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Case Study
Crafting and executing corrosion management strategy at multipurpose sea port

D. Dubey , Sr. Manager -Engineering Services- Corrosion Control Cell

M. Tech- Corrosion Science & Engineering, IIT Mumbai & NACE Certified Coating Inspector- Level3
Adani Ports & SEZ Ltd, Mundra, Gujarat ;
devendra.dubey@adani.com

ABSTRACT

Corrosion management for an operation is the systematic application of policies, practices and resources to control corrosion and provide reliable safe guard against unexpected failure and leaks that can jeopardize mechanical integrity, operation, health, safety and environment (HSE).
In times of tight budget, the life cycle management of long time to fail component requires a comprehensive strategy for condition assessments, data management and standardized tasking for restoration during maintenance availability period.

While today's sea port operational technologies are dramatically different from even half century ago , one issue remain fundamentally unchanged ; the impact of salt water environment & various chemical exposure on sea port infrastructure.

This paper uses examples from the Adani Ports & SEZ Ltd corrosion control program to execute corrosion management strategy. This paper also describes various successful continual improvements project to control corrosion & challenges way ahead.

Key Words: Corrosion management strategy, life cycle management, continual improvements, Key performance indicators.

INTRODUCTION:

Business Strategy

A company's business strategy is its action plan for outperforming its competitors and achieving superior profitability. In effect, it represents a managerial commitment to an integrated array of considered choices about how to compete.

The objective of well-crafted strategy is not merely temporary competitive success and profit in the short run, but rather the sort of lasting success that can support growth and secure the company's future over long run.

Charting a company's Direction: Its vision, mission, objective and strategies

The managerial process of crafting and executive a company's strategy consist of five integrated task

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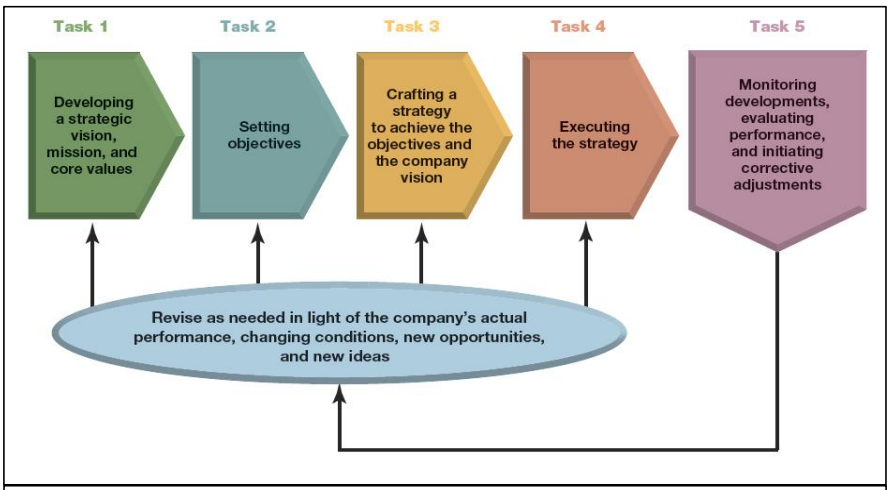
- Developing a strategic vision, a mission statement, and a set of core values.
- Setting objectives for measuring the firm's performance and tracking its progress.
- Crafting a strategy to move the firm along its strategic course and to achieve its objectives.
- Executing the chosen strategy efficiently and effectively.
- Monitoring developments, evaluating performance, and initiating corrective adjustments.



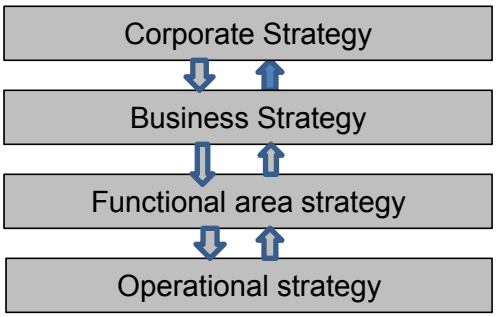
A Firms strategy making Hierarchy

Strategic Management Principle - Crafting Strategy

In most companies, crafting and executing strategy is a collaborative team effort in which every manager has a role for the area he or she heads; it is rarely something that only high-level managers do. Strategy making is often a collaborative process

The many complex strategic issues involved and multiple areas of expertise required can make the strategy-making task too large for one person or a small executive group.

