3CR12 IN ACTION

INTRODUCTION

This document has been compiled with the object of capturing and illustrating a number of applications where 3CR12 has proved it's worth with records extending over a number of years.

3CR12 is recognized as the original 12% Chromium utility stainless steel. Also known in Europe as type 1.4003 it is included in the specification pr EN 10028-7 for stainless steels suitable for pressure purposes. It is a weldable ferritic utility stainless steel and is not normally prone to stress corrosion cracking.

It is selected for it's corrosion resistance, it's strength and toughness and is particularly suited to wet materials handling due to it's ability to resist abrasion/corrosion. 3CR12 was developed as a superior alternative to coated carbon steel, cor-ten and aluminium. Atmospheric corrosion testing of 3CR12 has found an improvement of up to 250 times the life of unpainted carbon steel in certain marine environments.

3CR12 can be fabricated relatively easily and is weldable by conventional techniques. Where required it may be coated by means of brush, roller or spray, or powder.

3CR12 is included in Part 4 of SABS 0162—Code of practice for the structural use of steel and of significant importance is it's high strength and corrosion resistance.

This characteristic allows for mass savings together with the long term advantage of reducing maintenance and replacement costs.

Comprehensive data regarding technique viz. welding, forming, coating, handling etc. is readily available. Mechanical properties, rates of corrosion and design data may be obtained from SASSDA if required.

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CHAPTER 1:

3CR12 IN SUGAR PLANTS

For many years corrosion and abrasion have posed serious and costly problems for the sugar industry throughout the sugar-producing world.

Since 1980/81 when 3CR12 was introduced to the South African sugar industry it has proved itself in many applications in numerous countries in both cane and beet processing.

With 3CR12's resistance to corrosion abrasion and relatively low cost it has performed very well in most areas in sugar plants e.g. Cane Carriers, Diffusers, Bagasse handling, boilers etc.

The sugar industry is seasonally regulated with maintenance being carried out during the "off crop" period. Unplanned maintenance during the "crushing' period results in costly loss of production along with the cost of repairs.

A visit to a typical sugar mill in South Africa, which processes approximately 2 million tonnes of cane per annum, revealed many applications where 3CR12 is the preferred material of choice vastly out performing carbon steel.

For example the Main Cane Carriers where carbon steel needs replacement after 10 years maximum. 3CR12 was installed in 1985 and is still performing perfectly in 2003.

A chute lining in 6mm 3CR12 is still superb after 15 years of service.

The Diffuser housing, both roof and sides replaced in 3CR12 back in 1991.

Another excellent example is the Mixed Juice Scale where the lower tank was replaced in 3CR12 in 1988 with the upper tank following in 1989. Thickness tests conducted on both tanks recently (2003) found no significant loss of thickness.

Throughout the typical sugar mill one finds 3CR12 used in applications such as:

- Cane Carriers
- Juice Troughs
- Donnelly Chutes
- Bagasse Handling
- Ducting
- Scrubbers
- Centrifugals
- Ash Handling

Taking into consideration the fact that thinner 3CR12 than carbon steel may be used. Add the much longer life less the need for treating and painting, 3CR12 is a very cost effective material in the sugar industry.

***Fig.1:** Main Cane Carrier. Note Reflectivity of 3CR12 sides polished by service since 1985. Originally 10mm thick, now ≥ 9mm after 18 years service. Carbon steel lasts 10 years maximum in this application.*

Fig 2: Scalding Juice Heater cover. Note the condition of the carbon steel vs 3CR12.

Fig. 3: No. 1 and No.2 diffuser. Shells complete in 3CR12 in 1991.

Fig. 4: 3CR12 Manhole cover on diffuser No. 1

Fig. 5: Carbon Steel Manhole Cover on Diffuser

Fig. 6: ***3CR12 Frame and Carbon steel expanded metal.***

Fig.7: ***Egg grating in 3CR12***

Fig.8:   3CR12 Grating on Centrifugal Level

Fig. 9: Carbon Steel Egg Grating

Fig. 10: Centrifugal interior in 3CR12

Fig. 11: Centrifugals interior in 3CR12

Fig. 12: ***Mixed Juice Scale Tanks.***
Lower tank in 3Cr12 in 1988
Upper Tank in 3CR12 in 1989
Both were tested for thickness in 2003 with no loss in thickness reported.

Fig. 13 Exit from cane carriers

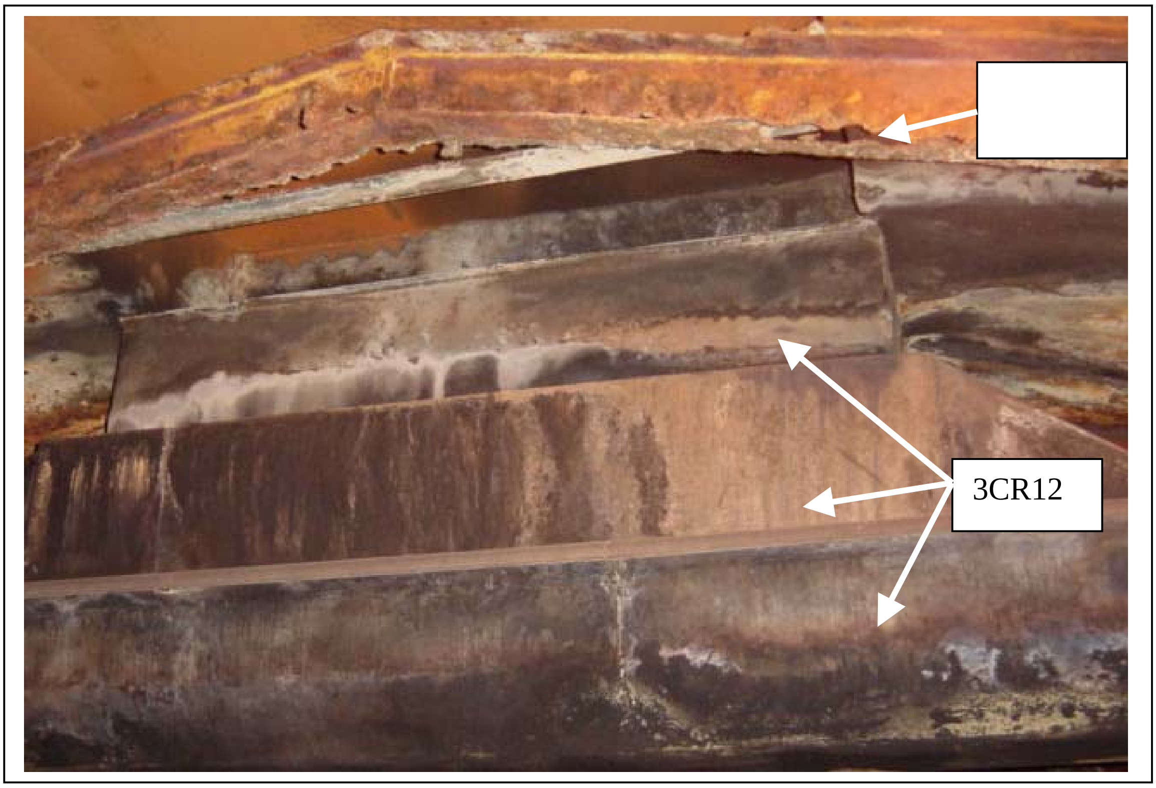


Fig. 14: ***Inside of roof of Diffuser***
Note Corrosion of Carbon Steel

Fig. 15: Slat Carrier. Note 3CR12 Side Plates and Runners.

CHAPTER 2:

3CR12 IN ELECTRIFICATION MASTS IN PORT ELIZABETH

A visual inspection was conducted on 18/03/2003 of the 3CR12 electrification masts erected along the railway line between Port Elizabeth harbour and North End. The railway line runs along the coast and is constantly exposed to sea spray during windy conditions.

The spot selected for the inspection is the nearest point to the sea viz. approximately 40 meters. In addition, there are various factories such as paints and chemical nearby, which may add to the corrosive environment.

The masts were erected in 1982 and are required to give maintenance free service for 40 years.

The previously documented inspection was carried out in January 1993. During this inspection some general discolouration was reported particularly on the seaward side. 10 Years later we find general "brown" overall discolouration equally on both landward and seaward sides (Fig. 4 and 5). In Fig 5 the tooling marks from the cold forming of the channel are still clearly evident.

