Corrosion in power plant steam generators may cause the failure of pressure components and a breakdown of their structure. This may require shutting down the steam generator and possibly the entire block. With incinerator plants, corrosion is the most
frequent cause for unplanned shut-downs of the incinerating line. It causes a reduction of online availability by 2% - 4% as well as increased repair costs and lost revenue for electric power or heat sales. An availability of 94% or more, desired by many power plant operators, can be achieved if only scheduled shut-downs and inspections need to be performed.

Coatings with a high-alloy nickel-chromium material increases corrosion resistance and extends the service life of the power components, (as the example of the industrial combined heat and power plant Andernach demonstrates.)

1. Introduction

The most frequent cause of unscheduled shut downs for repairs of power plants outside the scheduled inspection intervals is corrosion of the pressure components. This is especially true in incinerator plants (Energy from Waste – EfW), plants fired with biomass fuels, and plants operated with substitute fuels. Apart from the repair costs, revenue losses from the sales of power or heat can run into the tens of thousands EUR per hour.

Power plant operators are therefore quite interested in corrosion prevention and protection measures to avoid repair on pressure components. In addition, extending the service life is another objective in order to delay component replacement. Furthermore, carrying out the measure quickly and efficiently to prevent the extension of scheduled shut-downs is highly desirable.

2. Corrosion factors and types

The impact of corrosion depends on many factors, amongst other, the design of the evaporator, the power plant operation and its deviation from the practised and planned operating characteristics, and the make up of the fuel.

Because of the different compositions of waste, the fuel of incinerator plants is not identical. It may contain varying portions, for example, of paper, leather, wood, glass, metal, and kitchen or PVC waste. Incineration of the waste causes the release of corrosive gases such as HCl, SO₂, NaCl, KCl and heavy metal chlorides with different concentrations [2].
The following types of corrosion typically occur in a steam generator, and often simultaneously:

- corrosion in a gas phase, including active oxidation by HCl or Cl₂,
- condensation of alkali and heavy metal chlorides or sulphates,
- corrosion induced from deposits and sulphidizing of condensed chlorides,
- salt melts, causing the detachment of the oxide layer and the raw material,
- oxygen deficiency corrosion.

Oxygen deficiency corrosion can occur especially with sulphur-containing fuels, such as lignite, due to incomplete combustion [1]. Corrosion takes place in the evaporator on unprotected boiler tubes if H₂S, which reacts with non-alloyed or low-alloy pipe steel, is formed in addition to waste gas developing under reduced conditions. Instead of the magnetite layer common under oxidising conditions, with oxygen deficiency corrosion a layer of pyrrhotite (Fe(1-x)S) and magnetite (Fe₃O₄) forms on the tube surface. Pronounced crack formation as well as low adhesion on the metallic material is typical for these layers. Growth tensions, causing crack formation and layer detachment, develop in the layers themselves and new layers continue to grow. Thermal alternating stresses favour the detachment of the layer and, as a result, the depletion of the tube wall.

The extent of damage to evaporator walls or superheater components from corrosion depends on the temperature and velocity of the waste gas, the portion of oxygen and carbon monoxide in the waste gas, the entry of flue ash, along with many other influences. The temperature is one of the key factors.

Based on experience, corrosion of components in plants operated at a surface metal temperature on the tubes between approximately 350 and 430 °C and a waste gas temperature under 650 °C is relatively low. Corrosion could thus be already prevented in this manner due to the engineering design. However, operation at this temperature level in favour of higher output would require larger intermediate superheater areas, causing the evaporator to become larger and more expensive.

To obtain maximum efficiency, however, higher steam pressures and temperatures would be pursued because raising the wall temperature from approximately 400 °C to 500 °C is estimated to increase the output by roughly one fifth. The waste temperature required for such evaporators, however, lies much above 650 °C and thus in a range where corrosion in incinerator plants or power plants fuelled with biomass or substitute fuels strongly increases.

Figure 2: Corrosion damage behind SiC plates

Source: IHKW Andernach
3. Corrosion protection measures

To minimise corrosion, various protective measures are beneficial, in addition to design characteristics and the operating manner. These measures include ceramic lining, welded plates (tube shields), and spray coatings based on nickel alloys [3]. Each of these measures has its advantages and drawbacks.

