Sustainable Stainless Steel for Wagons

Ramesh R. Gopal
Executive Director

National Workshop on Stainless Steel Coach & Wagon Manufacture

Jadavpur University

8 - 9 September 2011, Kolkata

Iron and Steel are the most commonly used fabrication material for

Railway wagons

Reasons . . .

- Abundantly available
- Low initial cost
- Easy to fabricate, cast and forge
- Good strength
- Easy to enhance properties by adding alloying elements and heat treatment
- Recyclable & eco-friendly

ISSDA STAINLESS STEEL

BUT, they are

- Prone to general & other forms of corrosion.
- Corrosion protection, repair, maintenance and replacement processes are costly and time consuming.

Are there any options? Yes!

Aluminum for instance has different sets of limitations of fabricability, cost, strength, availability, recyclability and impact on environment.

ISSDA STAINLESS STEEL

VARIATIONS OF IRON & STEEL

LIKE STAINLESS STEELS,

PROVIDE A VIABLE OPTION.

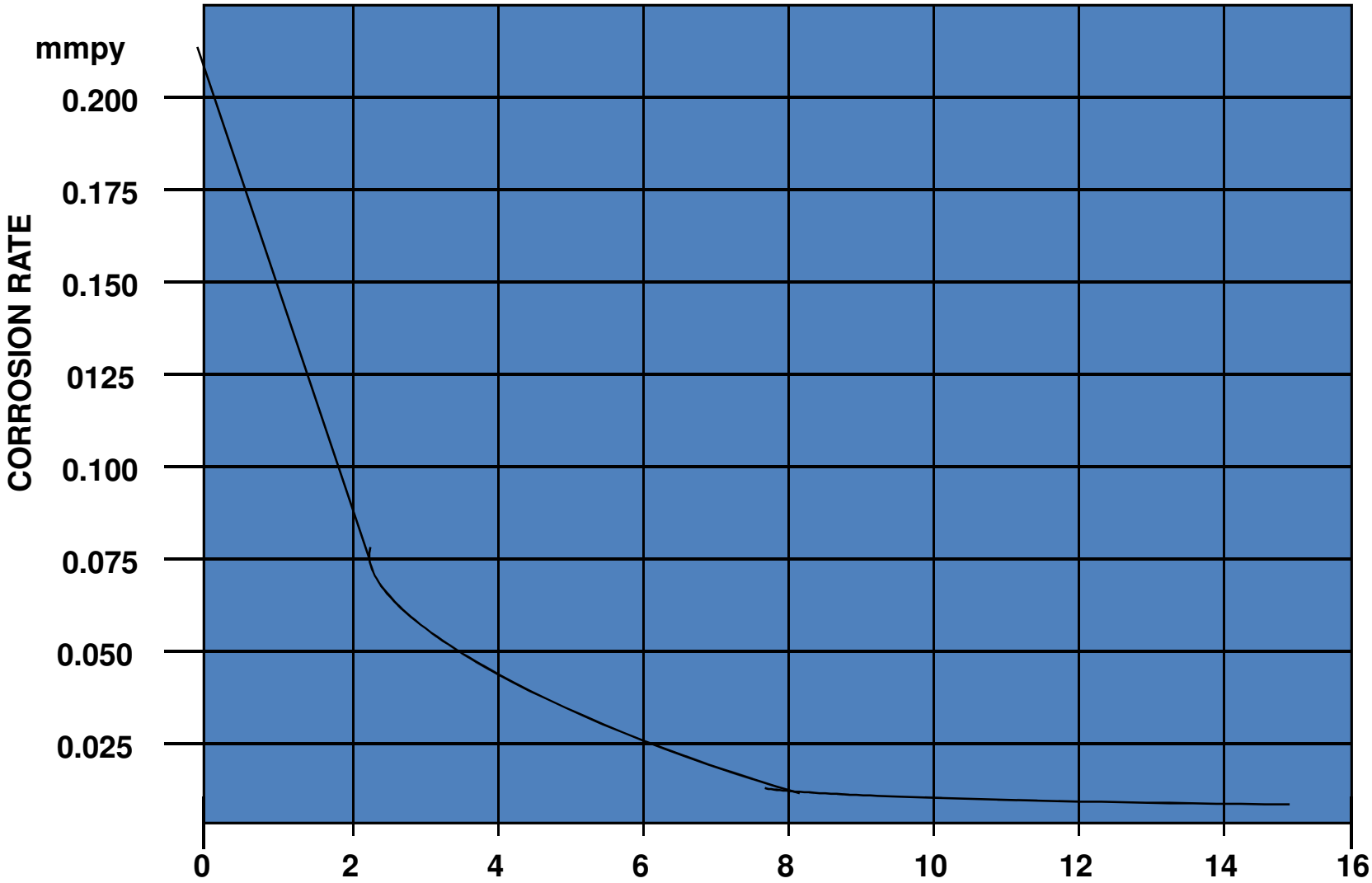
ISSDA STAINLESS STEEL

Which Stainless Steel?