Inspection of the welds found no indication of preferential attack in spite of the fact that they were not given any post weld treatment in pickling and passivation. See Figure 7 and 8.

Inspection of sheared edges found no appreciable difference as the masts are generally evenly discoloured with no significant corrosion evident at all.

In Figure 3 the condition of a painted carbon steel structure is clearly evident as is the condition of rails, which have been removed from service, Figure 6.

The only concern expressed by Spoornet during the inspection of Jan 1993 was the cracking of the concrete plinths caused by the carbon steel re-bar corroding inside the concrete. The concrete has subsequently been coated and could therefore not be inspected. However, re-bar is now available in 3CR12 and would eliminate the problem completely.

In conclusion, having seen 20 years of service it is abundantly clear that these masts will easily exceed the 40 years of maintenance free life required by Spoornet.

Fig. 1: General View towards harbour. Note replacement of carbon steel rail tracks.

Fig.2: View Indicating Proximity to the Sea.

Fig 3: Carbon Steel Electrification Box (Painted)

Fig. 4: Seaward Side

Fig.5:   Landside – Note original tool marks from cold forming of channel

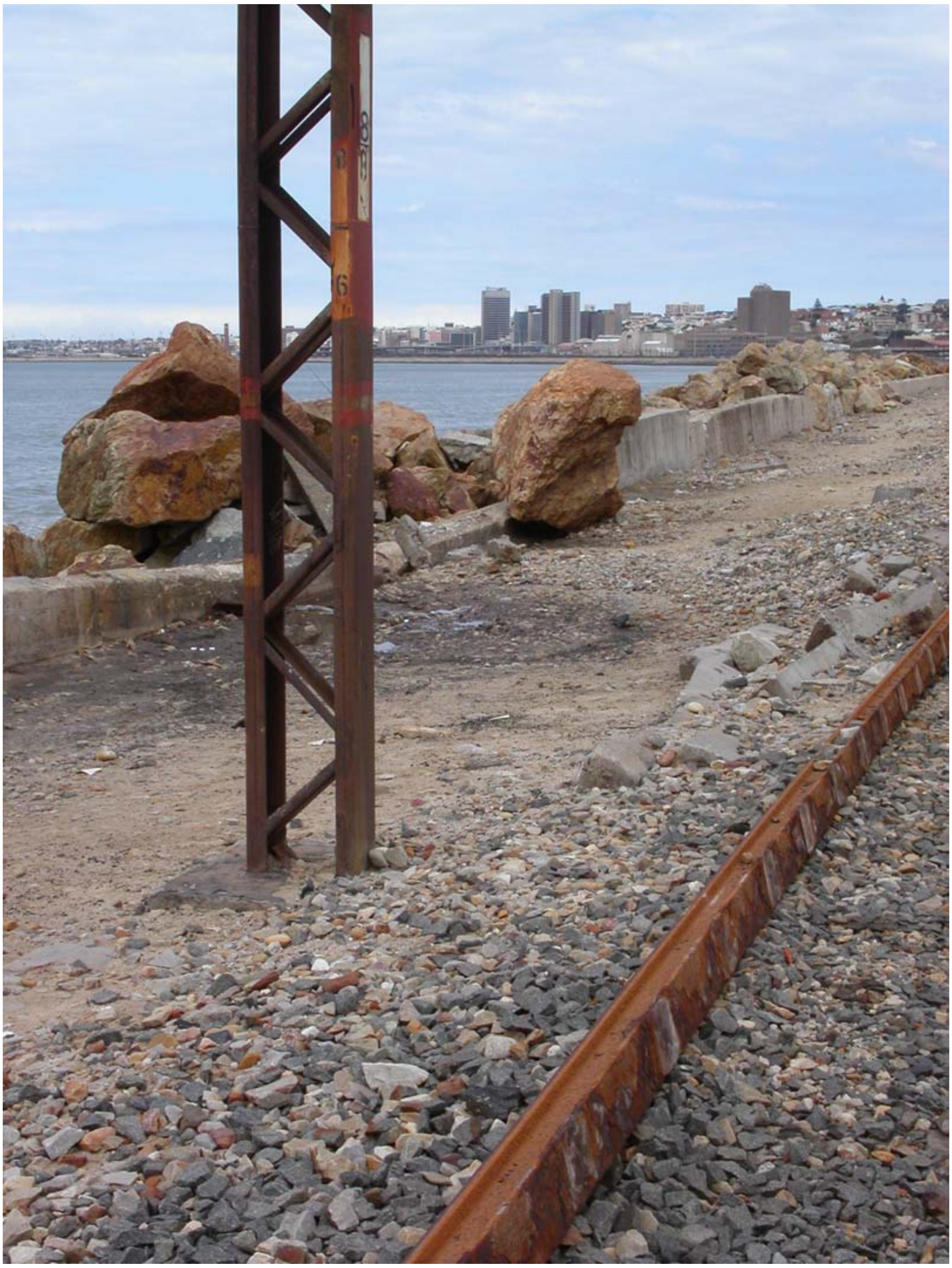


Fig. 6: Corrosion on rail tracks underside..

Fig. 7: Welded areas – No significant corrosion

Fig. 8: Welds Indicate No significant corrosion.

CHAPTER 3:

X-GRID PACKS IN POWER STATION COOLING TOWERS

Acknowledgement: Knight Piêsold

INTRODUCTION

Most power stations in South Africa rely on evaporative cooling through natural draught towers in order to dissipate waste heat.

Traditionally cooling towers utilised timber slats packed inside the towers. These slats serve to break the water up into droplets thereby facilitating the cooling process through the upward draught in the towers.

Due to the limited service life of the timber slats and the cost of repacking the towers an alternative was required.

Experiments were conducted using plastic and also asbestos cement without success.

X-GRID

The idea of using 3CR12 expanded metal mesh surfaced and after extensive tests a tower at Rooiwal Power Station was fitted with the mesh, which was named X-Grid.

X-Grid is manufactured from 1.2mm 3CR12. It may be produced to various opening sizes and strand widths depending on the relevant water quality and it's scale-forming properties.

The remaining towers were subsequently repacked with X-Grid, which has now been in service for up to 20 years maintenance free.

X-Grid has good heat transfer characteristics and is easily installed.

The suspension system however must be robust enough to support the grids (eleven layers) without sagging.

In these particular towers up to 10 tonnes of water per square metre per hour passes through the X-Grid for 24 hours per day while the tower is running. The design life of the X-Grid is 30 years.

As a consequence of X-Grids superior thermo dynamic efficiency the tower performance is improved thereby improving turbine efficiency, which in turn results in significant energy cost saving.

***Fig 1.:** View of the X-Grid layers inside the cooling tower after 20 years service. Diameter is approx. 52 meters.*

Fig 2: View from above looking down through the layers of X-Grid

Fig 3: View of the layers (11 in total) of X-Grid from outside the tower. Total Mass of X-Grid 36 tonnes

Fig 4: Note the efficiency of the break-up of the water into droplets thereby facilitating cooling.

CHAPTER 4:

FENCE IN 3CR12 EXPANDED MESH

In July 1990 the first sections of a fence were erected for Armscor near Grabouw in the Cape. Proximity to the sea is 16 km at the nearest point. The region is mountainous with very frequent mist and wet conditions.

The fence is of expanded mesh made from cold rolled (2B finish) 3CR12 and is approximately 35km in length.

The fence was designed to last for 25 years and has been subjected to investigation by the then Middleburg Steel and Alloys, the CSIR and J. Muller Laboratories due to the fact that discolouration appeared, especially on the sheared edges of the mesh as early as March 1991.

Inspection of the fence in 19/03/03 found the fence discoloured yet in perfect condition. Totally free of maintenance and actually blends in with the environment. The comment was made that when originally erected the "bright shiny" fence did not fit the surroundings.

Shortly before the inspection of the fence a grass fire had scorched the area with no effect on the 3CR12. Had the fence been of traditional galvanised wire mesh the heat of the blaze would have destroyed the benefits of the galvanising and exposed the carbon steel wire to the elements.

