CASE STUDY: POLYGLASS FOR BURIED LPG BULLET

'PUTTING LIFE EXPECTANCY FIRST'

CLIENT

Engen, the second largest integrated Oil & Petroleum Company in Southern Africa, in conjunction with DB Thermal, the Steel Fabricator.

HISTORY

The Refinery identified a need for longer lasting protection for their buried steel structures when inspection of the Bullets revealed that the specified coating was blistering owing to Cathodic disbondment within 5 to 6 years. (The required design life expectancy was 40 years)

The location is a high rainfall, marine industrial environment which rates as a C5 on the Corrosivity Index. In addition, the steel bullets are buried in coastal chloride-rich soils.

SCOPE OF WORK

The LP Gas Bullet comprises of three sections welded together to a total length of 63ms, and 5.5m diameter, fabricated from 50 mm thick carbon steel and weighing 357 Ton. The LP Gas Bullet was coated in 3 Sections and transported to the Refinery where the Bullet sections were welded together on site and final touch ups took place before the Bullet was "mounded" or buried in the ground.

- Grit blast to ISO 8501-1, cleanliness standard SA 2½
- Apply Polyglass VEF to a nominal dft of 1500 and minimum of 1000 µm
- High-voltage Spark Test to 10kV -DC.

APPLICATION DATE

August 2007 – Completed in 4 weeks

COATING SYSTEM & SELECTION CRITERIA

The longest possible anti-corrosion life expectancy, with the lowest risk of failure. The Refinery achieved this by:

- Revising the design requirement for the coating of buried structures.
- Comparative performance testing to destruction by an independent third party on various coatings, which were then ranked in terms of long-term anti-corrosion ability
- Based on the laboratory test results, the material with the best technical performance was recommended.
- The lowest Life Cycle cost was ranked as more important than lowest initial cost – this change in philosophy was a major departure from previous selection criteria.
  (The best performing coating was <u>not</u> the most expensive.)
- Engen won the Corrosion Institute's Annual Award in 2007 for the research they did on coating selection for this project.
- Further to the successful completion of this project, Polyglass VEF has been specified as standard for all buried structures by the Refinery, and the Corrosion Protection Refurbishment of old buried steel has started.

CORROCOAT

Corrocoat SA (Pty) Ltd., 31 Lincoln Road – Benoni South 1502
Tel: +27 11 845 4247 Fax: +27 11 845 1907
www.corrocoat.co.za

Historically the selection criteria used for anti-corrosion coating options has been to evaluate coatings to ensure that they meet a required Standard, and thereafter the different coating manufacturers compete with each other on a normal commercial basis. A secondary consideration is often the length of the references available for long term case studies. However the longer a coating's case history is in general terms, the older is the technology and therefore modern technological developments may be excluded by virtue of only having comparatively fewer and shorter case studies.

GENERAL INDUSTRY PRACTICE WHEN SPECIFYING COATINGS

The norm when many end-users or consultants specify coating systems is to follow 1 of 3 approaches:

1. They use or reference a coating standard for that type of equipment or service environment. These standards typically prescribe only the *minimum* selection criteria, such as the *generic* material type, and a *minimum* dry film thickness.

2. The compile minimum coating selection criteria as best they can, and solicit product names from a few of the large coating suppliers for products that conform to the minimum selection criteria, and then approve the various product names as acceptable systems from which the contractor can choose,

3. They describe the intended service environment as best they can, and rely on paint sales representatives from a few of the large coating suppliers for a recommendation of an appropriate coating system for that service environment, and then offer the various recommendations as acceptable systems from which the contractor can choose, or

1. Using reference standards

Various standards and specifications are in use in various industries, some prescribed, and others voluntary standards. This can for instance be a standard such as:

- UL 1746 - External Corrosion Protection Systems for Steel Underground Storage Tanks
- API RP 1631 - Interior Lining of Underground Storage Tanks
- ISO 12944-5 - Corrosion protection of steel structures by protective paint systems Part 5: Protective paint systems

The standard will typically be very elaborate, but when it comes down to it, the actual material selection section will be essentially as basic as "coat with a Zinc Silicate Primer, followed by an intermediate coat of MIO Epoxy applied at a DFT of 200 micron, and topcoat with recoatable Polyurethane at 50 micron DFT"),

The problem with using generic Standards is that Coating Standards are more often than not compiled as *consensus* documents by technical committees which are comprised of representatives from paint suppliers (the very people it tries to regulate), with only a sprinkling of (independent) end-users or technical consultants who can vouch for its actual in-field performance, at best.