When operations involve different products, industries and geographic areas, strategy-making authority must be delegated to functional and operating unit managers such that all managers have a strategy-making role—ranging from major to minor—for the area they head! **[1]**



A Firms strategy making Hierarchy

2 . PORT INDUSTRY OVERVIEW – INDIA:

The transportation industry of India is large and expansive. The roadways, highways, ports, aviation industry and railways, all form a part of the transportation industry. It is a growing sector which contributes around 8.5% to India's gross domestic product. The recent years have witnessed tremendous growth in demands for both transportation means and infrastructure. Indian railways are one of the biggest railways systems of the world, is managed under one authority and handles around 17 million passengers daily.

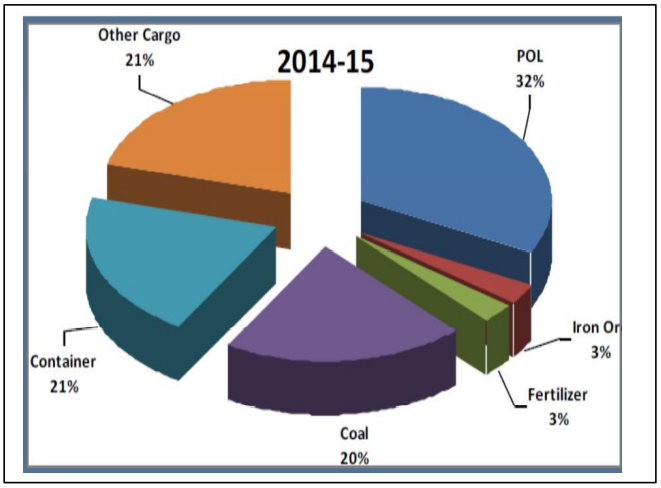
India has almost 5560 km of natural peninsular coastline strategically located on the crucial East-West trade route, which link Europe and the Far East. The coastline is serviced by 12 major ports and about 180 minor and intermediate ports. Ports have assumed enormous importance in the era of globalization with phenomenal expansion in world trade.

[2]

Year wise traffic handled at Major and Non-Major Ports

Year	(in Million Tonnes)			% share of Major Ports	% share of Non-Major Ports
	Major Ports	Non Major Ports	Total		
2001-2002	287.58	96.27	383.85	74.92	25.08
2002-2003	313.55	105.17	418.72	74.88	25.12
2003-2004	344.79	120.84	465.63	74.05	25.95
2004-2005	383.75	137.83	521.58	73.57	26.43
2005-2006	423.56	145.53	569.09	74.43	25.57
2006-2007	463.78	186.12	649.90	71.36	28.64
2007-2008	519.31	203.62	722.93	71.83	28.17
2008-2009	530.53	213.20	743.73	71.33	28.67
2009-2010	561.09	288.86	849.95	66.01	33.99
2010-2011	570.03	314.85	884.88	64.42	35.58
2011-2012	560.13	353.02	913.15	61.34	38.66
2012-2013	545.79	387.87	933.66	58.45	41.54
2013-2014	555.50	417.13	972.63	57.11	42.89
2014-2015	581.34	470.67	1052.01	55.26	44.74

Year wise traffic handled at major and non-major ports

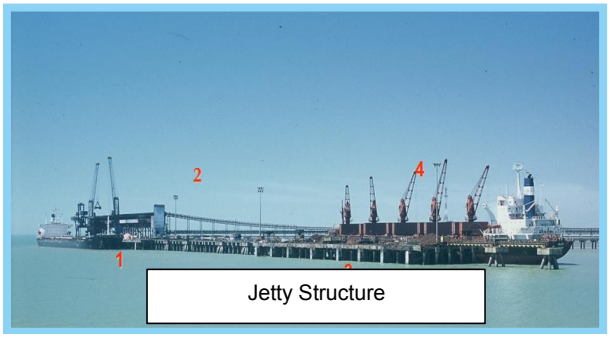


The composition of cargo at major port during FY 2014-15

3. CORROSION MANAGEMENT CHALALNGES AT MULTI PURPOSE PORT:

Port & harbor facilities should remain in service for longer duration of time ; so as to maintain their functions. It is therefore essential to give an appropriate consideration during the initial design of relevant structure ; as well as to conduct proper maintenance since their services start. Critical port asset & infrastructure as affected by corrosion are ;

- Jetty Structure.
- Bulk, Container & pipes loading cranes & other associated equipment.
- Conveyor.
- Bulk storage godowns
- Liquid Pipeline.
- Liquid Tanks .
- Tugs & Dredgers.
- Electrical towers , transformer & transmission line etc