Fig 1 Section of 3CR12 Expanded Mesh Fence extending 35km in the Cape Mountains. Note the burnt countryside.

CHAPTER 5:

3CR12 IN PROCESSING AND TRANSPORTATION OF COAL

3CR12 is a lower cost 12% Chromium containing corrosion resisting material. It has proved to be a cost effective material in coal preparation plants where it's greater strength and resistance to wet abrasion /corrosion have made it the preferred material in many applications. 3CR12 is not intended to replace stainless steel rather, it slots in between stainless and the more corrosion prone mild steels.

Coal beneficiation involves washing, separation and screening amongst various other processes. In many of these applications moisture is present together with the corrosive and abrasive nature of the coal. 3CR12's greater strength allows for lighter construction than with mild steels and it's superior slide ability reduces "hang-up" e.g. in chutes.

At this point it must be stressed that 3CR12 performs very well under wet, abrasive, corrosive conditions. However under dry abrasion or impact conditions 3CR12 will not perform any better than conventional mild steels. In addition, for certain applications such as piping in immersed conditions, tanks etc. research into flow rates, dissolved solids, chloride, sulphate and nitrate concentrations should be conducted.

Some examples of applications where 3CR12 has proved to be cost effective and successful in the processing of coal would include the following:

Bucket Elevators
Chutes
Bins and Silo's
Liner Plates
Conveyors Systems - Idlers and brackets
- Deck Plates
- Stringers
Dust Extraction
Launders
Piping
Screen Under Pans
Settling Cones
Sieve Bends
Structural Steel
Spiral Classification Plants
Distribution and Splitter Boxes
Electrical Boxes
Machine Guards
Screens
Flooring and Stair treads
Hand Railing
Cable Support Systems
Ducting
Perforated Plate

TRANSPORTATION OF COAL VIA RAIL WAGONS

Since 1985 when 3CR12 was first used in the manufacture of CCL monocoque coal wagons, many thousands of wagons have been put into service worldwide.

CCL "Jumbo" wagons which were previously built in Cor-ten have been replaced with 3CR12 using 6mm plate for the tubs and 4mm for the sides.

Since the introduction of 3CR12 in 1985 two wagons viz. No. 63-636-106 and 63-535-114 were inspected in 1986 and again in 1999. After 14 years of service the wagons were still in excellent condition with areas of high abrasion e.g. the sides having a smooth, shiny surface with extremely good slide ability.

With no apparent signs of fatigue, weld failure or pitting in the heal-affected zone these wagons were found to be in excellent condition and may be expected to last for approximately 50 years.

The CCL wagon is discharged by tipping and carries a load of approximately 82 tonnes.

Another type of coal wagon built in South Africa using 3CR12 was a fleet of 58 wagons for the rail link between Duvha Open Cast mine and Middleburg Mine Services. The wagons carrying 57 tonne loads discharge through discharge doors. 3CR12 was used in the body sides, discharge doors, under frame and bulkhead liners.

Inspection was carried out in March 2003. After little more than 10 years in service the wagons were found to be in superb condition with no apparent wear or any signs of fatigue or weld related defects.

Once again 3CR12 resistance to corrosion abrasion is demonstrated with the CCL wagon in particular. The CCL wagons are used on the rail line from the coal fields in the interior to the terminal at Richards Bay thus exposing them to corrosive marine conditions. While these wagons are free of corrosion inspection of Cor-ten wagons back in the eighties found large layers of corrosion product lifting off the steel surfaces which are knocked off when the wagon is loaded only to form again which results in severe loss of thickness through corrosion / abrasion.

Fig. 1: 57 Tonne Coal Wagon as used on the line between Duvha Open Cast Mine and Middleburg Mine Services. Was originally painted white hence the unusual appearance.

Fig. 2: Discharge Door

Fig. 3: Discharge door in the Open Position

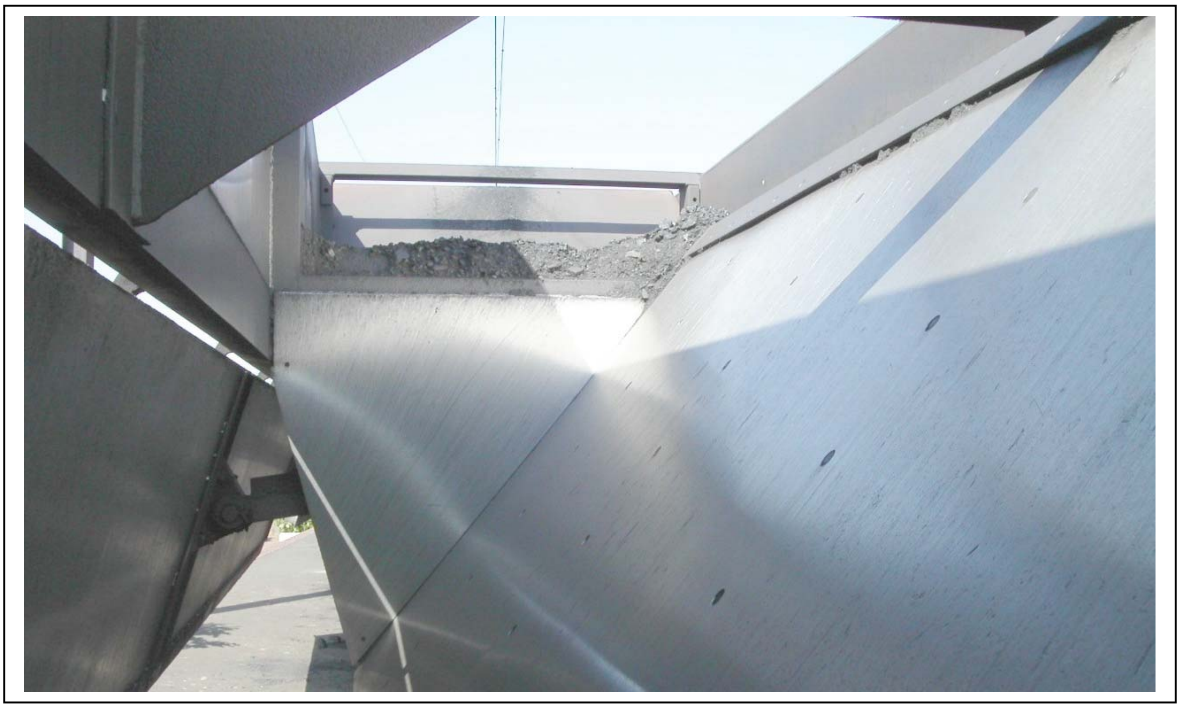


Fig. 4: View of the interior with the Discharge Door open.

Fig. 5: View of Liner Plate. Note the almost "as machined" bevel on the edge against which the discharge doors close.