- Stainless steels are part of the steel family containing a minimum of 10.5% chromium.
- They are much more corrosion resistant than most structural and engineering steels.
- There are more than 100 grades of standard stainless steels, and many proprietary grades.
- For wagon application, we will be talking about only one utility grade stainless steel 1.4003, which has numerous local names in different countries.

ISSDA STAINLESS STEEL

EFFECT OF CHROMIUM CONTENT ON CORROSION RATE



ISSDA STAINLESS STEEL

UTILITY STAINLESS STEEL GRADE 1.4003

• 3CR12	South Africa
• HYFAB 3/12	United Kingdom
• 1.4003	Germany
• F 12 N	France
• YUS 410W	Japan
• S41003	USA
• 409M	India
• IRSM 44/97	Indian Railways
• CK 201	Indian Railways

ISSDA STAINLESS STEEL

Utility Grade 1.4003

- Far more corrosion resistant than standard engineering steels, yet less expensive than high alloy stainless grades.
- Good resistance to Corrosion & Abrasive wear
- High strength (Yield Strength > 320 Mpa)
- Good weldability, easy to fabricate
- Can be welded using all known processes.
- Eminently suited where corrosive attack is accompanied by abrasive wear

ISSDA STAINLESS STEEL

Chemical Composition Utility Ferritic SS

Element %	X2CrNi12(1.4003) EN 10088 - 2 ASTM S40977	DIN 5512 Part 3 X2Cr11	IR CK – 201 X2CrNi12 (409M) 2002	IRS M 44/97
Carbon	0.03 max	0.03 max	0.03 max	0.03 max
Manganese	1.50 max	0.5 – 1.5	0.5 – 1.5	0.8 - 1.5
Phosphorous	0.04 max	0.04 max	0.04 max	0.03 max
Sulphur	0.015 max	0.015 max	0.03 max	0.03 max
Silicon	1.0 max	1.0 max	1.0 max	1.0 max
Chromium	10.5 – 12.5	10.5 – 12.5	10.5 – 12.5	10.8 – 12.5
Nickel	0.3 – 1.0	0.3 – 1.0	0.3 – 1.0	1.5 max
Nitrogen	0.03 max	0.03 max	0.03 max	Nil
Titanium	Nil	Nil	Nil	0.75 max

ISSDA STAINLESS STEEL

Mechanical Properties Utility Ferritic SS

Property	X2CrNi12(1.4003) EN 10088 - 2 ASTM S40977	DIN 5512 Part 3 X2Cr11	IR CK – 201 X2CrNi12 (409M) 2002	IRS M44/97
Yield Strength (MPa)	280/320	320	320	350 - 450
Tensile Strength (MPa)	450 - 650	450 - 600	450 – 650	500
Percentage Elongation	20	18 - 20	20	25

Why Utility Grade Stainless?

- Stainless steels account only for 2-3% of total steel production worldwide.
- Hence, carbon steels find use even in applications where expensive steps have to be taken to prevent corrosive damage, such as extra thickness as corrosion allowance or surface coatings.
- These add to the actual cost to the user.
- A lean stainless steel is a better option.

ISSDA STAINLESS STEEL

ADVANTAGES OF SS

- General corrosion and abrasion resistance is vastly superior to carbon / corten steel.
- Can be easily fabricated and indigenously available without supply constraints.
- Initial cost is higher per tonne, but over the life of the wagon (say 25/45 years) they are economical for the user.