Jetty Structure

Cranes & associated equipment

Conveyor

Bulk storage godown

Liquid Tank & Pipe line

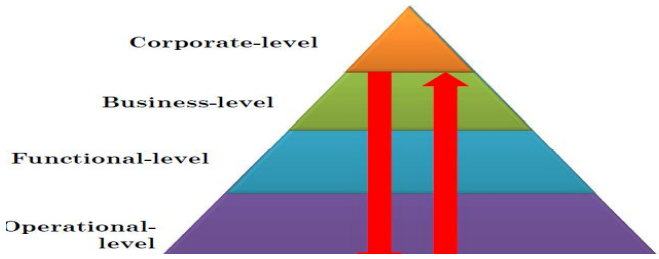
Tugs & Dredgers

4. CORROSION MANAGEMENT STRTATEGY IN PORT SECTOR:

Corrosion management strategy of any organization is part of operational level strategy. Hence, Crafting & execution of any operational level strategy such as corrosion management strategy should be aligned with corporate level strategy. The five generic competitive corporate strategies as may be adopted by any industry are,

- **Low cost Provider.**
- **Broad Differentiation**
- **Focused Low cost**
- **Focused Differentiation**
- **Best Cost provider**
- **Any other specific strategy**

The five generic competitive strategies [1]



Alignment of operational level corrosion management strategy with business strategy [1]

The overarching corrosion prevention and mitigation strategy is to transcend traditional corrosion control methods, organizations, management, and funding approaches and to apply modern technology and management techniques to prevent and control corrosion throughout the lifecycle of systems, facilities, and materials.

- Implement a dynamic and effective corrosion prevention and control organization at the highest level .
- Attack corrosion early in the acquisition or construction cycle—during design, manufacturing, assembly, and construction.
- Focus life-cycle corrosion research and development efforts on four primary areas.

- Materials and manufacturing processes that prevent or reduce the incidence and effects of corrosion
- Detection of the incidence, nature, and severity of corrosion in fielded systems and facilities as well as prognosis of the expected growth progression, potential impact, and predicted effects of mitigation actions
- Coatings, treatments, corrosion inhibitors, cathodic protection, moisture mitigation, and other applications to prevent, arrest, or retard corrosion, with emphasis on sustainable or “green” technologies
- Repair processes that restore corroded materials to an acceptable level of structural integrity and functionality.

- Knowledge sharing - Use every available communication channel to receive and convey all aspects of corrosion—nature, impact, approaches, and results.

- Work with and leverage the expertise of relevant professional societies and industry groups.

- Modernize corrosion specifications, standards, and other requirements, and develop standard, streamlined product introduction process for suppliers of corrosion-prevention technologies and products.

- Conduct studies and surveys, collect data, and analyze results to determine the impact of corrosion, pinpoint critical areas for concentration of prevention and mitigation efforts, and develop metrics to measure the effect of corrosion and the results of prevention and mitigation efforts.

- Publish and distribute direction and guidance that provide adequate details and instructions regarding implementation of corrosion prevention and mitigation policies and strategies and that apply to all levels of leadership and management in the port services.

- Conduct focused corrosion prevention and mitigation training that is tailored to the learning requirements at each management and technical level in the port services.

- Demonstrate and validate emerging corrosion control technologies to determine their suitability for port applications.

5. TYPICAL ORGANISATION STRUCTURE- MULTIPURPOSE PORT

Figure reflects current organization structure of Adani Ports & SEZ Ltd & hierarchical linkage of corrosion engineering function with top management.