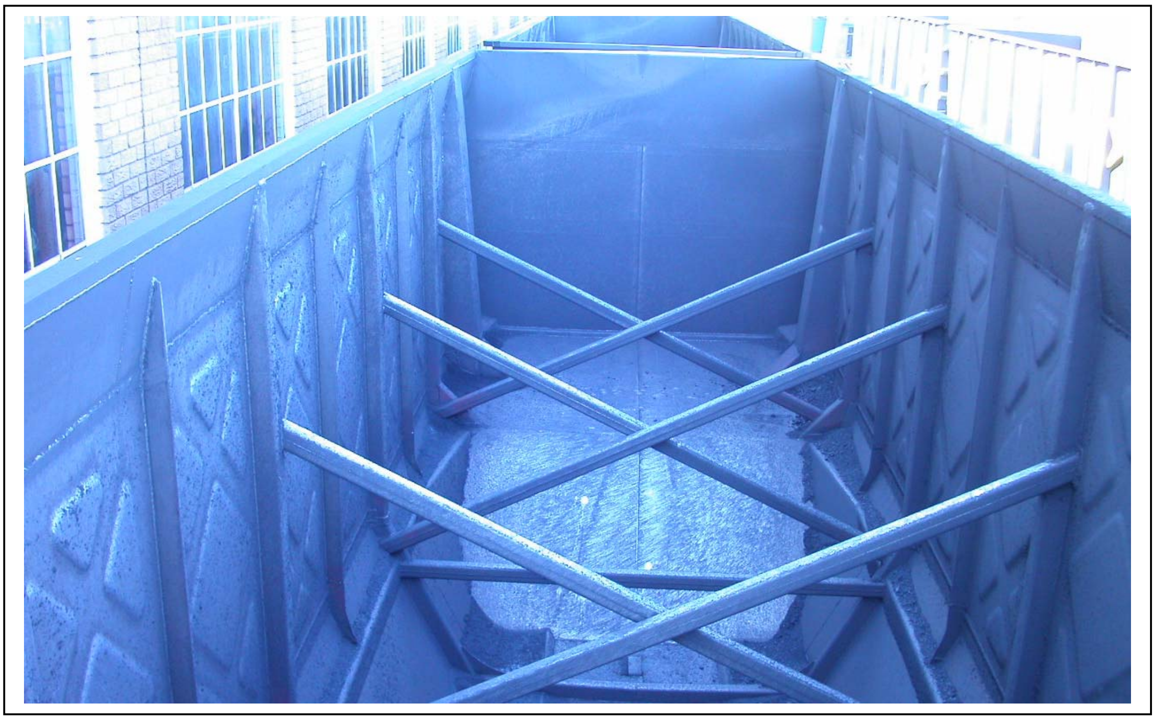


Fig. 6: Interior of an 82 Tonne CCL Jumbo Wagon

CHAPTER 6:

3CR12 REINFORCEMENT OF CONCRETE

Reinforced concrete is widely used for structures ranging from high-rise buildings to industrial process structures, tunnel linings and various forms of road works. Of the most visible uses of reinforced concrete is the construction of rail and road bridges, freeway interchanges and flyovers.

Reinforced concrete relies on the protection afforded by the concrete to prevent corrosion of the reinforcing steel. However, with time the diffusion of atmospheric carbon dioxide into the concrete will in the presence of water vapour progressively neutralise the alkaline elements within the concrete matrix thereby reducing the protection to the steel reinforcing.

This process known as carbonation is generally slow. Eventually when the pH of concrete in contact with the steel approaches 7, the iron salts become soluble and corrosion of the steel commences.

Chloride ions in a coastal or industrial environment are a particularly aggressive agent that results in the degradation of reinforced concrete. The chloride ion being one of the smallest, will penetrate most concretes and once they come into contact with the steel corrosion will commence.

The product of corrosion viz. iron salts and oxide occupy a considerably greater volume than the parent steel. Ongoing corrosion of the steel and the formation of associated corrosion products results in cracking of the concrete followed by spalling.

With major reinforced concrete structures such as harbours, bridges etc. on or near the coast being required to have a usefull life in excess of 100 years corrosion of the reinforcement poses a significant problem.
Efforts to combat corrosion within the concrete have ranged from coated carbon steel to the use of expensive stainless steel viz. 304 and 316.

The most commonly used protective coating is by hot dip galvanising. However, where chlorides in moderate to high concentrations are present the galvanising does not appear to impart any significant benefit. Epoxy coating of reinforcing has appeared extremely effective in protecting the carbon steel in laboratory tests. However, protection is dependent on complete and undamaged coating.

Experience with the handling and transportation of re-bars and pre-coated structural steel concludes that there is little likelihood of undamaged coated carbon steel re-bar being cast into concrete.

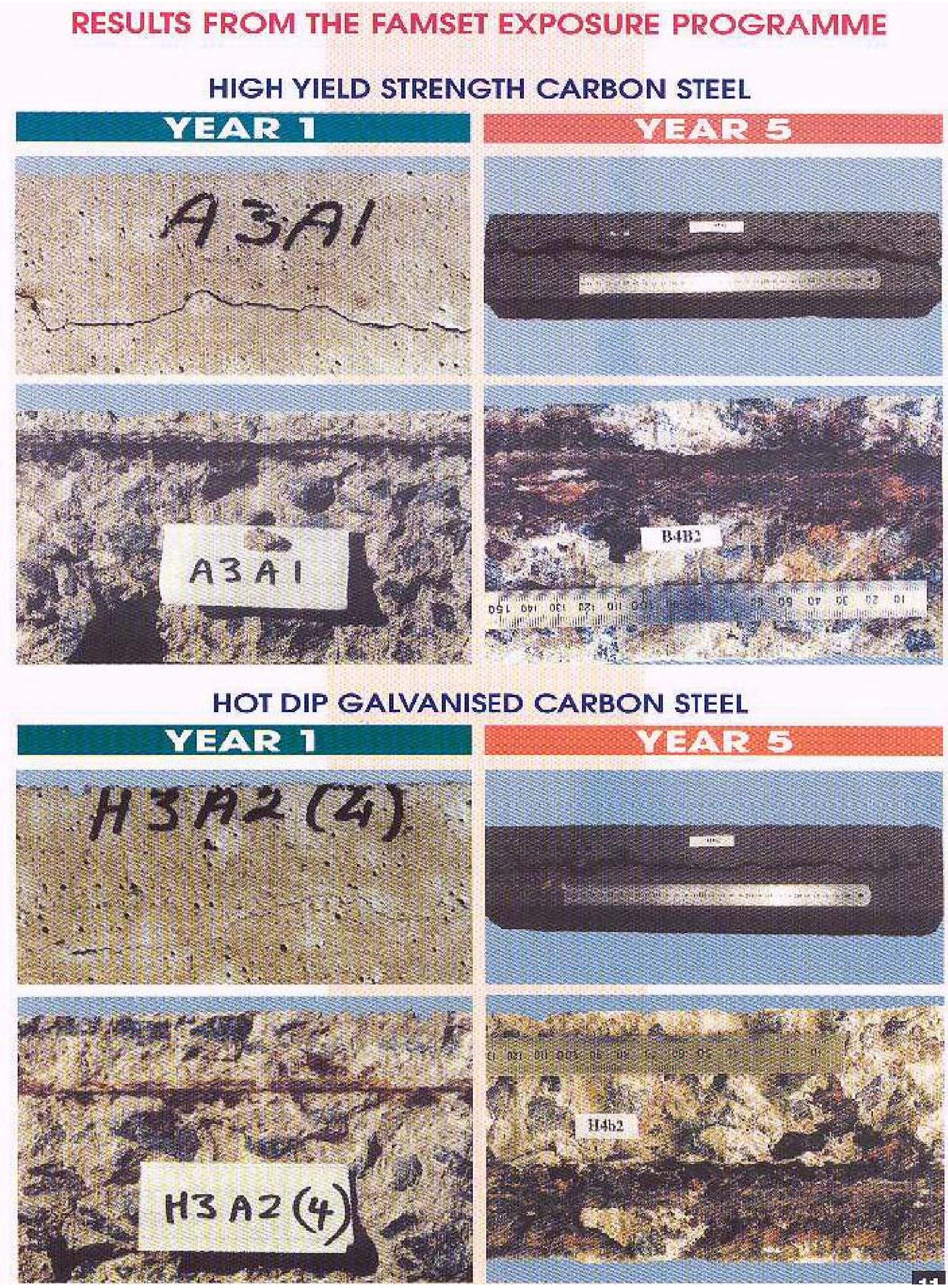
Extensive comparative tests have been conducted over periods of 5 years and found that both stainless steel and 3CR12 have excellent resistance to severe levels of diffusion into the concrete matrix.