ISSDA STAINLESS STEEL

ADVANTAGES OF SS

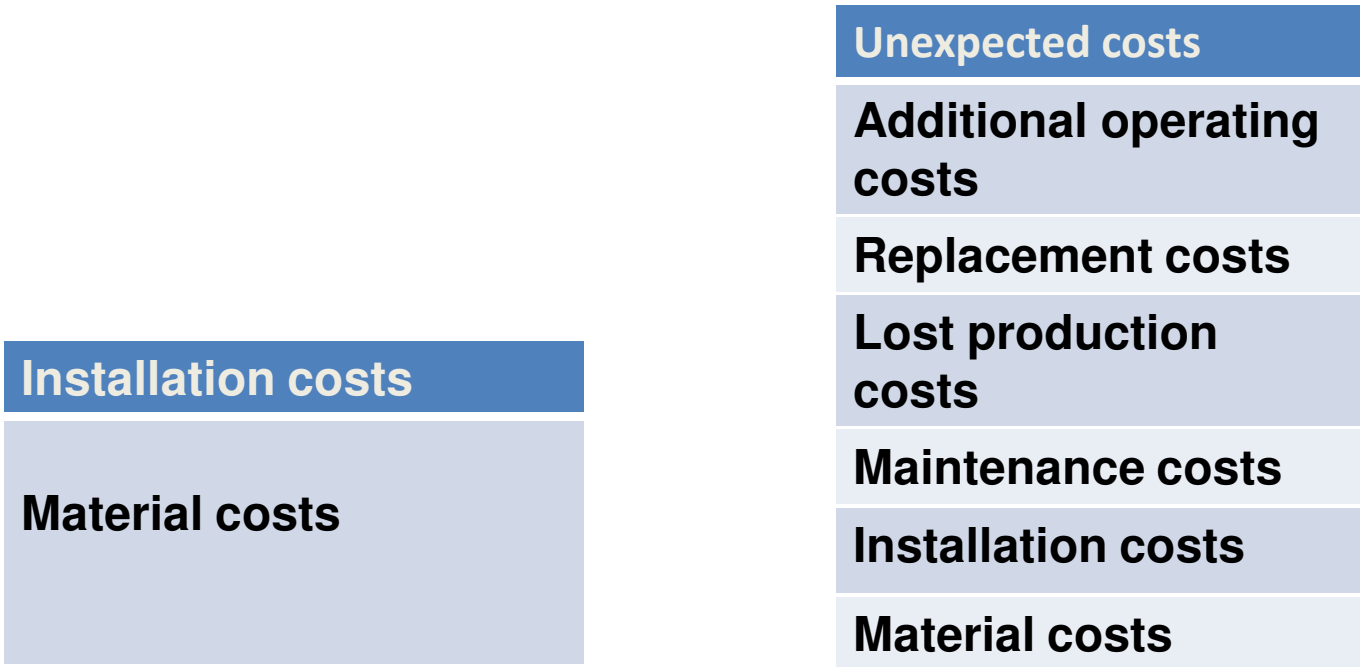
The most important benefit is that stainless steel is a sustainable material.

- (a) Over 60% of the raw material used for making stainless steel is scrap.
- (b) Stainless steel products highly durable, easily serviceable for several decades.
- (c) After a long service life, there is very little loss of material due to corrosion.
- (d) Almost 100% is available for recycling
- (e) Stainless steel is Recycled not DOWN cycled.

ISSDA STAINLESS STEEL

HOW IS IT POSSIBLE THAT AN EXPENSIVE MATERIAL CAN BE CHEAPER IN THE LONG RUN?

Comparison of life cycle costs
Schematic comparison



INTERNATIONAL DATA ON WAGONS

Life Cycle Maintenance of COR-TEN v Utility Stainless Steel

Carbon steel (COR-TEN)								
Years in service	0	6	12	18	24	30	36	42
Sides					Replace			
Ends	Paint	Paint	Paint	Replace	Paint	Paint	Paint	Scrap
Bellies	Paint	Paint	Replace	Paint	Paint	Replace	Paint	Scrap
Daysout of service		20	20	20	20	20	20	20
Utility stainless steel								
Years in service	0	6	12	18	24	30	36	42
		Inspection	Inspection	Inspection	Inspection	Inspection	Inspection	Inspection
Days out of service		3	3	3	3	3	3	3

ISSDA STAINLESS STEEL

CONTAINER

Grade 1.4003/410, painted
(frame and door panels)

ISSDA STAINLESS STEEL

COAL WAGON

Grade 1.4003/410 (panels), Columbus, S. Africa. In service for over 20 years.

ISSDA STAINLESS STEEL

COAL WAGON

Grade 1.4003/410 (panels), Columbus, S. Africa. In service for over 15 years.

COAL WAGONS

Grade 1.4003 (interior of previous), SASSDA, S. Africa

COAL WAGON

Grade 1.4003/410,
painted, Europe

COAL WAGON

Grade 409/410, painted,
TISCO, PRC

ISSDA STAINLESS STEEL

COAL WAGON

Grade 1.4003,
SASSDA, S. Africa

409M wagon under fabrication (IRSM 44/97)

ISSDA STAINLESS STEEL

Stainless Steel wagon painted (IRSM 44/97)

Stainless Steel wagons ready for service (IRSM 44/97)

ISSDA STAINLESS STEEL

Properties Desirable for Wagon Application

Utility grade ferritic stainless steel 1.4003 has the following characteristics of value in wagon applications:

1. CORROSION RESISTANCE
2. ABRASION RESISTANCE
3. IMPROVED SLIDEABILITY OF MATERIAL
4. NO ‘UNDER THE PAINT’ CORROSION

Corrosion Resistance

In medium to severe marine environment

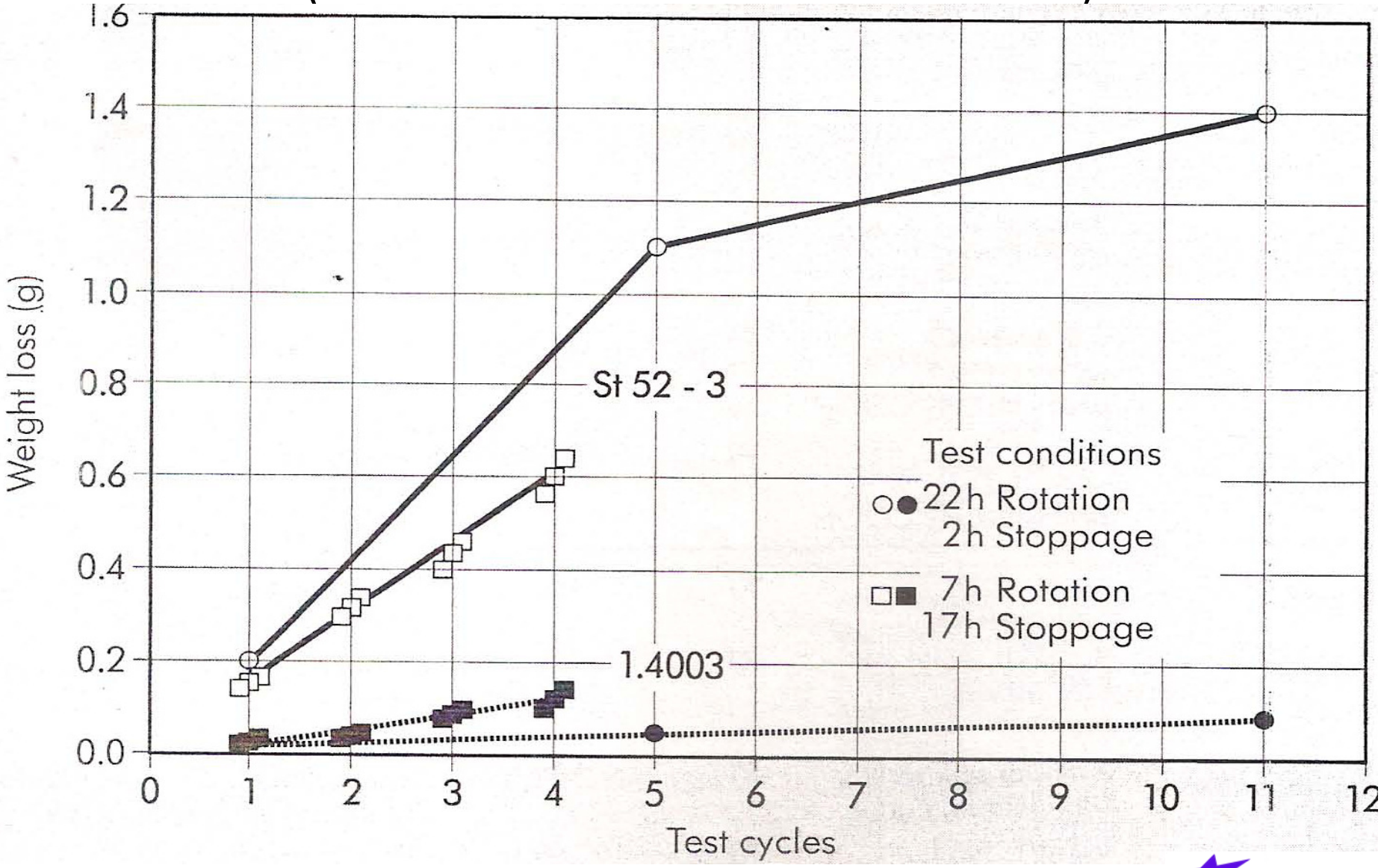
MS 5 yrs

1.4003 10 yrs

SS 304 20 yrs

Abrasion Resistance

(Abrasive – Corundum + 15-20% water)