(The writer is a member of such a technical committee for on of the leading international coating standard producing organizations – almost all the other members are suppliers within the area that the document we are tasked with producing is addressing, and lobbying and commercial interest pressure is intense.)

The specifications then end up reflecting what is generally recommended by the paint representatives at that time in any case, or what is currently done within industry as the norm, however good or bad that may be. These standards sets the bar low, based on current practice, as everyone of the large players involved must be able to comply and compete – it seldom if ever set aspirational targets, based on best service life, lowest lifecycle cost, or best risk management.

2. Publishing minimum performance criteria

The problem with the second approach is that the client might or might not describe the complete service environment (both as designed and during upset conditions), or in sufficient detail, and he might not be knowledgeable enough of coating behavior that he can determine and disclose ALL of the factors that might impact on a coating system's performance.

If a problem eventually arise, it is almost certain that the party under suspicion will find something in the operating environment that was not disclosed and is then considered "a major detrimental factor to coating performance".

Typical examples of anti corrosion coating selection requirements can include:

Coating performance criteria (fit for purpose)

- Chemical Resistance
- Temperature resistance
- Wear resistance
- Di-electric strength
- UV resistance
- Flexibility, elongation to break
- Substrate compatibility
- Cathodic disbondment resistance
- Moisture vapour permeation rate, diffusion resistance
- Adhesion values
- Aged bond-strength, adhesion deterioration over time
- Under-cutting resistance, resistance to under-film corrosion
- Over-coating ability

Cost

- Anti-corrosion life expectancy
- Initial cost of anti-corrosion protection
- Lowest life cycle cost (estimated)
- Dry film thickness required (quantity of material)

Practicality

- Surface preparation standard required
- Edge retention, stripe coating needs
- Ability to apply under restricted conditions
- Level of skill required to apply
- Application methods & equipment required for application
- Dry film thickness per coat achievable
- Drying time
- Curing time
- Availability
- Shelf life
- Maintenance requirement & schedule

It can be readily deduced that some of the above requirements will be mutually exclusive and that a single coating system will not be able to satisfy all the above selection requirements, so choices and compromise will have to be made – who assumes the responsibility for this?

A variation on the above is where the required performance criteria are determined and prescribed by industry- or standard setting bodies for a given service environment, and coatings then submitted by suppliers for compliance testing against the *minimum* criteria, after which it is approved or certified as compliant or pre-qualified. This includes regimes such as Norsok M501 pre-qualification of coatings for use on offshore structures in tidal zones, topsides etc, the IMO Type Approval of coatings for use as Ballast Tank linings, etc. Although the coating is now at least tested, it is again measured against a *minimum* acceptance criteria, and this is often based on what is currently the easily achievable norm in the industry.

3. Delegating the decision to a Paint Supplier

Paint Sales / Technical Representatives are appointed on their ability to *sell paint*, not their technical competence, and they gain their technical experience over time, usually when things do NOT work as planned, and usually at the client's expense.

The paint rep might or might not have suitable technical competence, experience, knowledge and skill to fully obtain all the relevant factors of the intended service environment (both as designed and during upset conditions), to comprehensively evaluate the full intended service environment, to correctly consider all the associated detrimental factors that might be present or that might still arise, and that the paint rep will then match this correctly with all of the performance capabilities of his coating products, and then select the product that will work best.

Additionally, the advice obtained from the paint rep is often highly dependent on the commercial situation at the time:

- If the rep is competing in an open bid against his competitors, they tend to recommend his *cheapest* product that will only *just* comply with the *minimum* specification requirements, or the cheapest coating that he sells that will *barely just* deliver acceptable results.

  He will then also recommend the dry film as low as possible, often too low.