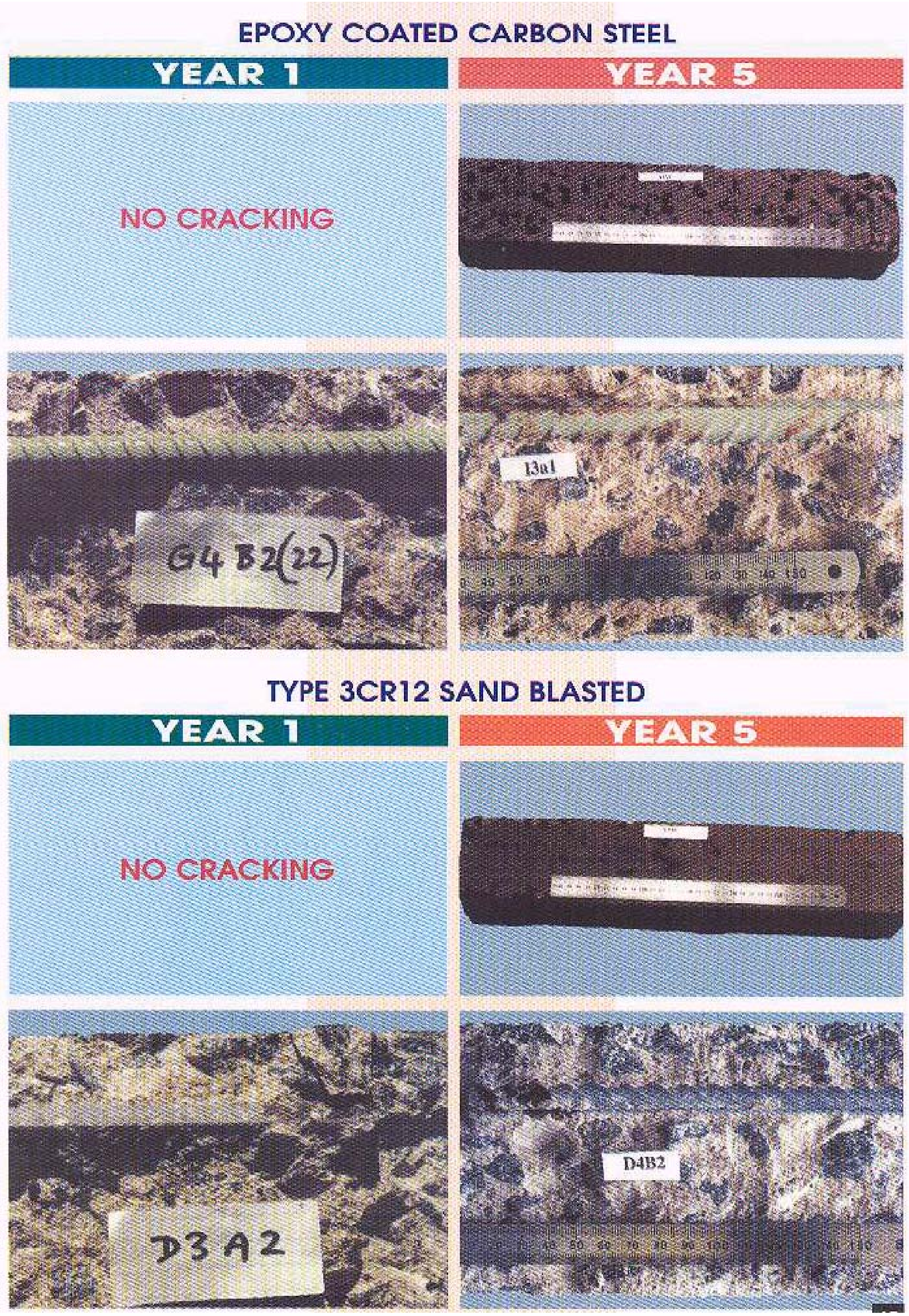
Long, maintenance free service life requirements in excess of 50 years for reinforced concrete structures in marine and some aggressive industrial environments will best be met by the use of corrosion resisting steel. Structures built using accepted concrete practices and using **3CR12 (1.4003)** or other stainless steel reinforcement will have long service life with no or minimal costs resulting from corrosion of the reinforcement.

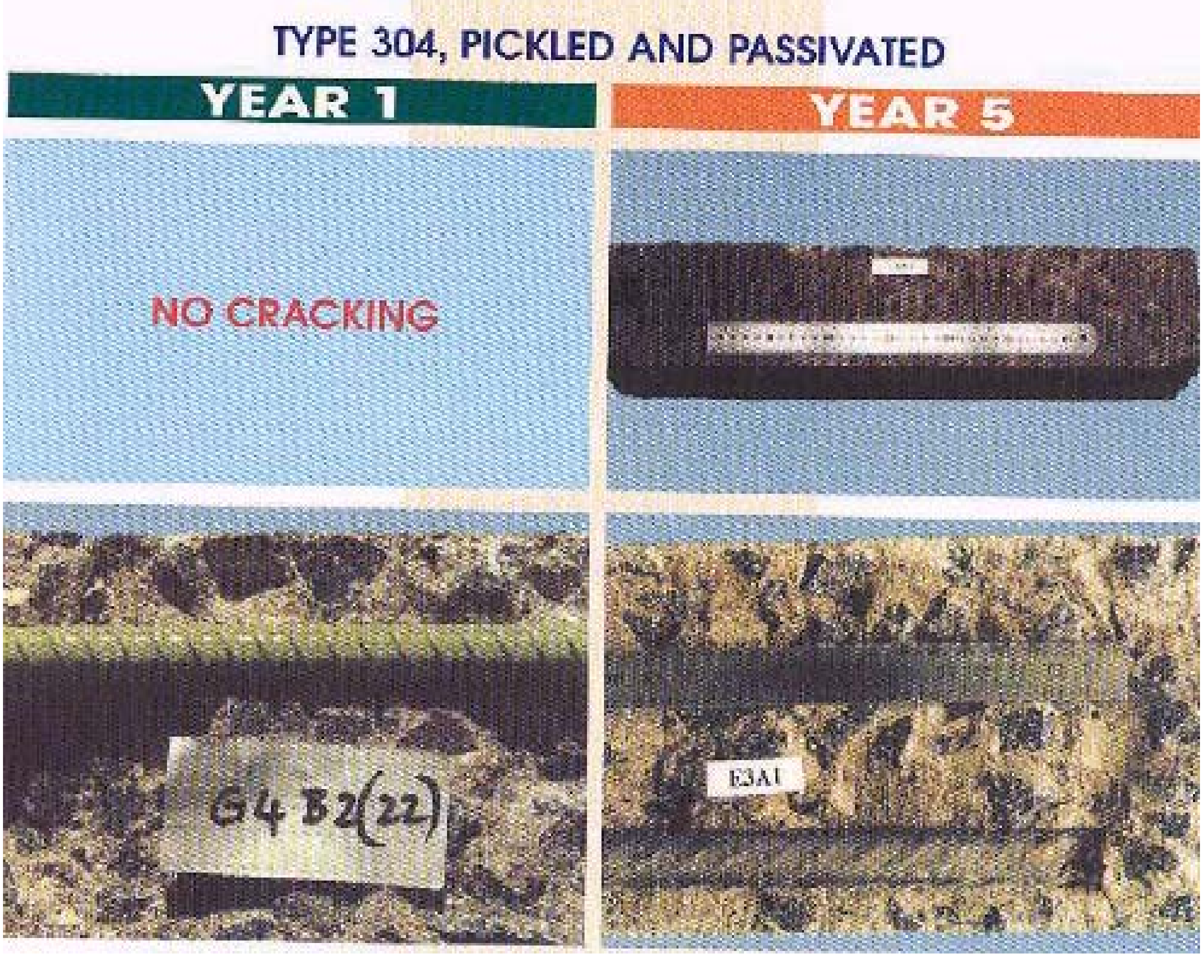
3CR12 (1.4003) reinforcement has been demonstrated to be economically viable over the life of a structure as an alternative to the rehabilitation costs of a conventional carbon steel reinforced structure. In the cost comparison carried out on the two KwaZulu-Natal bridges, the cost of high yield strength carbon steel reinforcement used in the comparison was R3 600 per ton, a figure substantiated by recent tendered rates. The comparable rate for **3CR12 (1.4003)** reinforcement is R6 000 per ton. The cost of the carbon steel reinforcement in the bridge beams and deck slab constitutes 11% of the total cost of those elements. The use of **3CR12 (1.4003)** reinforcement would increase the cost of the reinforcement to 24% of the total cost of the structure.

3CR12 (1.4003) is a material which demonstrates a definite economic advantage on a total life cycle costing basis if used for reinforcement of concrete structures on or near the coast, and in industrial structures in locations where there is significant risk of chloride ion diffusion into the concrete cover to the reinforcement.

