Facility Inspection & Condition Assessment Program (FICAP)

Corrosion Manual Training Course

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Module 1.1

Introduction and Course Overview

Corrosion Manual Training Course

Introductions

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Learning Outcomes

Module 1.1 Learning Outcomes

- Summarize the course structure and global learning outcomes.
- Describe course agenda.
- Summarize primary objectives of Corrosion Manual (CM).
- Provide overview and organization of CM.

Will not cover complete review of the FICAP Maritime Structures Manual


PORT HOUSTON
Facilities Inspection and Condition Assessment Program – Corrosion Manual

Issued for:
Port of Houston Authority
111 East Loop North
Houston, Texas
77029-4326

Version 1.0
October 2022

Global Learning Objectives

Inspectors and Engineers

- Describe hierarchy of terms
- Identify components and elements part of inspection
- Describe element condition codes and states to document result
- Conduct inspections per Corrosion Manual

Engineers Only

- Develop a Corrosion Inspection Plan per Corrosion Manual
- Assign component ratings and corrosion condition ratings for assets
- Recommend and prioritize follow-up actions

Course Modules

Module	Description	Participants
1	Course Overview and Introduction to Corrosion Manual	Inspectors and Engineers
2	Maritime Asset, Component, and Element Types	
3	Inspection Types and Reports	
4	Element Conditions and Condition States	
5	Corrosion Inspection Plan	Engineers
6	Assessment for Components and Rating Approach	
7	Recommended Follow-Up Actions	
8	Overall Documentation and Reporting Requirements	

Modules: Inspectors and Engineers

Module 1: Course Overview and Introduction to Corrosion Manual	
1.1	Introductions and Course Overview
1.2	Introduction to Corrosion Manual
1.3	Introduction to Inspection and Assessment Approach
Module 2: Maritime Asset, Component and Element Types	
2.1	PHA Asset Types
2.2	Component Groups
2.3	Elements
2.4	Asset Corrosion Condition Rating
Module 3: Inspection Types and Reports	
3.1	Inspection Types and Reports
3.2	Inspection Documentation
Module 4: Element Conditions and Condition States	
4.1	Element Conditions and Condition States
4.2	Documenting Element Condition States
Evaluation:	**Exam 1**

Modules: Engineers Only

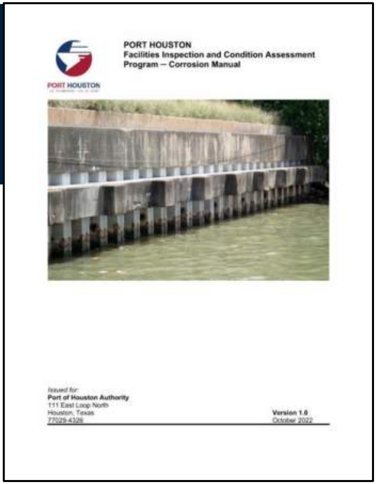
Module 5: Corrosion Inspection Plan	
5.1	Baseline Inspection Planning
5.2	Routine Inspection Planning
Module 6: Assessment for Components and Rating Approach	
6.1	Condition Assessment and Rating Approach
6.2	Corrosion Protection Component Ratings
6.3	Base Metal Component Ratings
6.4	Asset Corrosion Condition Rating
Module 7: Recommended Follow-Up Actions	
7.1	Recommended Follow-Up Actions
Module 8: Documentation and Reporting Requirements	
8.1	Overall Documentation and Reporting Requirements
8.2	Database Entry
Evaluation:	**Exam 2**

Module 1.1 Resources

- Table of Contents
- Chapter 1: Introduction
  - 1.1 Background
  - 1.2 Purpose of Inspection Program
  - 1.3 Corrosion Manual Basis and Objectives
  - 1.9 Manual Organization

Corrosion Manual Purpose

- Provide Port Houston with information on corrosion protection systems and the base metals they protect
- Indicate current and future performance (rate of deterioration)
- Used to prioritize and plan preventative and remedial actions to achieve or maintain service life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Asset Name	Corrosion Condition Rating (CCR)	Corrosion Protection Component Combined Rating (CP)	Base Metal Component Combined Rating (BM)
Asset 1	53	20	33
Asset 2	92	60	32
Asset 3	74	42	32
Asset 4	21	1	20
Asset 5	33	*1*	*32*
Asset 6	92	56	36
Asset 7	19	3	16
Asset 8	79	46	33
Asset 9	60	*50*	*10*
Asset 10	68	*40*	*28*

Corrosion Manual Introduction

- **Primary Objective Statement:** Provide a more complete indication of the current and future condition of maritime assets at Port Houston with specific focus on corrosion protection elements, along with the base metals those components protect
- **Goal of Manual:** Define the process, procedures, and requirements for completing corrosion inspections and condition assessments for corrosion protection components in a consistent manner and level of detail to meet the needs of Port Houston.