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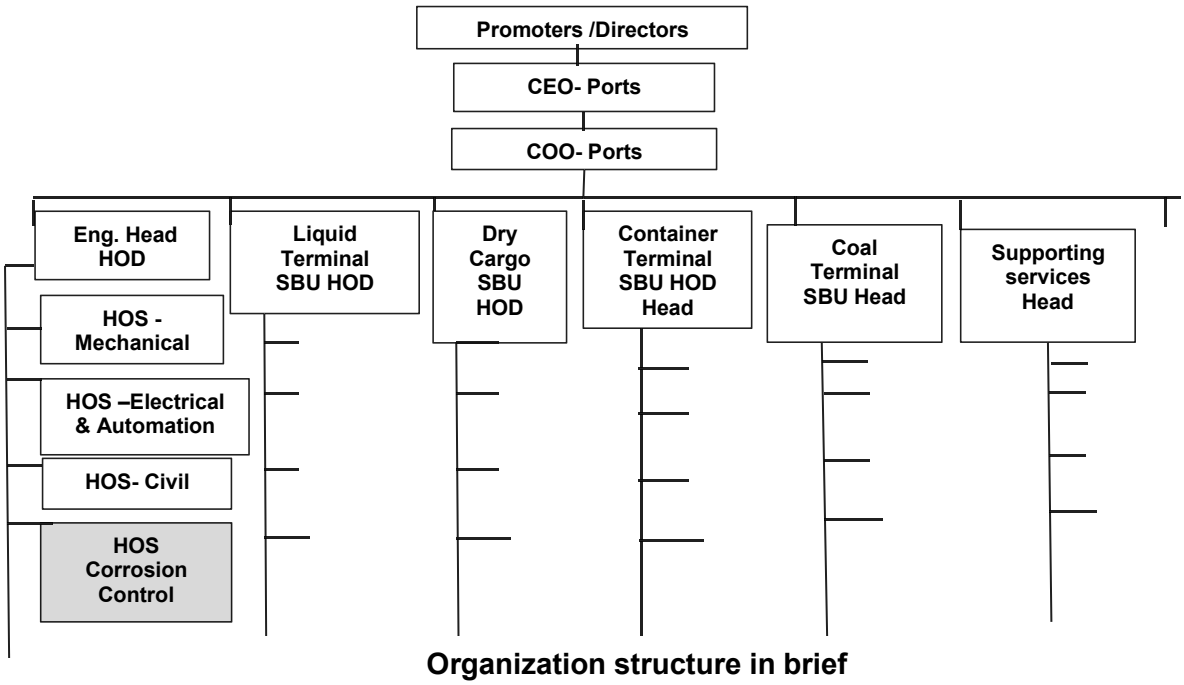
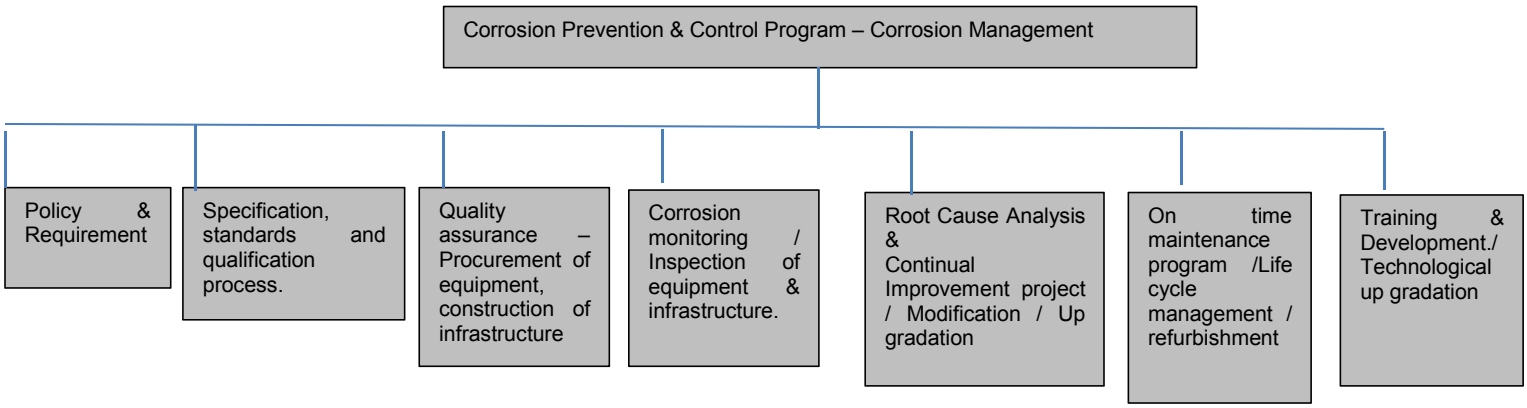


Organization structure in brief



Corrosion Prevention & Control Program

6. EXECUTION OF CORROSION MANAGEMENT STRATEGY:

Balance scorecards is widely used tool for execution & monitoring of operational level strategy (such as corrosion management strategy) with alignment of corporate level business strategy to achieve short term and long term goal

Example as mentioned below illustrated Adani Ports & SEZ where corrosion management strategy is attempted to link with corporate strategy & vision with key performance indicator, leading & lagging indicator. Corrosion monitoring inspection, preventive, predictive & corrective maintenance schedule are mapped in SAP PM Module for its effective implementation