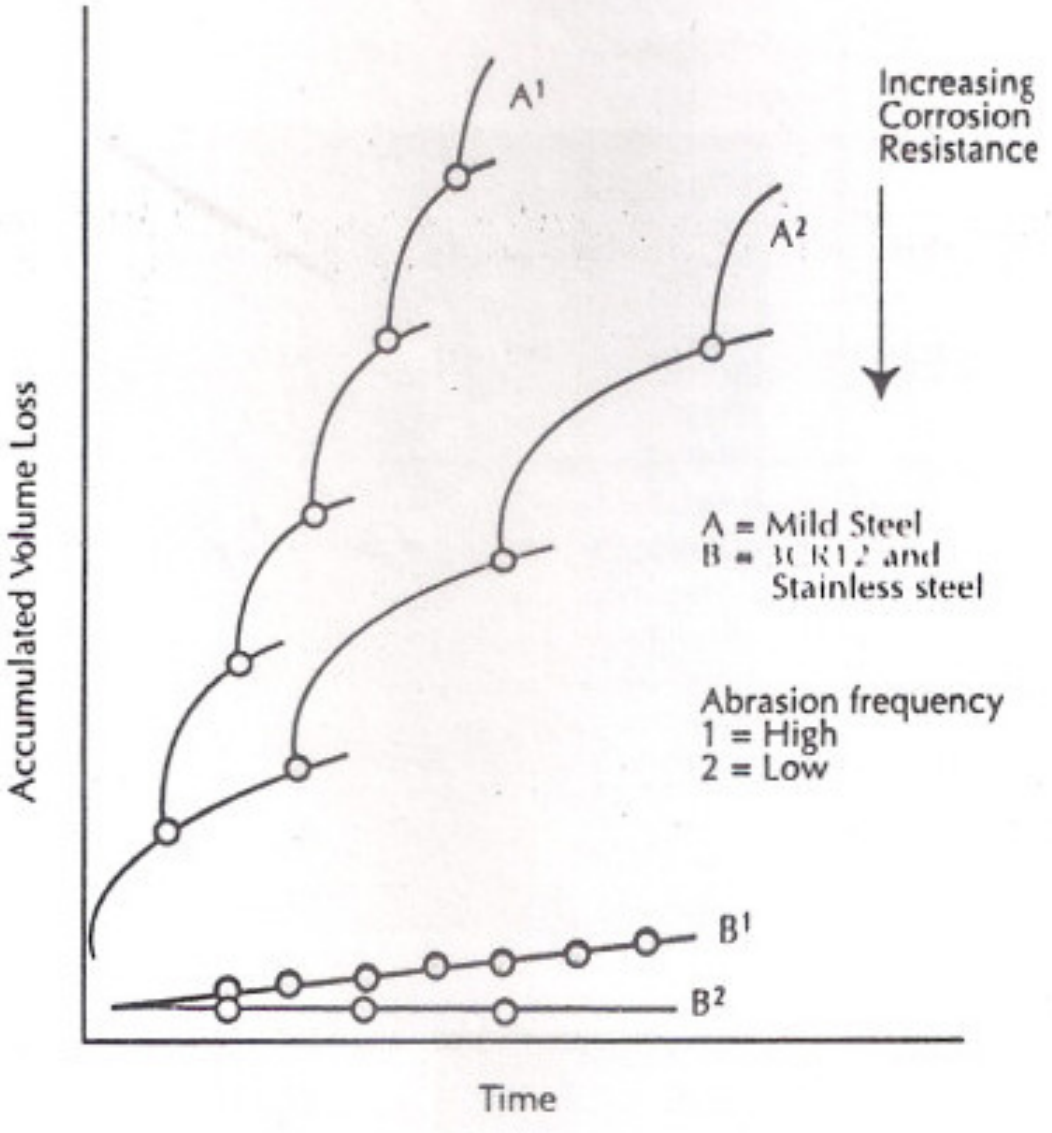
Abrasion + Corrosion

When Corrosion & Abrasion work together, in wet or damp conditions, both un-alloyed engineering steels and abrasion resistant grades fare very poorly; The main reason is their being easily prone to corrosion.

The damp conditions produce loosely adherent oxides of iron and abrasion removes the corrosion products, thus quickly exposing fresh steel surface for further corrosion. This accelerates the corrosion of steel.

NOT the case with corrosion resistant 1.4003

Abrasion + Corrosion



Slidability

- When Abrasion and corrosion work in tandem, the corroded surface of steel is rough and gouged in many areas and thus create hurdles to the flow of material over them.
- The relatively smooth surface of 1.4003, because of its corrosion resistance and high wear resistance, provides easy passage to materials flowing over them. THIS IS THE REASON FOR ITS HIGH SLIDABILITY QUOTIENT. This property is very useful in preventing ‘hanging’ which is very common in carbon steel wagons.

SS IN INDIAN RAILWAYS

- 1965 – Toilet pan, wash basin in SS 304
- 1984-85 – Trough floor in SS 301
- 1990 – Toilet inlays in SS 304
- 1990 – LHB Coach in SS in DIN 5512 – 1.4003
- 1995 – Internal furnishings in SS 304
- 1997 – IRS M 44/97 specs for wagons
- 1998 – Box N wagon in SS - 44/77
- 2000 – CK-201 specs of SS for coaches
- 2000 – 44/97 used for structural in ICF designed coaches.