Corrosion Manual Objectives

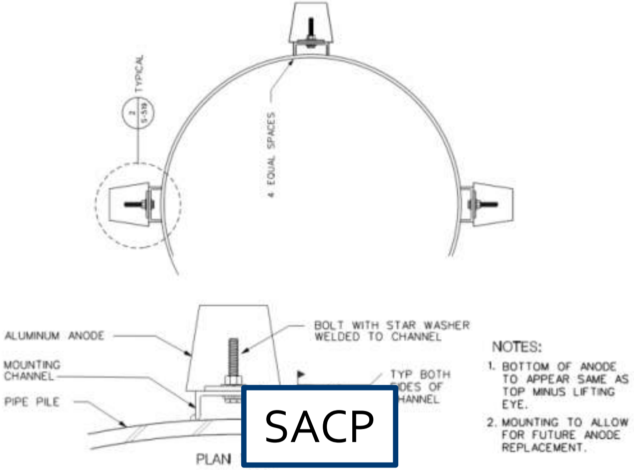
- Part of an overall corrosion management program for Port Houston's maritime assets, including:
  - Analysis of inspection data and performance for corrosion protection systems
  - Assessment of base metal performance via a corrosion damage index – tool to establish severity of corrosion and timeframes for repair
  - Data to predict performance, assess risk, and evaluate effectiveness of corrosion protection over time

Corrosion Protection Components

- Impressed Current Cathodic Protection (ICCP)
- Sacrificial Anode Cathodic Protection (SACP)
- Surface Protection (e.g. coating, wrap, and metalizing)

Base Metals are a separate component

ICCP

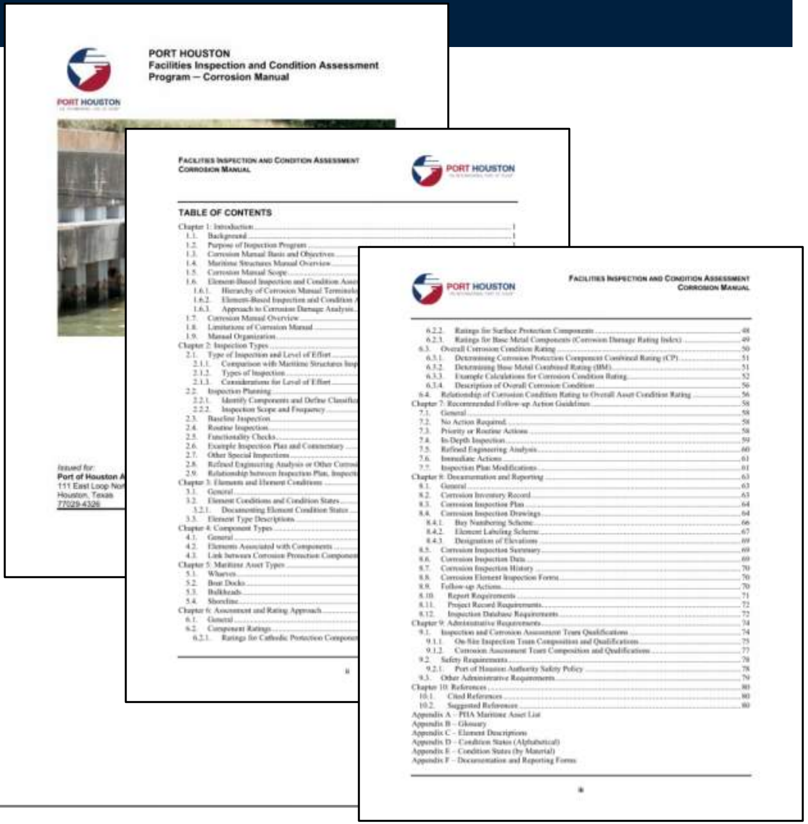


SACP

Surface Protection

Corrosion Manual Organization

1. Introduction
2. Inspection Types
3. Elements and Element Conditions
4. Component Types
5. Maritime Asset Types
6. Assessment and Rating Approach
7. Recommended Follow-Up Action Guidelines
8. Documentation and Reporting