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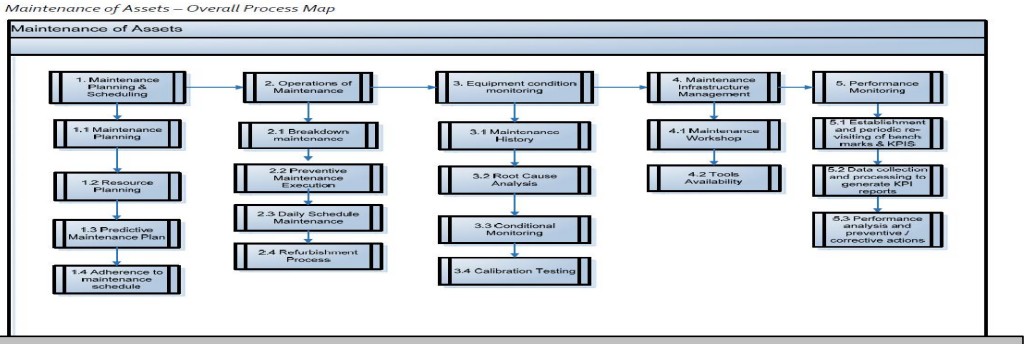
Adani Group Corporate Vision	Business Strategy	Internal Process (Corrosion Management- Key Performance; leading & lagging indicator)
To be globally admired leader in integrated infrastructure business with deep commitment to nation building. We shall be known for our scale of ambition; speed of execution and quality of operation	➢ Speed of execution. ➢ Safety. ➢ Services that surpass need. ➢ Customer satisfaction. ➢ Continuous improvement. ➢ Quality of employee. ➢ Shareholder expectation.	➢ Equipment availability affected by corrosion related failure. ➢ Equipment reliability affected by corrosion related failure. ➢ Mean time to repair for corrosion related failure. ➢ Mean time between failures due to corrosion related failure. ➢ No of repetitive failure. ➢ Root cause analysis. ➢ Preventive and corrective maintenance compliance (Planned v/s actual) ➢ Budget Variance (planned / actual) ➢ Lost time injury due to corrosion and related maintenance. ➢ No of improvement project initiated and completed per year. ➢ Life cycle cost of equipment related to corrosion control.

Process documentation

Maintenance of Assets – Overall Process Map



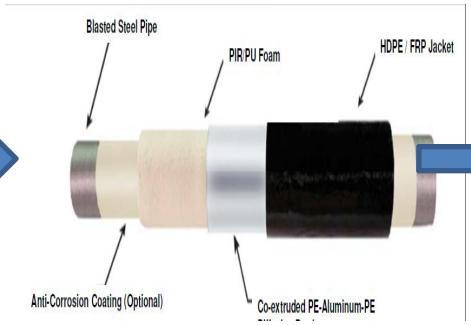
SAP BASED PM MODUME- CORROSION MANAGMENT

7. CORROSION MANAGEMENT & CONTINUAL IMPROVMENT AT LIQUID TERMINAL:

7.1 : Corrosion under insulation of pipeline – Preventive action in new projects

Background & problem:	**Solution explored & implemented:**
➢ Conventional rock wool insulation are prone to damage at site ➢ Under insulation corrosion. ➢ Heat loss controls are not consistent. ➢ High Life cycle cost.	➢ Factory applied PU foam insulation. ➢ Damage proof at site ➢ Minimized / Negligible under insulation corrosion ➢ Operational effectiveness to prevent heat loss ➢ Low Life cycle cost & maintenance.

Conventional Rock wool Insulation



Factory applied PU foam based insulation

7.2 : Corrosion under insulation of Tank & Pipe line – Corrective action

Background & Problem	Solution explored & Implemented
➢ Difficult to identify. ➢ Some of Tanks and pipe line had already crossed 10 year of service life	➢ Inspection of all tanks and pipe line after opening of inspection window ➢ Decided priority for refurbishment based on severity. ➢ Refurbishment of tanks with re insulation after blasting and coating.

Identification of under insulation corrosion

Insulation renewal after tank repair & Blasting coating

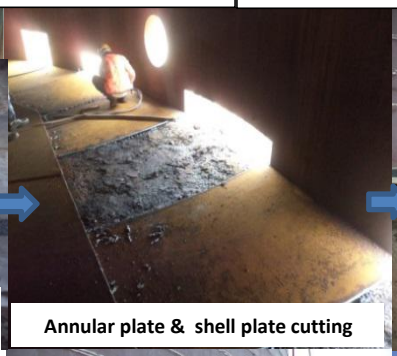
Background & problem :

- Thinning of tank bottom plate & annular plate after 10-12 year of service.
- Observed Pitting over nearby area of tank shell.
- Cathodic protection was not considered during project stage.

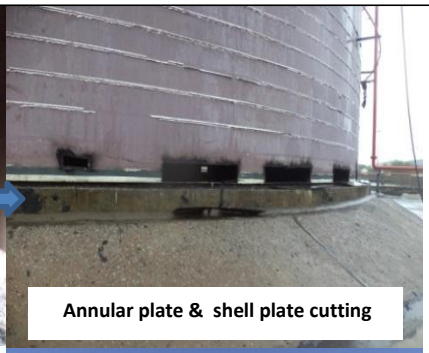
Solution explored & Implemented

- Replacement of tank bottom & annular plate as per inspection findings.
- External corrosion protection through water base flexible tank seal system

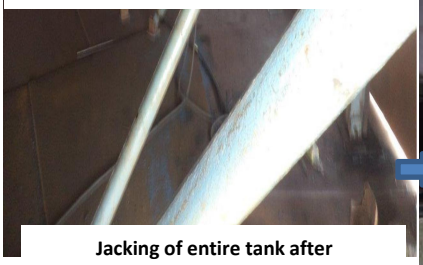
Initial condition - Tank annular plate and bottom plate thinning