Advantages of spray coating (7)

Amongst others, the time factor is an advantage of spray coatings. They can be applied to the walls of the steam generator on site and in a short amount of time during a planned outage. Another advantage is that spray coatings can be applied to walls that have almost reached the minimum wall thickness (as a result of advanced depletion) stipulated for operation. The application of weld overlay is not possible with thin walls if the wall thickness is near MWT. as the risk of burn through is high. The abrasive process used for preparatory cleaning of the base material is a limiting factor with spray coatings because the wall thickness becomes reduced during the cleaning process. Also, as spray coatings do not add structural integrity to the underlying tubes, consideration must be given to tube wall thickness at which time tube replacement may be the safest option.

Methods for the application of spray coating

The following, for example, are common methods for the application of spray coating:

- arc spraying, (twin wire arc)
- plasma spraying,
- flame spraying,
- high-speed flame spraying (High Velocity Oxy-Fuel - HVOF).
(Do not think this is a factor. Effect on heat transfer is negligible.)

4. Characteristics of high-quality spray coating

High-quality coating applied through layer coating onto the steam generator heating surfaces is marked by the following characteristics:

- high density of the structure,
- low permeability,
- coating thickness variability to be able to react adequately to varying corrosion risks,
- low internal tensions, thus little tendency to form cracks or to chip,
- resistance against mechanical influences (such as abrasive-erosive effects from flue ash or similar),
Corrosion Protection and Measure for Evaporator Walls

- good bond on the base material,
- ease of repair.

Requirements such as the following need to be added; they primarily affect the spraying process:
- quick application,
- simple handling of the spray gun for exact work with on-site coating,
- as insensitive as possible toward different methods of work when applied manually,
- processing even under flat spraying angles without major effects on the thickness or quality of the coat,
- uniform processing of the material (e.g. in regard to application, particle size),
- little heat impact on the steam generator heating surfaces to avoid the necessity of cooling the base material during application.

In addition, the material should not be magnetic to be able to conduct non-destructive wall thickness measurements after applying spray coating.

Still, even with careful application of the spray coat differences of the thicknesses cannot be avoided due to the geometry. Because of the curvature of the tubes there are areas where the material is applied at a steep angle and a thick layer is consequently created; a flat angle develops at other areas during spraying and consequently lesser thickness. At the same time, the main direction of impact of the spray particles affects the structure – more or larger pores may develop at flat angles and low thicknesses and so-called shadow porosity develops (Fig. 3). Gases or liquids may reach even the base material through these pores – corrosion protection would be disrupted. Shadow porosity must therefore be avoided.

5. Characteristics of high-quality spray coating

High-quality coating applied through layer coating onto the steam generator heating surfaces is marked by the following characteristics:
- high density of the structure
- low permeability,
coating thickness variability to be able to react adequately to varying corrosion risks,
low internal tensions, thus little tendency to form cracks or to chip,
resistance against mechanical influences (such as abrasive-erosive effects from flue ash or similar),
good bond on the base material,
ease of repair.

Requirements such as the following should be considered as they primarily affect the spraying process:
quick application,
simple handling of the spray gun for exact work with on-site coating,
as insensitive as possible toward different methods of work when applied manually,
processing even under flat spraying angles without major effects on the thickness or quality of the coat,
uniform processing of the material (e.g. in regard to application, particle size),
little heat impact on the steam generator heating surfaces to avoid the necessity of cooling the base material during application.

In addition, the material should not be magnetic to be able to conduct non-destructive wall thickness measurements after applying spray coating.

6. Spray coating with the HVCC process
In consideration of the aspects mentioned in section 5, the coating material AmStar 888 and the High Velocity Continuous Combustion (HVCC) process, favoured by ALSTOM and reviewed below in more detail, was developed.
The patented material is an iron-free, austenitic nickel-chromium alloy. It is a filled wire where the sheath of the wire consists of 43 percent nickel, 41 percent alloyed chromium and additional metallic elements, e.g. titanium or aluminium. The filling, amongst others, contains additives of boron as well as chromium carbides and other ceramic material.