  This is done in order to ensure that when the paint contractors solicits prices, they will select his product during tendering or execution, as this decision is almost always made on lowest *initial* price alone.

- Alternatively, if the paint rep is already the preferred supplier, they tend to *over* specify, and will then recommend the *most expensive* product, at the *highest dry film thickness*, in order to sell the largest volume of paint and earn the largest commission.

The first problem with all 3 of the approaches is that the *client* assumes the risk of coating failure, as long as the contractor's workmanship is up to standard, and as long as the paint supplied is conforming to its manufacturing quality standard – if it was inappropriately selected or specified, he will seldom if ever be able to enforce a performance guarantee, against either the contractor or the paint supplier.

> The Spearin Doctrine: "…it is well-established that a contractor who performs according to detailed plans and specifications is not responsible for defects in the results."

The second problem with these approaches as that throughout the normal industry process of specifying coatings, the specifications and quality standards are dumbed down:

- by the designers/consultants when they prescribe a "*minimum* coating standard",
- by the client who might omit small details from the service environment or not knowing how this can affect coatings,
- by the paint rep who recommend his *cheapest* coating, and applied at the *thinnest* thickness, and
- by the contractor who select the paint supplier that offers him the *cheapest* product at the *minimum thickness* he needs to apply, or by the contractor who appoints the *cheapest sub-contractor* to do the work.

Nowhere in this process is there an effective attempt to *minimise risk*, nor to get the best possible *life cycle cost*, instead initial cost and conformance to a *minimum* acceptance criteria is normally the only considerations.

(Contrast this to the Corrocoat approach, where we actively seek to assume *all* responsibility, for the entire value chain: from investigating the service environment, determining the performance criteria, selecting the most appropriate coating material, compiling the detailed coating specification, supplying the coating material, through to performing the surface preparation, coating application, quality control and -assurance, in-house using own resources, with the entire risk chain guaranteed by a single-source Corrocoat warranty.)

In recent years there has been a commendable trend towards better risk management by doing *comparative* performance evaluation and *ranking* of anti-corrosion performance of coatings using accelerated test protocols that replicate the intended service environment. The coatings that perform technically best are then considered for further evaluation on cost.

THE ENGEN LPG BULLET PROJECT

In the late 1990s Engen had anti-corrosion work performed on the externals of mounded (buried) LP Gas Bullets. At the time these mild steel LP Gas Bullets were considered very large structures being approximately 48 m long and 5 m in diameter. As these LPG bullets operate under very high internal pressures, external corrosion protection is very important.

A series of LP Gas Bullets were coated, with what was then considered a good quality coating from a well known international paint manufacturer, by arguably the largest paint application company in South Africa.

The service environment was given as the externals of a buried mild steel tank, subject to cathodic protection, plus high rainfall and humidity in coastal soil, high ambient temperatures and the resultant thermal expansion and associated soil stress. All parties were aware of the service environment as well as the use of CP on the LPG bullet. The coating application was overseen by CATS, Corrosion Advisory Technical Services, a leading South African inspection company.

Premature coating failure

A subsequent inspection by CATS showed that after only 5 to 6 years service, the coating on the old LP Gas Bullets was blistering. A failure analysis was performed by Corrolec, a leading corrosion test facility & consultants, which indicated that the cause for the coating blistering was due to cathodic disbondment. Cathodic disbondment can occur when coated steel is subject to cathodic protection. Cathodic protection induces a small voltage, typically -0.8 volt on the steel surface so that in the event that a coating defect such as a pinhole or chip occurs, the current is leaked to the ground at the coating defect site and no corrosion takes place at the coating defect. However coatings must have very good resistance to cathodic disbondment or else they have a propensity to blister.

The indirect costs of dealing with coating failures means opening up the steel through excavations and hand digging to expose the mounded bullet and these indirect costs were considerable in relation to the cost of blasting and painting the bullet. The failures also had environmental and safety impact, as well as disruption to the plant and lost production.

Engen had originally anticipated (based on coating manufacturer’s promises) that coatings on the externals of buried steel structures should last approximately 40 years, and with the best intentions, numerous coating manufacturers volunteered products which they felt would offer this service life, of which was one was selected, yet failed to life up to expectation or promise.