ISSDA STAINLESS STEEL

History of Ferritic SS for Wagons/Coach

- 1980's – developed in South Africa and UK as 3 CR12 grade utility SS for coal/ore transportation. (low carbon, 11% Cr and Titanium)
- 1990's – Modified 3 CR12 for better toughness (low carbon, 11% Cr, 0.3 minimum Ni, Ti removed)
- DIN 5512 of German Spec for railway SS specify this grade for freight wagons and passenger coach as 1.4003
- LHB specifies DIN 5512 (1.4003) for new coach design in India. LHB approves Indian manufacturer.
- 1997 – IR specifies 44/97 (containing Ti max for trial wagons)
- 2000 – ASTM spec UNS – 40977 for Utility Ferritic SS (low carbon, 11% Cr, minimum Ni, no Ti)
- 2001 – IR specifies in CK – 201 utility Ferritic matching 1.4003
- 2005 – Internationally EN 1.4003 and UNS – 40977 specifications followed for utility grade Ferritic SS (Low carbon, 11% Cr, 0.3 min Ni and NO Ti)

ISSDA STAINLESS STEEL

Painting of 1.4003

Type 1.4003 provides good corrosion resistance, excellent abrasion resistance, hence does not need coating or painting systems to be applied for performance reasons. For aesthetic reasons it may be desirable in some applications to apply paint, especially as type 1.4003 will tend to discolor in corrosive conditions. Type 1.4003 has exceptional under-paint corrosion resistance and will continue to resist corrosion even where the paint coat has been damaged. Normal preparation is required such as ensuring a clean surface free of grease and other contamination. A primer coat is recommended for cold rolled material due to its smoother surface, but hot rolled 1D finish material may be suitably painted in a single coat.– Krupp Thyssen

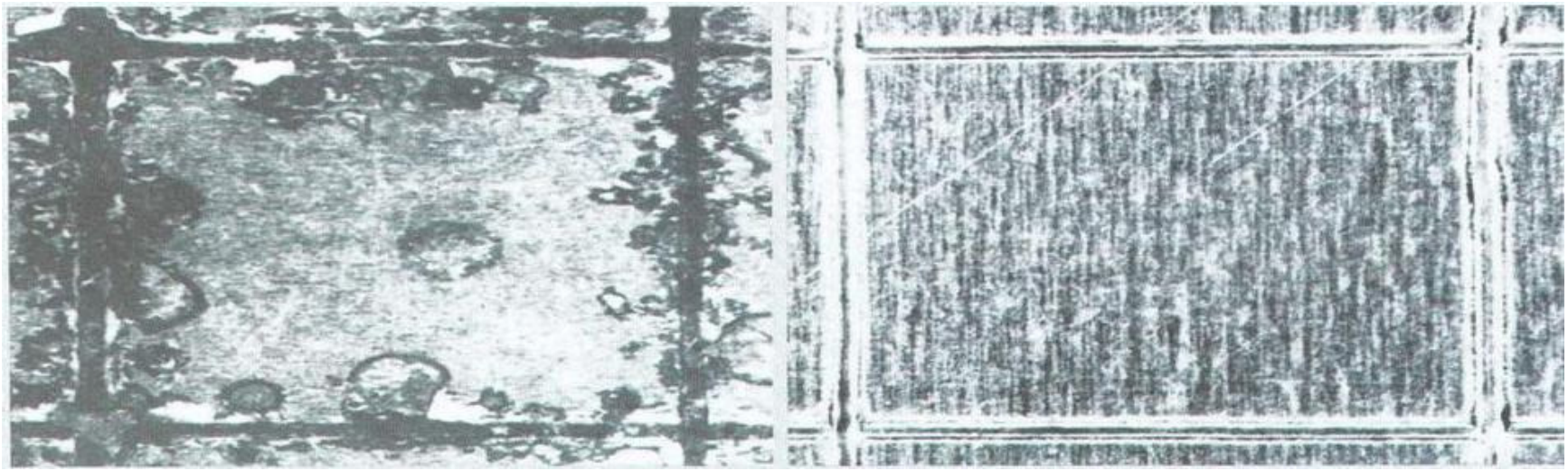
ISSDA STAINLESS STEEL

Under the Paint Corrosion

Corrosive attack visible on steel surface after removal of acrylic paint coating (200 cycles of high humidity exposure)

Unalloyed Engineering Steel – Severe corrosion under paint

1.4003 – No corrosion under paint (Unaffected)



Painting of utility grade SS wagons

In moderate marine environments, 1.4003 gives an improvement of 250 times the life of unpainted mild steel under the same conditions.

In aggressive environment, it will tend to form a light surface rust coloured patina. This discoloration is superficial and does not affect the structural performance of the steel.

If needed, wagons could be given one coat of primer.