FAMSET = Facility for Accerlerated marine Exposure Testing



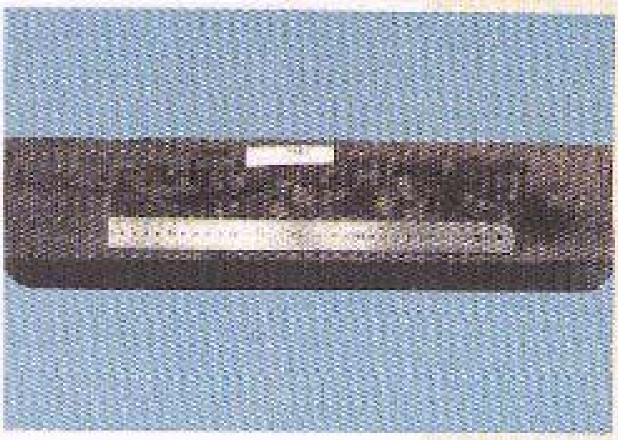

EPOXY COATED CARBON STEEL
YEAR 1
YEAR 5
NO CRACKING
G4 B2(22)
13a1
TYPE 3CR12 SAND BLASTED
YEAR 1
YEAR 5
NO CRACKING
D3A2
D4B2


TYPE 304, PICKLED AND PASSIVATED
YEAR 1
YEAR 5
NO CRACKING
G4 B2(22)
E3A1

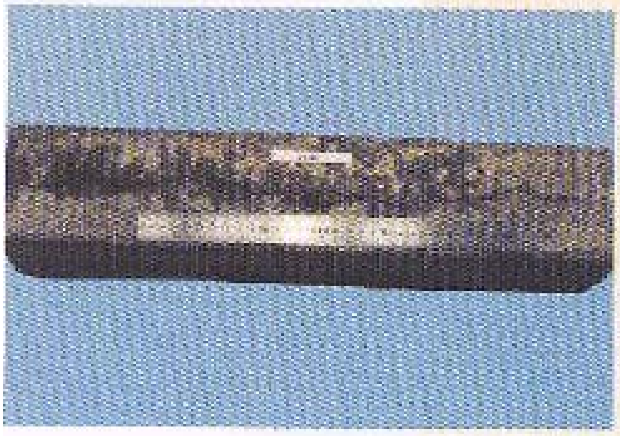
RESULTS FROM THE DURBAN BLUFF EXPOSURE PROGRAMME

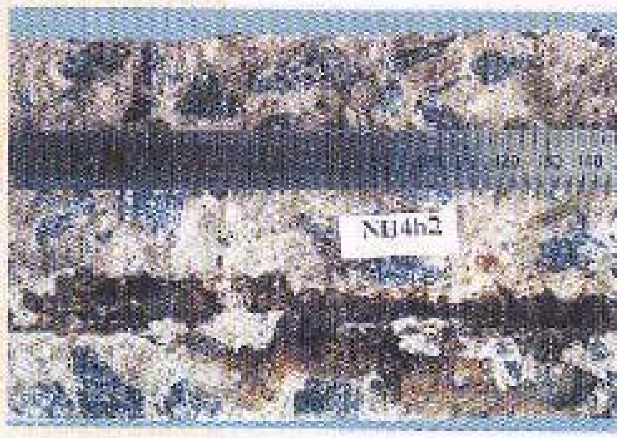
AFTER 5 YEARS EXPOSURE

HIGH YIELD STRENGTH CARBON STEEL



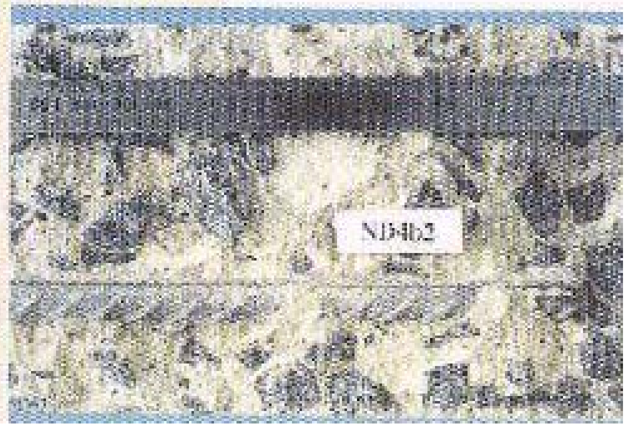
HOT DIP GALVANISED CARBON STEEL





TYPE 3CR12 SAND BLASTED

NO CRACKING



CHAPTER 7:

3CR12 IN COATED APPLICATIONS

Due to the fact that 3CR12 will discolour and form a layer of rust coloured patina, painting or coating may be considered either for aesthetic reasons or to increase corrosion resistance.

3CR12 has exceptional under paint corrosion resistance as well as resisting under paint creep where the coating has been damaged.

Surface preparation is extremely important and may be performed either by acid pickling or mechanical means such as blasting. The type of cleaning and the extent or severity is dependent on the type of coating and it's application.

Coatings may be applied by brush, roller or spray or electrostatic spray in the case of powders and it is recommended that all paints for a particular coating system be obtained from one manufacturer.

Note that coating types, their application as well as surface preparation should always be per recommendations of the manufacturer of the coating system.

Fig 1: Powder Coated 3CR12 Post Boxes

Fig. 2: Electrical Distribution Box at Richards Bay approximately 20 years in service.

Fig.3: Paint lifted from bottom of box revealing good Cold Rolled 3CR12 underneath.

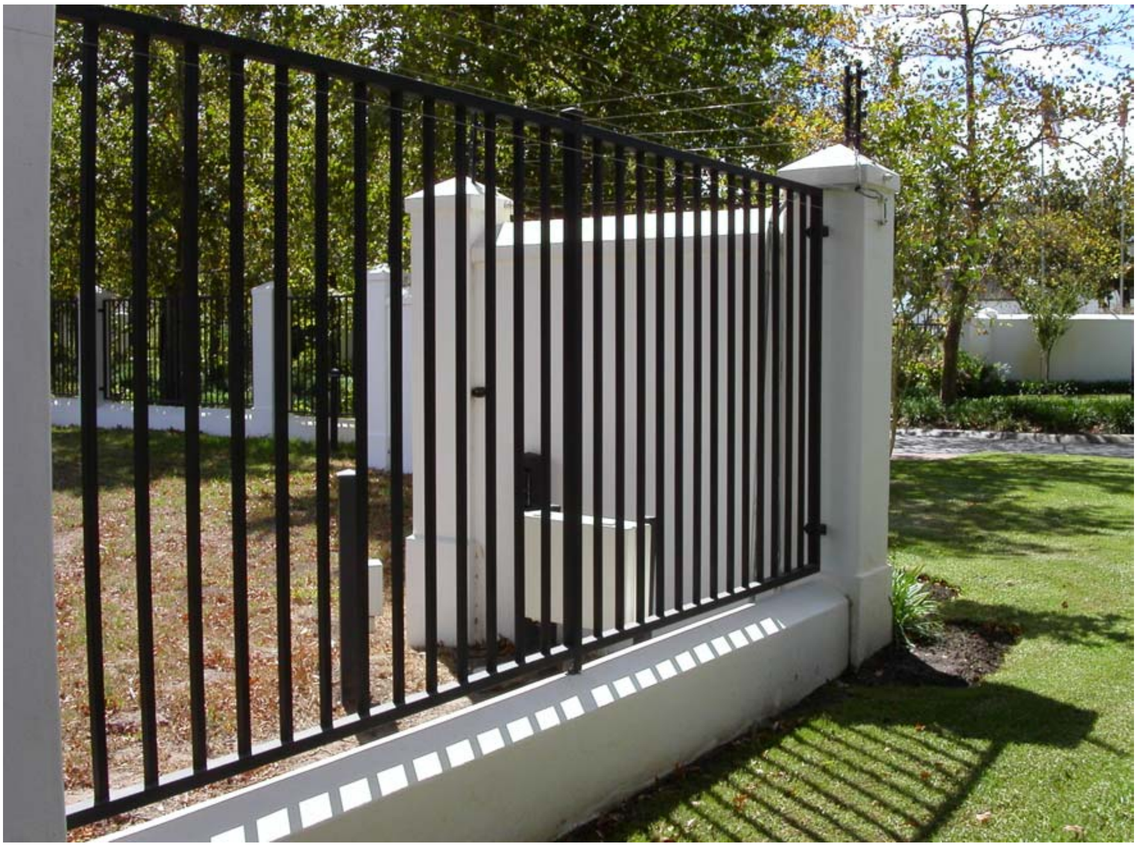


Fig 4: Painted Fencing at Erinvale Estate in Cape Town.