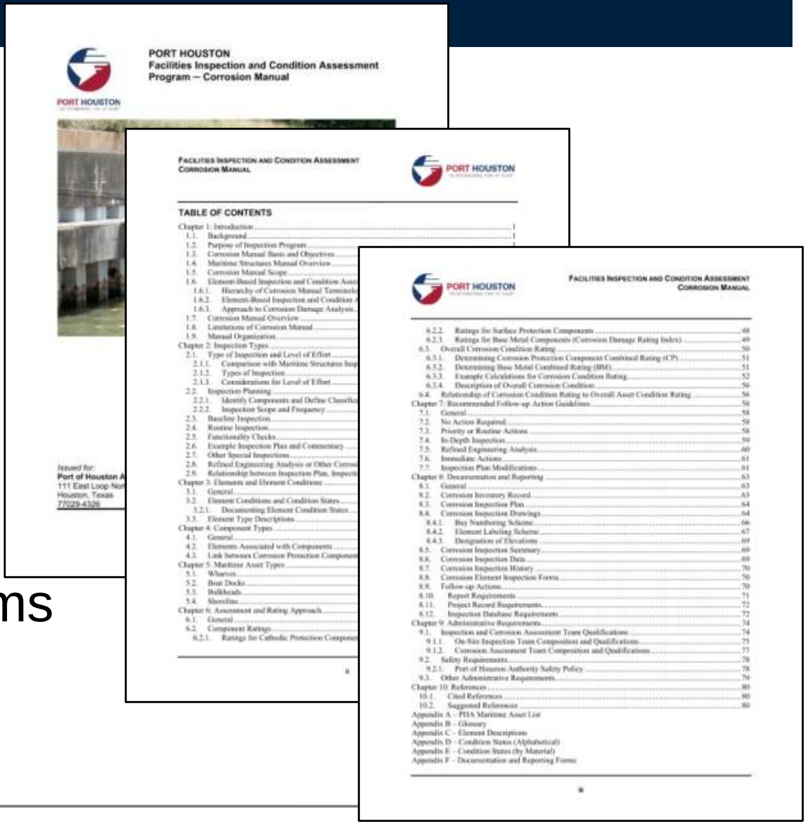


Organization of Corrosion Manual

9. Administrative Requirements
10. References

Appendices:

A. PHA Maritime Asset List
B. Glossary
C. Element Descriptions
D. Condition States (Alphabetical)
E. Condition States (by Material)
F. Documentation and Reporting Forms
G. Corrosion Inspection Drawings
H. Reference Information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FACILITIES INSPECTION AND CONDITION ASSESSMENT CORROSION MANUAL
TABLE OF CONTENTS

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END OF MODULE

Module 1.2

Introduction to Corrosion Manual

Corrosion Manual Training Course

Overview

Module 1.2 Learning Outcomes

- State the purpose of an inspection and condition assessment program.
- Relate this purpose to the needs of Port Houston.
- Describe the scope of the Corrosion Manual.

Module 1.2 Resources

- Chapter 1: Introduction
  - 1.2 Purpose of Inspection Program
  - 1.3 Corrosion Manual Basis and Objectives
  - 1.5 Corrosion Manual Scope
  - 1.6 Element-Based Inspection and Condition Assessment Approach

Introduction to Corrosion Manual

- Goal of Corrosion Manual is to define:
  - Process
  - Procedures
  - Requirements
- In a consistent manner and level of detail to meet needs of the PHA
- Intended to be used by qualified engineers and inspectors

Purpose of Inspection and Assessment

- Define corrosion protection components and elements in use on PHA maritime assets
- Estimate of corrosion protection performance and corresponding impact on the base metal elements
- Better informed resource allocation decisions for maintenance of components and assets

Element-Based Inspection

- **Inspection:** evaluation procedure in which a qualified team leader carries out or supervises the observation, classification, and documentation of the physical condition of a corrosion protection system or associated metal element through:
  - Visual
  - Tactile
  - Non-Destructive Evaluation
  - Testing / Measurements

Determine corrosion-related distress, including:

- Type
- Severity
- Location(s) and extent

Condition Assessment

- **Condition Assessment:** evaluation of the inspection results considering the significance of observed and measured conditions
- Based on engineering judgment considering qualitative and quantitative inspection findings
  - May be supplemented by engineering calculations
- **Outcome:** Determine the need and priority of maintenance, repair, or rehabilitation actions for a given component or asset