6.1. Surface preparation
The process application begins with the surface preparation with fused alumina (Al₂O₃ (AlOₓ)). The AlOₓ is used to sandblast the area to be sprayed so as to clean the surface of scale and deposits. A roughening of the surface, thereby increasing surface area and allowing for a greater bonding surface, is also achieved. Because AlOₓ is available on the market in different grain sizes, a larger grain is used for preparation of new or uncoated tube surfaces (typically a 16 grit.) When cleaning surfaces with an existing coating (as in repair work), then a smaller grain size is used (a 20 – 24 grit). This allows for less damage and breakup of the existing coating.
The use of oil and moisture free air is essential to allow for greater efficiency and to avoid adding contaminants to the surface during cleaning. Because surface preparations significantly affects the result of the spraying and cladding protection, the party carrying out the coating should assume responsibility in the scope of quality assurance.

6.2. Application of the coat

The coating material develops its full effect by using the appropriate spraying process, in this case High Velocity Continuous Combustion HVCC (Fig. 4 and Fig. 5). It was invented in 1993 and uses wire for feeding.

The wire material is heated in an arc and melted to particles with a size of approx. 30 µm (10 to 50 µm). This process takes place within a nozzle from which oil-free and water-free compressed air escapes. This arrangement allows for the effective transport of the liquid metal, relatively uniform droplet size and quick application to the base material.

The nozzle generates a larger spraying cone than is common with processes other than High Velocity Continuous Combustion. As a result, a relatively uniformly thick coat application takes place even in spite of velocity differences.

Application takes place at spraying angles between 90° and 20°. The risk of shadow porosity is low even with flat spraying angles. Subsequent treatment (e.g. induction heating) after the application of the HVCC process is principally not required.
6.3. Simple and secure handling

The equipment needed for coating the steam generator walls has been specifically designed for on-site deployment to allow achieving the ensured quality properties even under difficult space conditions. The spray gun weighs only approximately 0.5 kg to allow the operator to work without fatigue even with extremely demanding applications, e.g. coating a steam generator ceiling. In addition, no additional gases are required to melt the wire, by contrast to some other methods. The power plant operator only needs to provide oil and water-free compressed air and adequate power supply to allow performing the application. The heat introduction with the HVCC method is so low that cooling of the steam generator surfaces during processing is not necessary. Thus, simpler handling of the equipment and the materials is ensured also in regard to work safety.

6.4. Low permeability

A key property of the AmStar 888 material described in this chapter is its low permeability for gases or liquids. This property is aided by the HVCC process. Because of the high velocity of the particles they deform at the moment of impact into thin platelets with a height-width ratio of approximately 1:5. Compared to rounder particles, more layers of particles and tight spaces are produced with identical overall layer thickness. This makes the entry or penetration of gases or liquids through the layer more difficult (Fig. 6 and Fig. 7), a property known as toruosity. Moreover, the disk-like shape of the particles produces a smooth surface that offers less of a corroding surface for the particles. The wear of the corrosion protection coat is therefore low.

6.5. Self-sealing and diffusion-resistant

Due to the large temperature differences between the cool base material (T = 60 to 80 °C) and the sprayed on liquid metal (T = 1,550 to 1,650 °C) internal tensions develop in the layer when the metal solidifies on the base material, which can be traced to a volume reduction during solidification. The additional introduction of boron gives the applied material greater brittleness so that stress cracks developed at the transition from the liquid to the solid state and the internal stress is broken down.
Furthermore, free chromium, now present in the elementary state, is introduced in addition into the protective coat. The free chromium reacts quite readily when the steam generator is started. Operated waste gas, with its various ingredients such as sulphur, oxygen, chlorine and other components, acts on the protective coat and reacts with the elementary chromium, to form chromic oxides, chromium chlorides and chromium sulphates. These reaction products close – sometimes due to the volume increase accompanying the reaction – the stress cracks. The coat is thereby sealed diffusion-resistant against waste gases. Underlying corrosion is thus prevented. Compared to many other spray coatings, the risk of chipping or cracking with AmStar 888® material is reduced because of the relief of the internal stress.

The material and process described produces coatings with an erosion resistance roughly five times higher than that of carbon steel; corrosion resistance exceeds that of Inconel 625 by a factor of 18, which has been confirmed through different laboratory tests.

6.6. Coating application with appropriate thickness

The coating application can be made with different thicknesses, depending on the application scenario. For steam generator heating walls layer thicknesses between 0.1 mm and 0.3 mm are typical to protect the walls against corrosion.

For erosion attacks, the spray coating may be many times thicker in localized, high wear areas. The layer thickness is adjusted to the depletion rate and the planned service life so that the protection of the base material can be ensured over several years.