CHAPTER 8:

3CR12 IN WATER APPLICATIONS

3CR12 has been used extensively in aqueous environments since it's introduction in 1979. It's resistance to general corrosion has often been good however, as with any material relying on the formation of a passive film for corrosion resistance certain factors must be considered such as:

Design
Fabrication
Aeration and flow rates
Suspended solids, scaling and fouling
Water quality and temperature
PH value
Microbial activity
Chloride activity
Sulphate and nitrate

3CR12 has been used successfully in numerous applications such as piping, tanks, X Grid packing in cooling towers, settlers, immersed plate, animal drinking troughs etc.

Since the early eighties 3CR12 has been successfully used in the purification of domestic sewage. Due to it's wet abrasion/corrosion resistance it has proved to be an excellent alternative to coated carbon steel e.g. in the controlled breakdown of sewage. Aerators, which were traditionally made from coated carbon steel, were replaced in 3CR12 in 89/90 with success.

Typical applications for 3CR12 in sewage are weir plates and scum boards, sluice gates, scum troughs, egg grating and stair treads. In the Middelburg sewage works a DAF thickener has been operating since 1989. The thickener is 8000mm in diameter and 3600mm in height. Produced in 6mm and 10mm plate, was pickled and passivated on site and outward appearance as good as new in 2003.

Due to the fact that the corrosiveness of water can vary considerably according to it's chemical composition it is of utmost importance that applications be thoroughly researched beforehand. Considerable research work has been done by various academic institutions and R&D organisations throughout South Africa and guidance is available through the South African Stainless Steel Development Association.

Fig 1: DAF Thickener built in 1989 for the Middelburg Municpality..

Fig 2: ***DAF Thickener. Note condition of Welds..***

Fig 3: ***Painted carbon steel piping in close Proximity to the DAF Thickener***

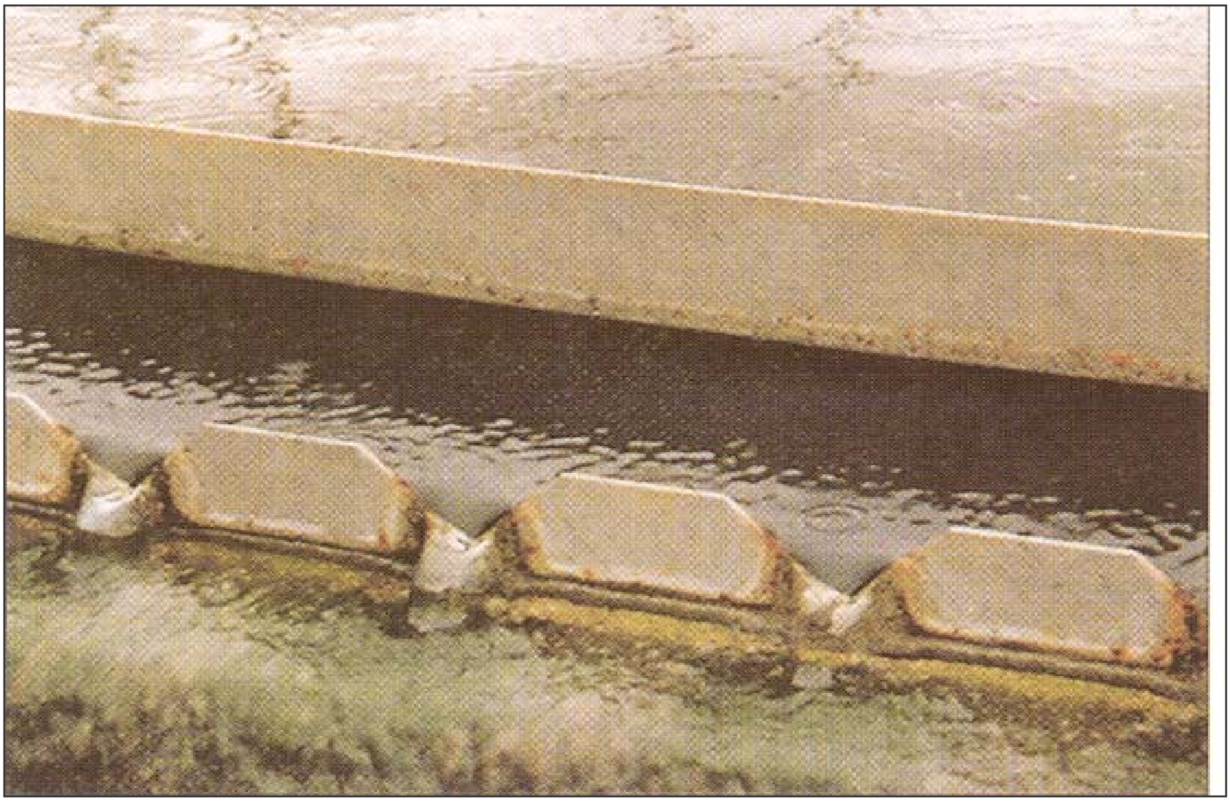


Fig 4: 3CR12 weir plates at Klipriver after approximately two and a half years in operation

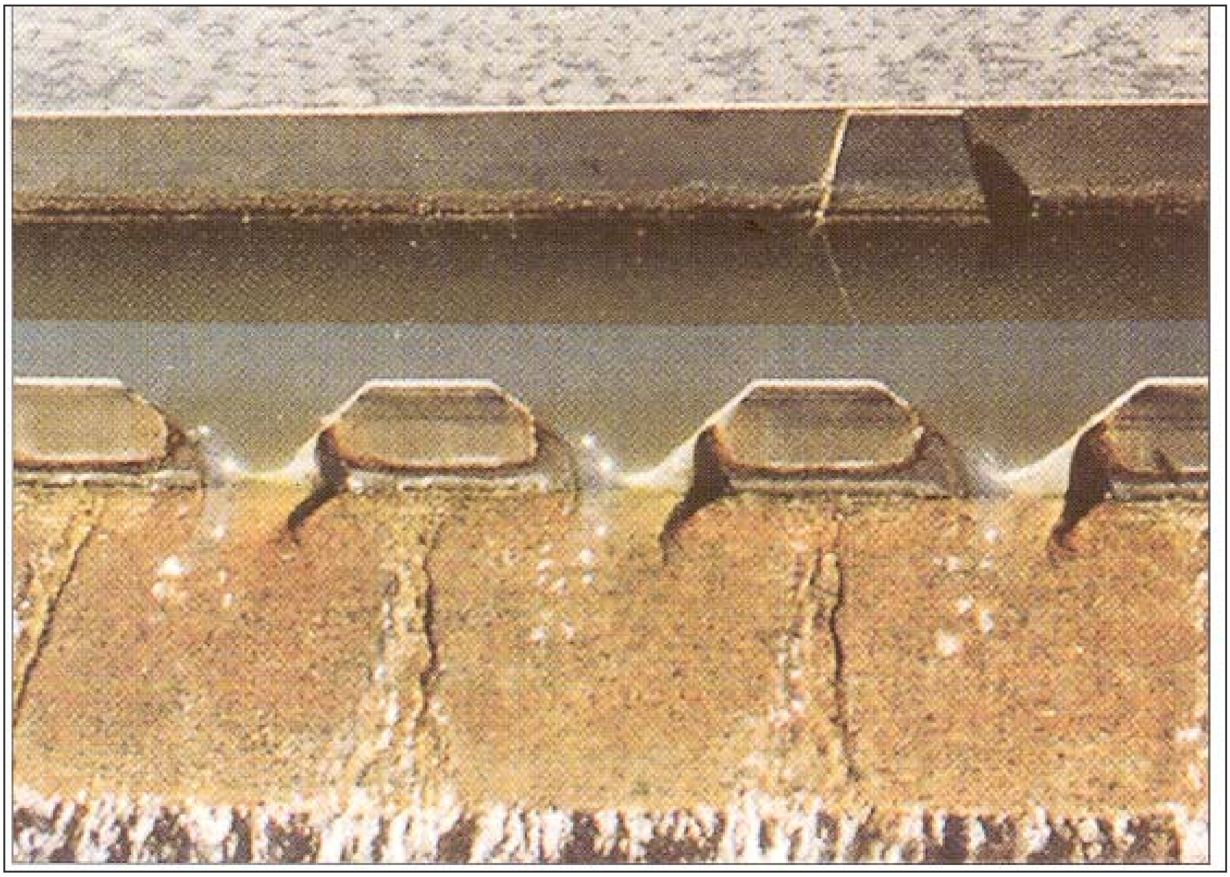


Fig 5: 3CR12 weir plates at Klipriver after approximately six and a half years in operation.