IN SOME COUNTRIES (SOUTH AFRICA & AUSTRALIA) THEY DO NOT PAINT THEIR WAGONS OF 1.4003

Suggestions

- Modify IRSM – 44 in line with CK 201 to meet International standards. This will help improve weldability, especially in thicker (>8mm) sections.
- Use 308 L consumables, and 309L for thicker sections
- Can avoid painting for wagons (if required one primer coat)

Growth of Rolling Stock Demand

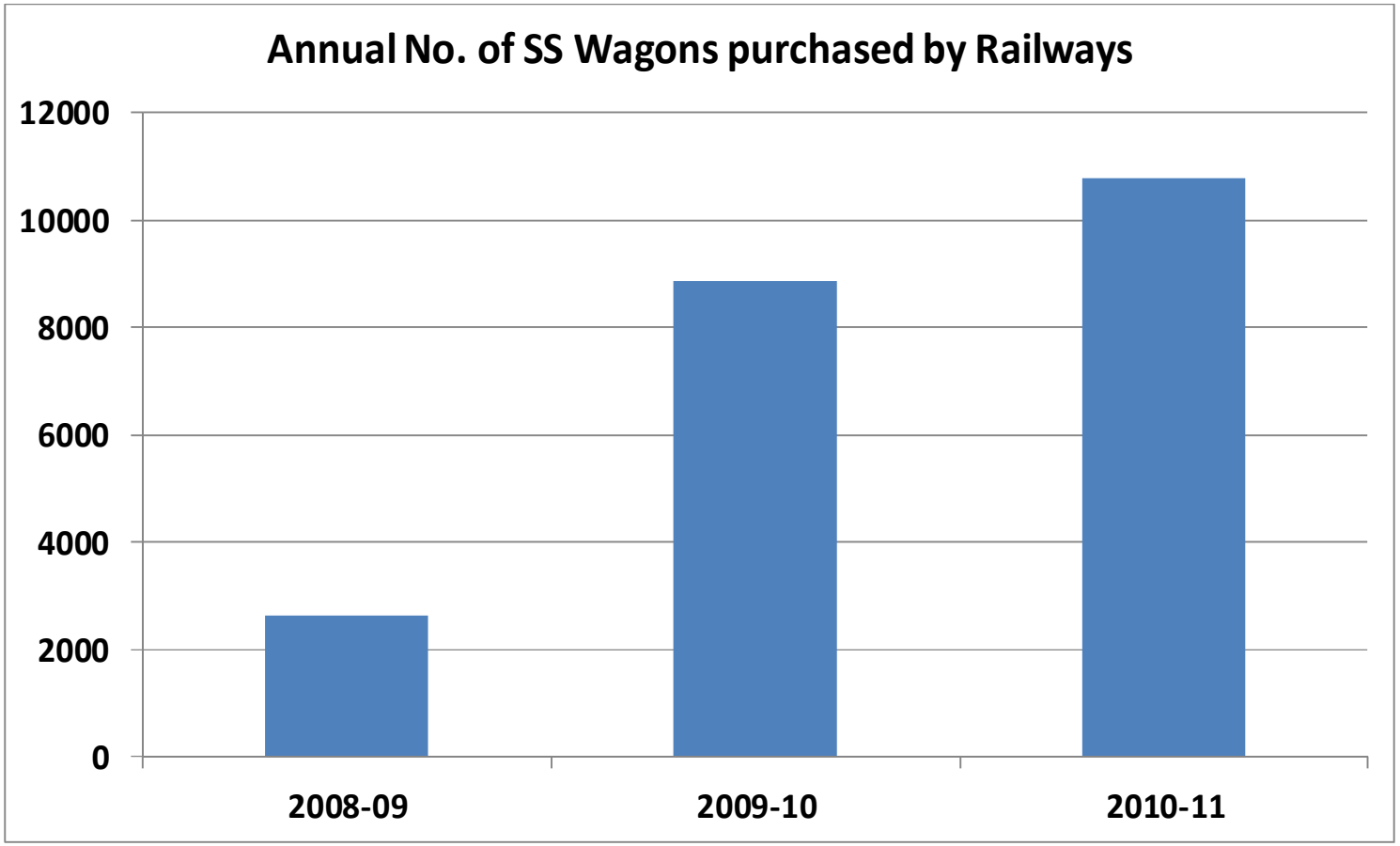
Rolling Stock Type	Extra rolling stock required under Vision 2020	Average Annual Demand of Rolling Stock	Present estimated Manufacturing Capacity	% Demand excess over capacity
Electric Locomotives 3-phase	2595	259	230	**13%**
Electric Locomotives Conventional	1686	168	40	**320%**
3-Phase AC EMU	600	60	30	**100%**
Diesel Locos	5334	533	260	**105%**
Coaches	**50880**	**5088**	**3000**	**70%**
Wagons	**289136**	**28913**	**14000**	**107%**