A special application scenario based on this property is the application of the coating above the fire resistant zone installed in a steam generator (e.g. SiC compound or plates), which causes the formation of steps. Turbulences of the waste gas develop directly above this stepped transition up to a height of roughly 20 to 40 cm. The turbulence causes fixed particles present in the waste gas to have an erosive effect on the membrane wall. To protect this area against erosion, a so-called wearpad, with a thickness of up to 6 mm, is applied. To a height of one to two metres above the fire resistance, the wearpad is tapered down to 0 millimetre to avoid a step in the coating with consequent formation of turbulence.

6.7. Multiple coating possible

With the use of AmStar 888, in combination with the HVCC process, repairs of existing coating is possible due to the nearly tension-free coating. Localized damage can be successively removed with the help of abrasive methods and reinforced or replaced with new coating. The risk of systematic cracking of the coating does not exist here.
6.8. More rapid implementation than with cladding

In regard to the coating time on site spray methods enjoy a clear lead over weld-overlay. Approximately 3 to 8 m² of spray coating can be applied per twelve hour shift and machine, that is, roughly ten times more area than with corrosion protection through weld-overlay. This time estimate includes both surface preparation and the spray application itself.

The removal of already existing old spray coating may prolong the application. Based on experience, stripping of existing material takes approximately four hours per m².

7. Experience at combined heat and power plant Andernach

The properties of the AmStar 888 material have confirmed themselves in practice during the past decade. Coating was applied in more than 250 projects worldwide. The later projects include the industrial combined heat and power plant (IHKW) Andernach.

The IHKW Andernach plant supplies the industrial area of ThyssenKrupp Rasselstein with energy in the form of steam and electric power. The overall plant consists of four steam generators with a thermal fuel power of roughly 150 MW altogether. Steam generator 2 serves as back-up boiler, steam generators 3 and 4 as peak load plants. These three steam generators are operated using natural gas. Steam generator 1, which serves as main energy supplier to the Rasselstein rolling mill and will be examined more closely below, has a thermal fuel power of 60 MW and is fuelled, amongst others, with substitute fuel. The fuel consists of waste (up to 140,000 t/a) as well as used rolling mill oils (up to 8,000 t/a) and press slurry (up to 7,500 t/a) from the industrial operation. In 2013, the chlorine content in the fuel amounted to 1.10 percent on average, the sulphur content to 0.45 percent (each relating to the dry substance). The fuel data and mode of operation produce an increased risk of corrosion, which exceeds the risk of a waste-to-energy power plant fuelled with communal waste.

Figure 9: Typical erosion attack above the fire-resistance with the coating examined here with turbulences being the cause.

Both SiC plates and claddings applied at the factory are installed in steam generator 1. Nonetheless, a first major steam generator tube damage occurred after 10,800 operating hours. Damages occurred in the area of the evaporator wall of the first steam generator above the SiC plates (Fig. 9) or the transition from cladding to galvanized steel tube, and can be traced to erosion and corrosion. The tube walls above the cladding therefore had to be replaced completely in 2010.
This damage and additional corrosion influences were the reason for considering protective measures. As an alternative to weld-overlay, an application of AmStar 888 was performed here in October 2013 for the purpose of a comparison test. The coating was applied after a grit blast cleaning was performed on a test area of the old cladding in the first steam generator above the SiC plates shortly before the steam generator ceiling (Fig. 10, below Site A). Another coating was applied on an evaporator bulkhead downstream next to the cladding (Fig. 12, Site B), directly in the area of impact of the water cannons-installed in the steam generator ceiling.

The choice of both areas by the IHKW Andernach in connection with the CheMin GmbH company was made because no major damage would be expected in the event of systematic failure of the coating.

The following was in favour of Site A, in addition:

- application on older cladding already exhibiting spot corrosion,
- direct comparison of the corrosion protection of the spray coating as well as cladding possible.

The following was in favour of Site B:

- application on older galvanized steel tubes,
- direct comparison of the corrosion protection of the spray coating as well as weld-overlay possible,
- impact of water cannon cleaning on spray coating can be assessed.

To conduct transparent success monitoring, the project is supported on the customer side by representatives of CheMin, an engineering consulting firm.

![Figure 10: The hand-welded surface of the existing cladding at the IHKW Andernach after blast cleaning with special fused alumina, before coating. The undercuts present a challenge since the material application cannot be made there at a steep spraying angle.]