CHAPTER 9:

3CR12 IN TUBULAR BUS FRAMES

3CR12 is utilised in the construction of tubular bus frames in order to minimize the effect of corrosion in numerous countries world wide.

Manufacturers in Europe and South Africa have selected 3CR12 as the material of choice for the construction of bus frames due to it's excellent weldability and high mechanical properties.

Due to it's corrosion resistance together with it's high proof stress, maximum passenger safety is achieved while guaranteeing long term structural integrity.

The use of 3CR12 can realise a mass saving of up to 900 kg due to its higher strength which allows for lighter gauges to be used.

In South Africa, TFM Pty Ltd supplied the first single decker passenger buses to the Johannesburg City Council, early 1994. Inspection of one of the buses in 2004 found the 3CR12 framework to be in excellent condition. See Fig 3 & 4.

Fig 1. New TFM Bus in 1994

Fig. 2: TFM Bus in 2004

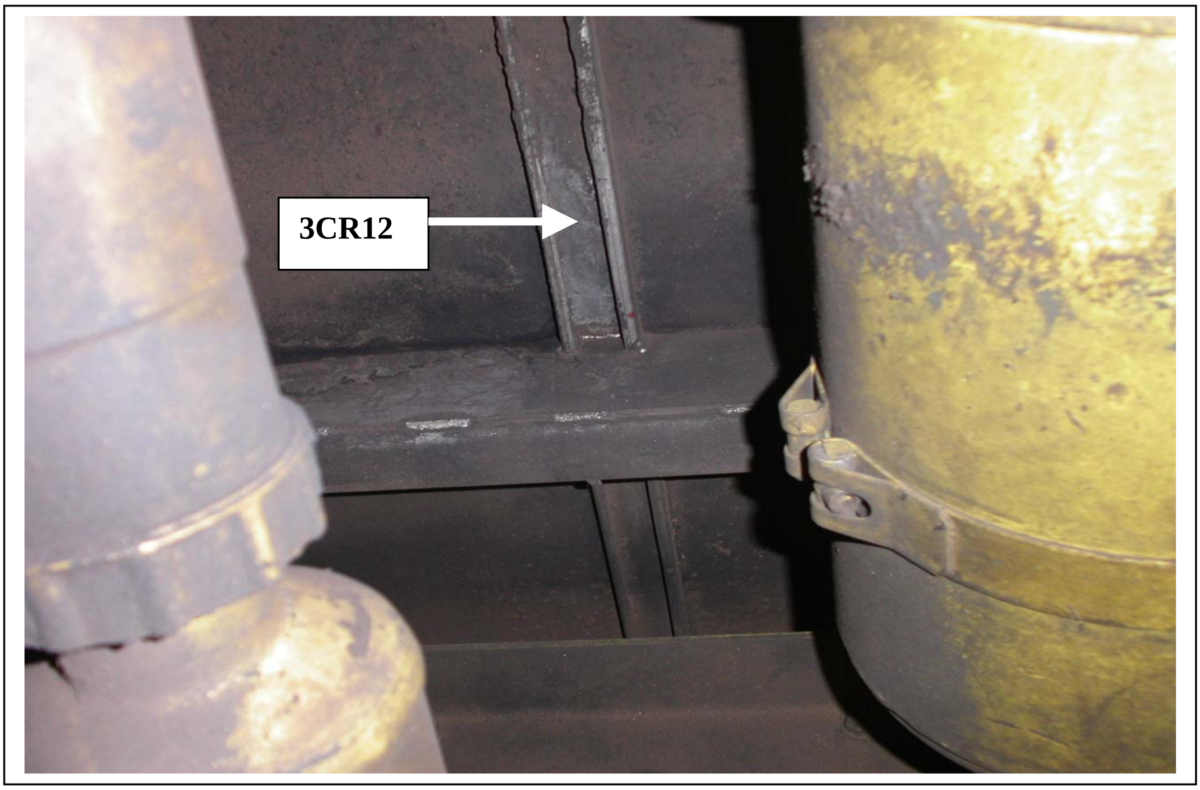


Fig. 3 View of 3CR12 Framework underneath Bus. Approximately 10 years old

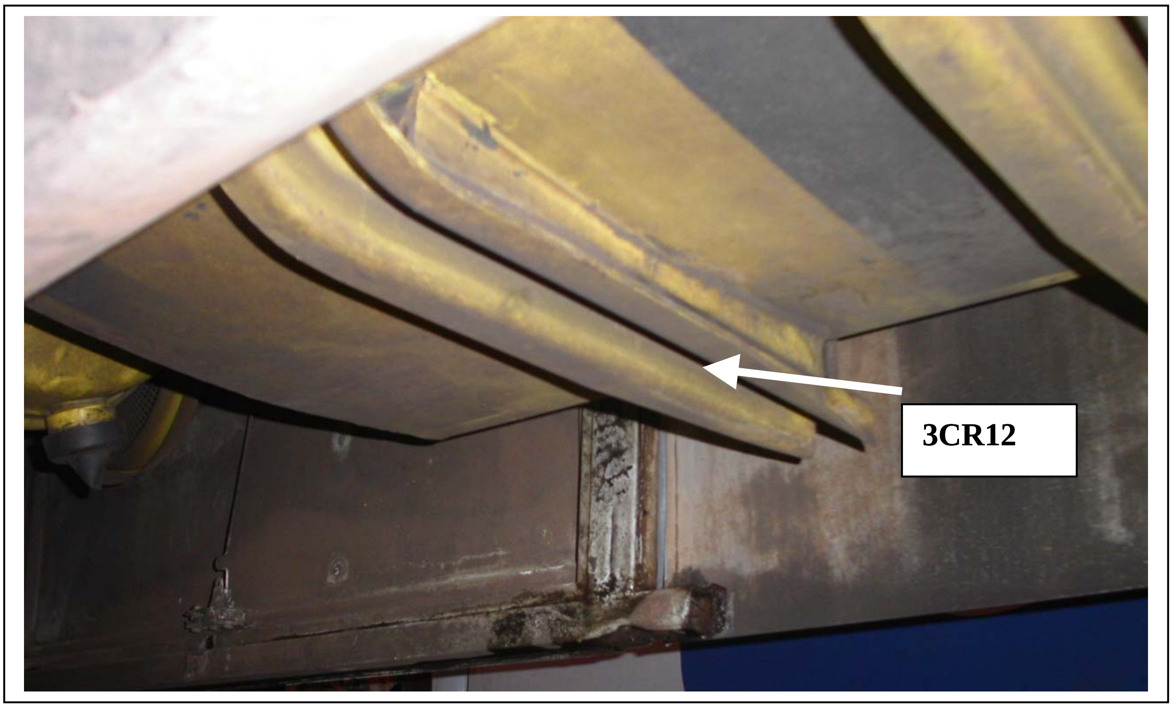


Fig. 4: Underframe of 10 Year of TFM Bus

CHAPTER 10:

AN APPLICATION WITH A DIFFERENCE

Fig. 1   The Dodgem Car Arena

In the early eighties serious maintenance problems were being experienced by the owner of the Dodgem Car facility at the Beachfront playground in Durban.

The floor of the Dodgem Car arena consisted of carbon steel, which continually corroded. The corrosion generally occurred during the downtime such as overnight or out of season. The subsequent layer of oxide would then be pulverized and picked up by the cars and then contaminate the electric motors giving rise to costly maintenance and repairs.

The decision was taken to replace the carbon steel flooring with 3CR12. The plates (6 x 1000 x 2000mm) were bolted to the floor with countersunk bolts and have been in service for over 20 years. A visit to the playground in July 2003 found the floor to be shiny and smooth and maintenance on the cars reduced by approximately 80%.

Fig.2: ***6 x 1000 x 200mm 3CR12 plates bolted to the dodgem car floor.***