 bar.
Coating System	- 5891/1391S
Application Date	- 2008
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 850 microns in 2 coats

Spray Applied Coatings – Application Histories

Equipment	- New Construction Offshore Process Vessels
Location	- Indonesia
Material of Construction	- Carbon Steel
Service Conditions	- 60 to 95 C and pressures up to 25 bar.
Coating System	- 1521
Application Date	- 2008
Specification	- Grit blasting to SA 2.5 with a surface profile of 75 microns followed by the application of the coating at a thickness of 750 microns.

Spray Applied Coatings – Application Histories

Equipment	- Portable Methanol Storage Tanks
Location	- Australia
Material of Construction	- Carbon Steel
Service Conditions	- Ambient Temperature (50C +)
Coating System	- 5891
Application Date	- 2004
Specification	- Grit blasting to SA 2.5 with a 75 micron profile after which coating was applied at a thickness of 600 microns



Spray Applied Coatings – Application Histories

Equipment	- Effluent Treatment Tank / Dearator
Location	- China
Material of Construction	- Carbon Steel / Concrete
Service Conditions	- Ambient Temperature 15 – 50C
Coating System	- 5811
Application Date	- 2005
Specification	- Grit blasting after which coating was applied at a thickness of 600 microns

Spray Applied Coatings – Application Histories

Equipment	- Chemical Treatment Tank
Location	- Thailand
Material of Construction	- Carbon Steel
Service Conditions	- Ambient Temperature 55 – 80C
Coating System	- 5891
Application Date	- 2006
Specification	- Grit blasting after which coating was applied at a thickness of 600 microns

Developments in Spray Applied Coatings

Summary

Development of these high temperature spray applied coating systems suitable for immersed service conditions at elevated temperatures has now been completed although there are still future opportunities to improve application characteristics as well as performance.

The range of products currently available is summarized as follows :

- Coating for immersion service conditions up to 50C (5811)
- Coating for immersion service conditions up to 95C (5891)
- Coating for immersion service conditions up to 120C (1391S)
- Coating for immersion service conditions up to 150C (1521)

Developments in Spray Applied Coatings

Coating Characteristics

Sprayability

Suitable for application using single component
of dual component heated airless spray systems.

Temperature Resistance

Immersion temperature resistance up to 150C in aqueous a
and hydrocarbon service and resistant to steam out conditions
at temperatures up to 210C

Chemical Resistance

Good resistance to hydrocarbons / aqueous solutions as well as
amines (MEA / MDEA etc) used for the removal of acidic gases at elevated temperatures.

Developments in Spray Applied Coatings

Limitations

- Not suitable for dry heat conditions where no moisture is present in the process
- Application thickness needs to be strictly controlled to avoid over-stressing the coating.

NOTE :

ANY COATING IS ONLY AS GOOD AS THE APPLICATORS APPLYING THE PRODUCTS AND THE INSPECTOR / SUPERVISOR CONTROLLING THE JOB

Developments in Spray Applied Coatings

Application Controls and Training

- Fully documented procedures available

BELZONA
Repair • Protect • Improve

METHOD STATEMENT FOR VESSEL COATING

WITH BELZONA 1111/1391 FOR ..... TAG NO. ASEDA V 4255

Project:
Prepared By: Belzona Polymerics Ltd
E-mail: belzona@belzoan.com
Date Prepared: August 19th 2008

REVISION NO.	Rev.2 - 19/08/08			
APPROVED **Belzona Polymerics Ltd** (MANUFACTURER)	Simon Latty			
APPROVED **Belzona Service Nord** APPLICATOR				
APPROVED FABRICATOR				
APPROVED DESIGNER				
REVIEWED (COMPANY)				

Tag No. ASEDA V 4255 **Rev.2 - 19/08/08**

Developments in Spray Applied Coatings

Application Controls and Training

- Factory Training available for Coating Supervisors

Developments in Spray Applied Coatings

Application Controls and Training

- On-Site Project Supervision and Inspection Services available from NACE level 1 to NACE Level 3 manufacturers personnel
- On-Site training available

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THANK YOU FOR YOUR ATTENTION