Success monitoring

Services provided by CheMin were to include application monitoring, visual inspection or layer thickness measurements after coating as well as assessments and measurements roughly at six month intervals during the scheduled shut-downs. However, because the application was moved up on short notice to the night shift to allow starting the steam generator approximately twelve hours earlier, the experts from CheMin were not on site themselves during the coating work. The experts performed a visual inspection and layer thickness measurement the following morning.
At Site A, an eddy current measuring device (Fig. 11) was used to measure the layer thickness directly after coating near the undercuts of the cladding with a nominal thickness specification of 0.5 mm. The layer thickness in the processed area was approximately 0.4 to 0.7 mm.

![Layer thickness measurement](image1)

**Figure 11:** Layer thickness measurement of the corrosion protection layer on an old cladding in the first boiler set of the IHKW Andernach.

![On bulkhead 1](image2)

**Figure 12:** On bulkhead 1 – here before coating – coating was applied next to a cladding area. The area to be coated is pitted and depleted on one side from the thermal flow.

![The coating compensates corrosion](image3)

**Figure 13:** The coating compensates corrosion pits (clearly visible at the left before coating, at the right after applying the corrosion protection layer in October 2013.

![Coating after half a year of operation](image4)

**Figure 14:** Coating after half a year of operation: Salt and ash deposits but visibly good durability of the coat.

**Initial condition assessment after practical application**

An initial condition assessment of the coated surfaces took place in May 2014. At Site A, a brown-white salt-ash build up could be seen (Fig. 14). The visual inspection and the measuring results determined a good durability of the coating. Black oxide coats were found at the adjacent membrane wall, which became moist after several days and peeled off. Greenish salt liquid appeared beneath it. This phenomenon, by contrast, could not be observed at the surface coated with the AmStar 888 at Site A. However, layer
thickness measurement revealed an increase of the layer thickness. It has not been fully cleared up yet whether this increase of volume can be traced to the self-sealing effect of the coating, incompletely cleaned surfaces and/or the fact that finding the exact measuring point represents a major challenge with the measuring method.

The following could be clearly confirmed:

- **the test area ... shows a continuous brown and white salt-ash coat**
- **a good service life behaviour of the coat can be assumed <<as-is>>**
- **black oxide coats are found at the surrounding membrane wall of the cladding, which become moist after several days and peel off. A metallic-blank cladding surface with green salt fluid is found beneath it**
- **these or similar symptoms cannot be found on the test surface**
- **the ...<<test surface>>... no black oxides << shows >> and the coating remains dry even after several << days>>**

The findings for Site B (bulkhead) were similar. However, the wall was accidentally cleaned by blasting after the measurement. Furthermore, weld-overlay was applied in the immediate vicinity to the existing membrane wall, at the lower edge of the spray
coating without having first removed the spray coating by abrasive means. This represented an enormous challenge since metal containing boron is nearly impossible to weld and welding represents great thermal stress for the adjacent coat.

With this surface the CheMin employee noted the following:

- The layer thicknesses determined and the visual findings allow assuming only minor removal at a pipe flank (left) and in the web area; whether this was caused by corrosion or cleaning is not yet clear.
- No negative impact on the test surface in the form of selective removal in the area of the cleaning hose was apparent.
- <<At the lower edge>> lies <<now>> coat detachments and removal coming from the service.
- Green liquid drops can be seen in the metallic-blank cleaned area. They indicate chloride-based salts in the coat and were probably made visible through abrasive jet cleaning.

Accompanying blasting and welding tests

Furthermore, the customer performed a blasting test and subsequent welding tests to check the repair feasibility of the material with simple means that would also be close to actual reality.
The blasting test was performed on a spray-coated surface which was exposed to a similar temperature range and atmosphere as they prevail in the steam generator, using an oven at the manufacturer’s facilities. The sample was taped off except for the area to be blasted in order to subject only a certain section to the blasting test with abrasive material.

The area with a starting layer thickness of roughly 290 to 460 µm could not be removed at a jet distance of approximately one metre, however, after reducing the distance to 0.5 m the layer could be removed in a short amount of time already to 160 to 310 µm. The blasting test was continued until the entire coat war removed in the area that was not taped off.

Subsequently, the two test sheets were mechanically cut in the centre of the surface blasted clean, and each of the partial areas was subjected to a welding test.

Two of the areas were welded with a fillet weld according to the welding instructions and two of the areas with a butt weld, and the quality of the weld was checked by dye penetration testing.