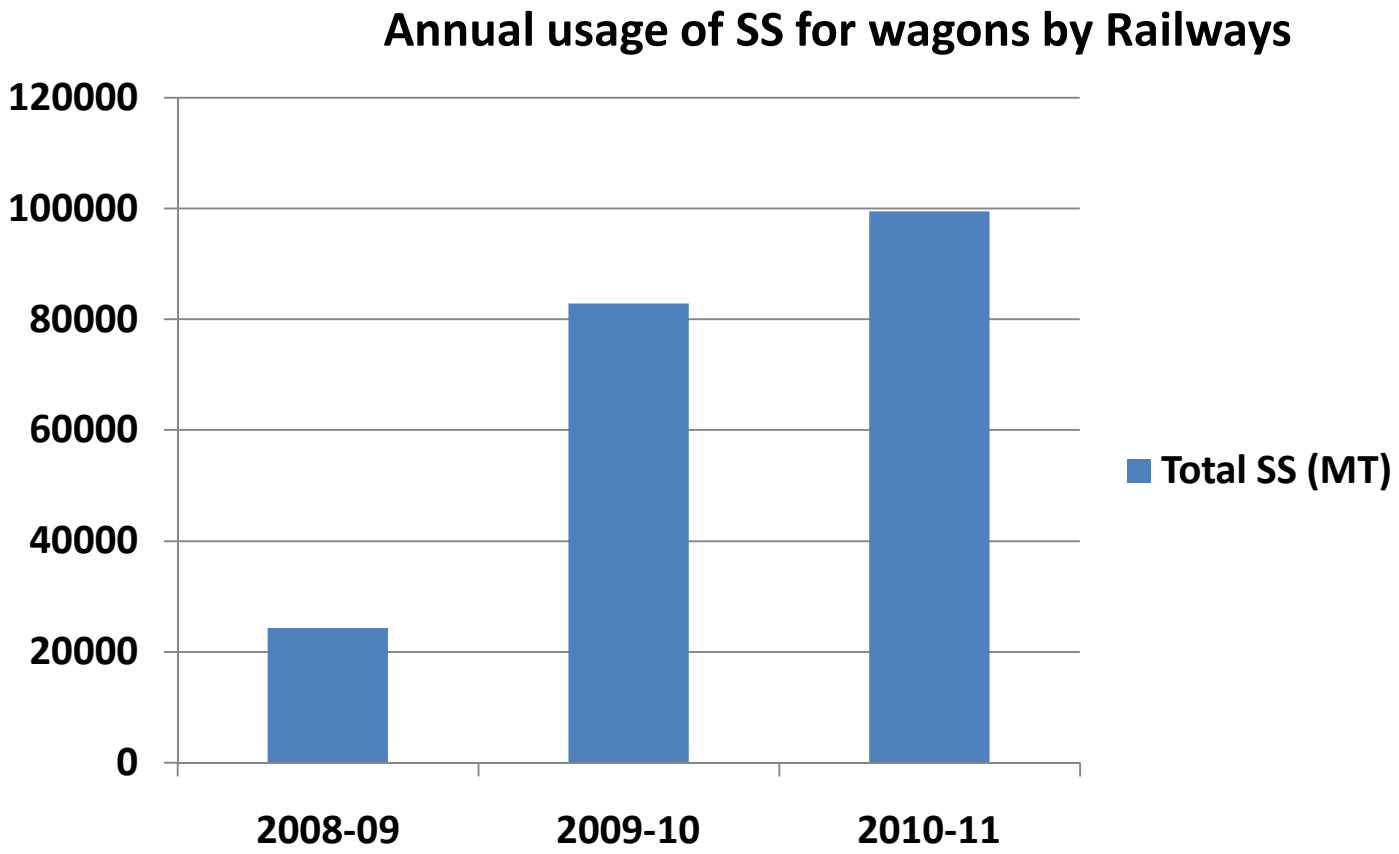
1.Population of wagon till date : 2,25,000 (approx)

2. SS wagons till date : 22,300 - 25,000 (approx)

Wagon Production & IRSM-44 Consumption

2008-09			2009-10		2010-11	
WAGON	**No.**	**TOTAL SS (MT)**	**No.**	**TOTAL SS (MT)**	**No.**	**TOTAL SS (MT)**
BOXNHL	2000	21600	4992	53913	5000	54,000
BCNHL	115	977.5	3068	26078	4800	40,800
BOXN-R	500	1800	800	2880	1000	3600
BOBRN	0	0	0	0	700	1120
BRN 22.9	0	0	0	0	0	0
TOTAL	**2615**	**24377.5**	**8860**	**82,871**	**10,800**	**99,520**


Annual No. of SS Wagons purchased by Railways
12000
10000
8000
6000
4000
2000
0
2008-09
2009-10
2010-11


Annual usage of SS for wagons by Railways
120000
100000
80000
60000
40000
20000
0
2008-09
2009-10
2010-11
Total SS (MT)

Future Prospects for Stainless Steels in Rail Wagons

- Covered Wagons
- Oil tankers

For further details contact:

INDIAN STAINLESS STEEL DEVELOPMENT ASSOCIATION (ISSDA)
L-22/4, Ground Floor, DLF Phase-II, Gurgaon - 122 002
Tel. 91 124 4375501, 02, 03 Fax : 91 124 4375509
Email : nissda@gmail.com
Website : www.stainlessindia.org