Annular plate & shell plate cutting



Annular plate & shell plate cutting



Jacking of entire tank after replacement of bottom plate

New bottom shell replacement

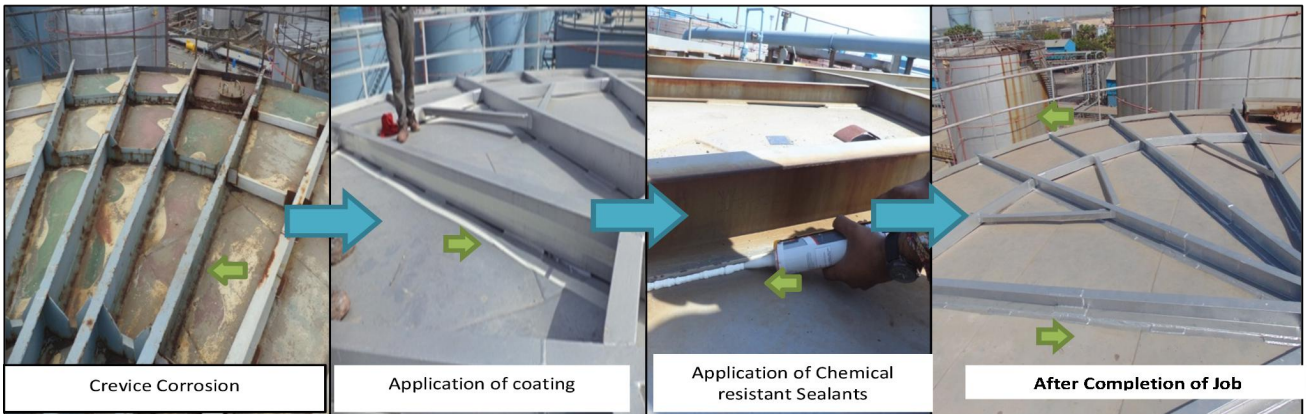
Blasting & coating of entire tank

Replacement of tank annular plate & bottom plate after 10-12 year of service life

Water based flexible tank bottom seal system implementation over all above ground storage tank

7.4 Prevention of crevice corrosion (MS & SS structures over tank roof) :

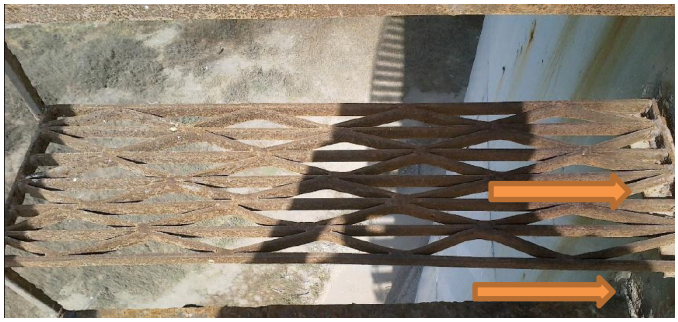
Background & Problem:	**Solution explored & Implemented**
➢ Inaccessible area & crevice between MS structure & SS roof plate. ➢ Deposition of chemical spillage (e.g. acetic acid) over crevices. ➢ Rust staining over tank shell.	➢ Prequalification of chemical resistant Modified silane polymer sealant. ➢ Application of sealant over crevice after coating application. ➢ Observed satisfactory performance.



Crevice corrosion control measures through sealants / caulking compounds

7.5 Design modification of Tank stair case to minimise corrosion :

Background & Problem	Solution explored & Implemented
➢ Old Design – Fabricated & painted gratings. ➢ Grating are difficult to paint at site and prone to paint failure. ➢ Defect of Design -Corrosion prone design over gratings & weld joint between grating & Tank.	➢ Tank Design change initiation for new tanks and modification of older tanks. ➢ Painted hot dip galvanized gratings with new stringer type stair . ➢ Minimized no. of welds directly with shell. ➢ Improved design.



Old stair case design- multiple welds with shell

Improved design with hot dip galvanized grating

7.6 Selection of Internal coating based on business need:

Background & Problem:	Solution explored & Implemented
➢ Tanks are dedicated for multiple cargo storage. ➢ Frequent change in grade of cargo ➢ Due to nature of business next cargo grade cannot be forecasted.	➢ Selection of cost effective novalac phenolic epoxy as tank lining material. ➢ Suitable for vast range of chemical in optimized cost as per business need. ➢ Post curing is not mandatory.