As a result it could be noted that the layer can be successively removed by blast cleaning; it does not chip off but is removed starting at the surface. The dye penetration test does not indicate any quality deficiencies, however, this should be confirmed by micrograph analysis.

Results after one year of use in practice

A second opinion of the coated surfaces in the evaporator of the IHKW Andernach took place in October 2014, that is, roughly one year after the application. Amongst others, detachments of the layer, which had formed near a subsequently made weld, were examined here. The welding work was performed several months before the opinion and spontaneously cause local detachment. Since then, the detachment area has not grown, because contrary to some other corrosion protection layers, the material used here is not undercut. The defective spot can therefore be repaired.

At Site A, oxide formations could be found again on the membrane wall (next to the coating), on which moisture formed. With this second opinion, the effect already observed in May seemed to be even more pronounced. By contrast, the coating applied to the adjacent test area was free of these deposits.
The spray coating also exhibited greenish chlorides in the layer itself, however, based on experience they did not pose a risk to the coating. There are different hypotheses that describe this process – in regard to the underlying chemical and possibly metallurgical process they will be subjected to intensive analysis in another step.

Altogether – just as in May 2014 – a positive impression was obtained regarding the durability of the coating. Removal or abrasion of the protective coat could neither be substantiated through visual inspection nor through measurements.

8. Validation planned through measuring probes

Parallel to the treatment of the existing walls at the IHKW Andernach, material probes sprayed with the AmStar 888® material were installed in the steam generator of the industrial combined heat and power plant. Thanks to the inside temperature probes and a temperature graph it can be determined exactly at which point of the probe which temperatures occurred. This allows evaluating the impact of the temperature on the loss of layer thickness (or possible corrosion). The probes were investigated at the laboratory after 836 hours to examine coating, corrosion, the condition of the layers and other factors. Positioning at different sites allows comparing locations with little strain with metal temperatures up to approx. 400 °C and high strain, such as near the soot blower, where metal temperatures up to 500 °C were measured. Concepts for future use of the coating shall be derived from the results.

Figure 19:
Structure of the material probe

Figure 20:
Sections through the coated material probe after actual use
9. Quality control with alternative methods

Established layer thickness measurement has shown to be a major challenge in the context of the coating process. For years, cladding has been cleaned annually or even semi-annually to detect the condition of the coating and to perform layer thickness measurements with the eddy current method.

A reliable approach has been the use of locally destructive measuring methods, i.e. the abrasive removal of the spray coating and subsequent layer thickness measurement using adequate measuring equipment. This can present issues if care not taken in the cleaning as the underlying cladding can be damaged or have thickness removed. However, with the HVCC spray method and the utilization of the AmStar 888 material, these localized areas can be repaired and sprayed back to the thickness specification.

A paradigm shift would have to take place in favor of non-destructive testing: The operators would have to accept that not the layer thickness but already the existence of the layer (which is hardly removed when corrosion sets in) ensures corrosion protection. The presence of the coat could then be confirmed with alternative methods, for example, utilizing spectral analysis for the identification of boron.

10. Conclusion

The systematic – but unpredictable – failure of spray coating often observed in the past can be traced to internal stresses. Relieving these stresses – as outlined in section 5 – leads to a reliable, scalable and repairable coat with many advantages for the operating company.

The coating described in this article can be applied at the customer’s site, both on new and old galvanized steel tubes as well as on new or old cladding. The application can be performed roughly eight times faster than weld-overlay, and because of the coating process, no pressure testing of the steam generator is necessary.

Local damages of the coating – in the welding work application scenario described in section 6 – do not destroy the entire coat. Repair is possible if the surface is damaged.

The coating service provider offers a 99% guarantee on the coating on either new coating or on any repairs performed by the provider. They ensure that operation-related detachments (spalling) within a period agreed on with the customer occur only at one percent of the coated surface at the most. Comprehensive experience from various projects – including biomass and waste-to-energy power plants – show that the HVCC process in combination with the AmStar 888 introduced here has proven successful.

On test surfaces at the IHKW Andernach site (see section 6) the coating exhibits at least the same good service life as the existing overlay. Effective corrosion protection is therefore possible at the customer's site, which can extend the service life of clad or black membrane walls nearly at the end of their useful life or near minimum wall thickness.
11. Sources/Bibliography