Engen’s new approach to coating selection

In 2005, Engen revised the design requirement for the coating from minimum selection criteria to the *longest possible anti-corrosion life expectancy,* supported by independent third party *testing*. Engen therefore commissioned one of the leading anti-corrosion firms, Corrolec, to perform coating evaluations, to recommend coating materials, and to generate coating procedures for the re-coating of the externals of several old LP Gas Bullets, as well as coating of new LP Gas Bullets, still to be constructed.

Submissions were invited from industry and again several paint manufacturers felt that they had products that would meet the revised life expectancy requirements of at least 50 years. Engen, in order to cut through the marketing hype, stipulated that Corrolec should perform *comparative performance testing* on the products and rank the coatings in terms of long-term anti corrosion ability.

A secondary ranking was done in terms of coating cost. It is noteworthy that the best performing coating was <u>not</u> the most expensive.

This change in philosophy was a major departure from previous selection criteria, which was that the coating simply had to meet a certain standard.

The independent corrosion test lab then performed a series of tests to destruction and ranked the relative performance of these coating materials. The anti-corrosion coating material with the best technical performance after the accelerated test protocol was a material called Polyglass VEF, supplied by Corrocoat. This material was then recommended to Engen. After review the Engen engineers dictated that both the refurbishment of the old LP Gas Bullets externally, as well as the coating of the new LP Gas Bullets should be performed using Corrocoat’s Polyglass VEF material.

The detailed application procedure together with the quality control requirements were stipulated by Corrolec. The first old LP Gas Bullet was refurbished externally in August 2006, on site at Engen's plant in Durban. Due to the high profile and high risk nature of the work Corrocoat elected to use their in-house application teams to perform the coating work, and Kwenza, an R J Southey affiliated BEE company performed the scaffolding and grit blasting operations. CATS were the third party quality control and inspection authority.

After the successful completion of refurbishing the first old LP Gas Bullet, the same coating material was used to protect the newly constructed LP Gas Bullets. Engen selected D B Thermal, one of the leading manufacturers of pressure vessel equipment, to fabricate additional LP Gas Bullets. The size of the new L P Gas Bullet (horizontal pressure vessel) with two hemispherical dished ends was an overall length of 62 meters, and shell thickness of circa 50mm, with some sections up to 100mm thick. The bullet, complete with legs weighed approximately 357 tonnes.

Engen in conjunction with D B Thermal, elected to coat the L P Gas Bullet in three sections at the manufacturer's works in Gauteng, and transport the sections to the Engen Plant in Durban, where the Bullet sections were welded together on site, and the field weld repair and touch ups were done on site before the Bullet was mounded. Once again Corrocoat elected to use its own staff to perform the anti-corrosion coating work. Bulldog Projects were the Gauteng blasting contractor and CATS were the third party inspection authority.

CorrISA Annual Corrosion Excellence Award 2007

Engen's departure from this norm was not innovative, as the risk management and life cycle approach is habitually followed when high risk work is undertaken, such as for instance lining high value plant against aggressive chemical attack where down time cost for remedial action will be exorbitant. As example, when lining acid reactors running at high temperature or gas scrubbers at steel mills etc, a careful study is normally made and the coating product that will deliver the best service life, with the lowest risk of premature failure, with the lowest projected initial and subsequent repair over the expected economic life of the equipment (not the coating) is usually prescribed, often as the only option and by brand name.

However, following this risk management approach for selecting a coating for relatively benign atmospheric & soil buried service, and then basing this on life cycle cost instead of the traditional initial cost, was novel and well worth commending. Preventing unnecessary future work and replacement is also the best form of energy saving available.

Engen won the Corrosion Institute of Southern Africa's Annual Award for Corrosion Excellence in 2007 for the research and specification development work done for this project.

Corrocoat is proud to have been associated with the Engen LP Gas Bullet project, as the supplier and applicator of the Polyglass VEF coating material which was eventually ranked top in the technical evaluation, and yet nowhere nearly the most expensive product evaluated.
Our second coating submitted for this evaluation was ranked almost at the top of the technical performance, yet was the *cheapest* of all the products evaluated.