Application of Novalac phenolic epoxy as tank internal lining

7.7 Field Joints of pipes corrosion control:

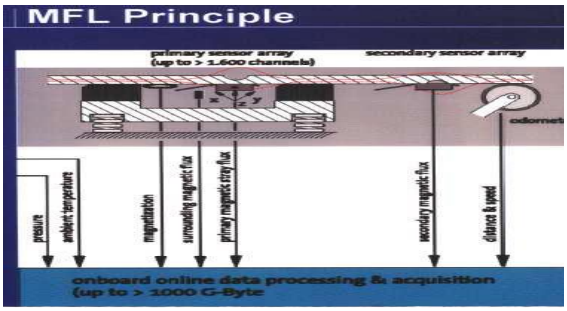
Background & Problem:	**Solution explored & Implemented**
➢ Field joints of factory applied 3LPE coated pipes or site applied blasted and coated pipes are prone to corrosion. ➢ Hot work permit & localized abrasive blasting was concerned due to continue operation.	➢ Cold applied special thick layer polymeric system after surface preparation by non-sparking power tool. ➢ Heat shrink hot applied system after bresel blasting in case hot work permit are available

Heat shrink sleeve application in case of Hot work permit availability

Cold applied thick layer polymeric coating over non-sparking power tool cleaned surface.

7.8 Corrosion monitoring of above ground pipeline through Intelligent Pigging:

Background & Problem:	Solution explored & Implemented
➢ Fitness for service inspection through conventional UT thickness gauging was not observed reliable. ➢ Leakage of older pipeline.	➢ Explored such pipeline which are suitable for intelligent pigging as per design. ➢ Carrying out of intelligent pigging & corrective action as per inspection finding.



Photoaraph durina launchina of MFL intelliaent pia in 24" line

Challenges Ahead :

- ➢ To explore technique for intelligent pigging in non piggable pipe line where ;
- No provision for Launchers/ Receivers
- Reduced bore mainline valves & check valves
- Low flow conditions resulting in reduced velocity
- Miter bends
- Less than 3D bends
- Large diameter unbarred Tee

.

7.9 Pipe support corrosion control

Background & Problem:	**Solution explored & Implemented**
➢ Crevice corrosion of Pipe support area. ➢ Localized corrosion over welded are of corrosion pads ➢ No corrosion pads over certain area.	➢ Surface preparation with power tool and application of thick metallic putty having good adhesion.

Pipes without corrosion pads

Crevice corrosion of pipes support

Crevice corrosion of pipes support

Problem: No corrosion pads or crevice / localized corrosion over pipe support area

Solution Implemented: Surface preparation with power tool and application of thick metallic putty with good adhesion

8 CORROSION MANAGEMENT & CONTINUAL IMPROVEMENT AT BULK TERMINAL :

8.1. Galvalume Sheet corrosion & perforation:

Background & Problem:	**Solution explored & Implemented**
➢ Less than 03 years of observed life of Galvalume / Aluminum / GI . ➢ Root Cause: Deposition / stagnation of fertilizer for longer duration	➢ Change in grade of MOC from Galvalume to UV & Fire resistant FRP sheet ➢ Isopthalic polyester resin base FRP for vertical sheet. ➢ Vinyl ester resin base FRP for roof sheet.

Perforation of Vertical Galvalume sheet

Isopthalic polyester resin base FRP sheet

Fertilizers spillage over roof sheet & subsequent corrosion & perforation in AL & Galvalume sheet.

Selection & implementation of vinyl ester based FRP sheet with top side gel coat

8.2 Conveyor's metallic Hood cover corrosion & perforation:

Background & Problem	Solution explored & Implemented
➢ Earlier Utilized GI / Galvalume Hood Cover are prone to corrosion due to fertilizer exposure.	➢ Customized designed of 3 MM Iso pthalic polyester Hood cover with Gel Coat (Having fire resistant & UV resistant property.).

GI painted Conveyor Hood Cover

Customized design FRP hood cover

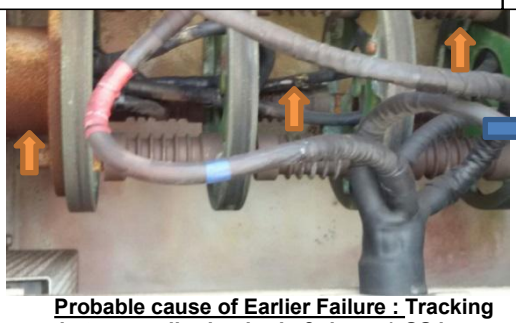
8.3 Corrosion control of hydraulic joints fitting of mobile equipment :

Background & Problem	Solution explored & Implemented
➢ Frequent failure of electroplated hydraulic joints fitting due to corrosion. ➢ Difficult to paint due to design constrain.	➢ Selection of petrolatum tape over hydraulic joints of critical equipment. ➢ Easy to open during routine maintenance & re application after maintenance.

Corrosion protection of hydraulic joints by petrolatum tape

8.4 Insulating Coating Implementation over 11 KV slip ring & SS box of mobile harbor cranes

Background & Problem	Solution explored & Implemented
➢ Break down in monsoon or high humid season or Dusty Operation.	➢ Single component grafted copolymer base Insulating Coating . ➢ No breakdown in monsoon or high humid season & Dusty Operation.



Probable cause of Earlier Failure : Tracking between slip ring body & bare / SS box .

Complete Insulation coating over SS box & Slip ring accessories

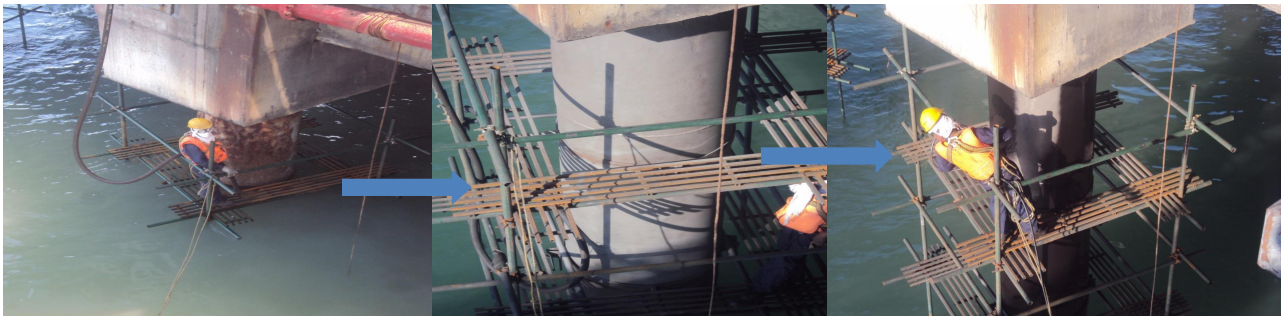
9. CORROSION MANAGEMENT & CONTINUAL IMPROVMENT - PORT'S COMMON ASSET

9.1 Jetty Metallic Pile corrosion control & improvement:

Background & Problem:	**Solution explored & Implemented :**
➢ Splash zone environment. ➢ Requirement of coating which can cured under water or with fast curing property. ➢ Only few month are available in a year for maintenance due to sea condition or due to operation.	➢ Product prequalification for 03 different specification . a) Elastomeric polyurethane with pot life of few seconds. b) Converted fast curing epoxy. c) Non-cross linked, non –crystalline, monolithic viscous polymer based, prefabricated wrap coating with cold flow,

Monolithic viscous polymer based coating

GOOD AFHESION & NO UNDERFILM CORROSION AFTER 3 YEARS OF SEA WATER EXPOSURE



Application of converted epoxy over splash zone area

9.2 Concrete Corrosion control of Jetty Structures:

Background & Problem:	**Solution explored & Implemented:**
➢ Concrete corrosion. ➢ Rebar corrosion. ➢ Cracks & spalling of concrete	➢ Removal of top layer loose concrete. ➢ Rebar corrosion treatment. ➢ Fixing of zinc anode buttons (sacrificial) ➢ Fast curing polymer mixed concrete application. ➢ Application of anti-carbonation coating

Concrete Corrosion & refurbishment project – Underneath Jetty surface

10 . Development of In house Material & corrosion testing lab :

Background & Problem:	Solution explored & Implemented
➢ Dependency on external agency to cater inspection & analytical testing need. ➢ On time, availability of resources was concerned considering remote location.	➢ Development of In house Material & corrosion testing lab. ➢ Availability of Resources • Coating Inspection & performance evaluation tools • Welding inspection tools. • Continuous up gradation . • Training & Development / certification



In-house material & corrosion testing lab & availability of inspection equipment

CONCLUSIONS:

The corrosion control strategy described in this paper has been elaborated from crafting to executing the corrosion management program in highly completive & challenging environment of port sector in line with corporate business strategy & vision.

This paper uses example from the Adani Ports & SEZ Ltd corrosion control program to execute corrosion management strategy. This paper also describes various successful continual improvements project to control corrosion & challenges way ahead

Understanding the corrosion and controlling it along with the process conditions that cause damage can only achieve by effective corrosion management strategy. An effective corrosion management is of utmost importance today, which, if better managed, can improve organization's profitability, safety, health & environment considerably.

It is needed to work out corrosion management programs with planned investments at each stage of design ; fabrication ; implementation of anti-corrosion measure , operation ,monitoring , inspection ,maintenance , education ; knowledge transfer ;training and research.

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