Inspection and Condition Assessment

- Element-based inspection approach (similar approach to FICAP Maritime Structures)
  - Type of observed condition (e.g., broken connection, missing anode, error in output display)
  - Severity of observed condition (e.g., size of defects, impact on element performance, severity of section loss)
  - Scope or extent of observed condition (e.g., number of locations, surface area of element affected)

Condition States
for each condition per element

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Element Based Approach

- **Elements:**
  - Condition States based on Inspection
- **Components:**
  - Numerical rating based on judgment and functional condition
- **Asset**
  - Corrosion Condition Rating (based on component ratings)

Table 1.1: Summary of Element-Based Approach

Level	Purpose	Comment
Asset	▪ Corrosion assessment for asset guides follow-up actions and asset management decisions.	▪ Overall corrosion condition rating (CCR) is a numerical rating and is supplemented by a qualitative (descriptive) assessment.
Component	▪ Component condition assessment indicates condition of corrosion protection or base metal components. ▪ Where appropriate, inspection measurements provide basis for overall component condition. ▪ Provide basis to determine overall corrosion condition.	▪ Numerical component rating is based on an engineering interpretation of the element condition states, inspection data, and their corresponding implication(s) on the functional condition of the component. ▪ Base metal component rating is based on the estimated corrosion damage rating index of critical, typical, and redundant elements.

Element	▪ Condition states document occurrence of damage, deterioration, or defects at time of inspection in terms of:
	  ▪ Type of condition(s) (i.e. damage mechanism)
	  ▪ Severity of defect (i.e. moderate, severe)
	  ▪ Extent of defect (i.e. localized or general)
	▪ Correlates conditions to element and material type.
	▪ Tracks conditions over time as indicated by inspections conducted at regular intervals.
	▪ Selective measurements of key parameters provide basis for corrosion damage rating index of overall component.
	▪ Provides basis for component rating.
		▪ Detailed visual inspections are conducted at the element level.
		▪ Element condition states are assigned based on predefined categories and quantified to define element condition.

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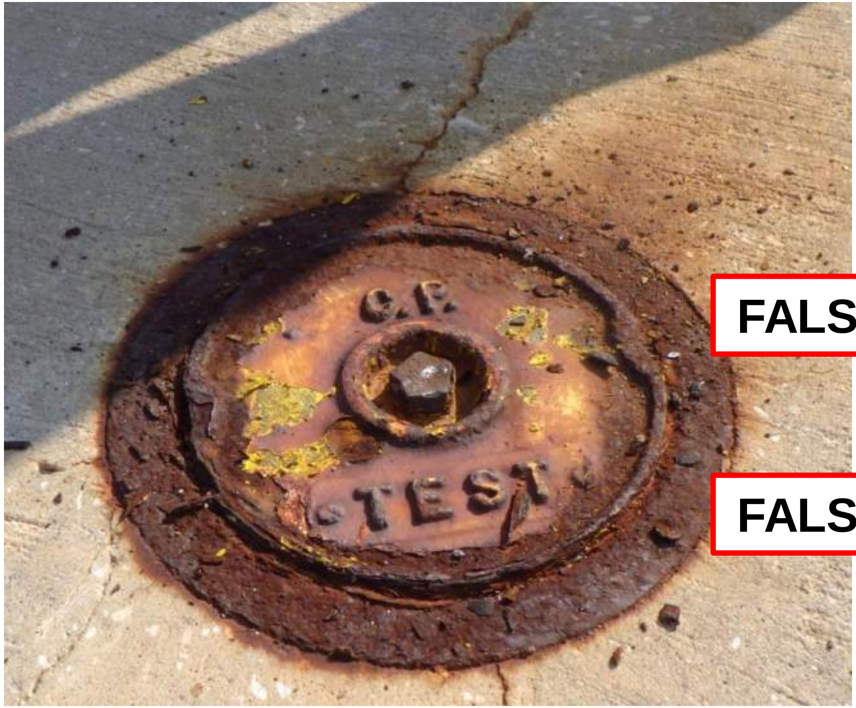
Knowledge Check: True or False?



- Corrosion Manual follows an element-based inspection approach **TRUE**
- Corrosion Manual is based on visual inspection only **FALSE**
- Corrosion Condition Rating is assigned based on engineering judgment **FALSE**

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END OF MODULE

Module 1.3

Inspection and Assessment Approach

Corrosion Manual Training Course

Overview

Module 1.3 Learning Outcomes

- Explain hierarchy of facility terms
- Define application of element-based approach to corrosion inspection and assessment program

Module 1.3 Resources

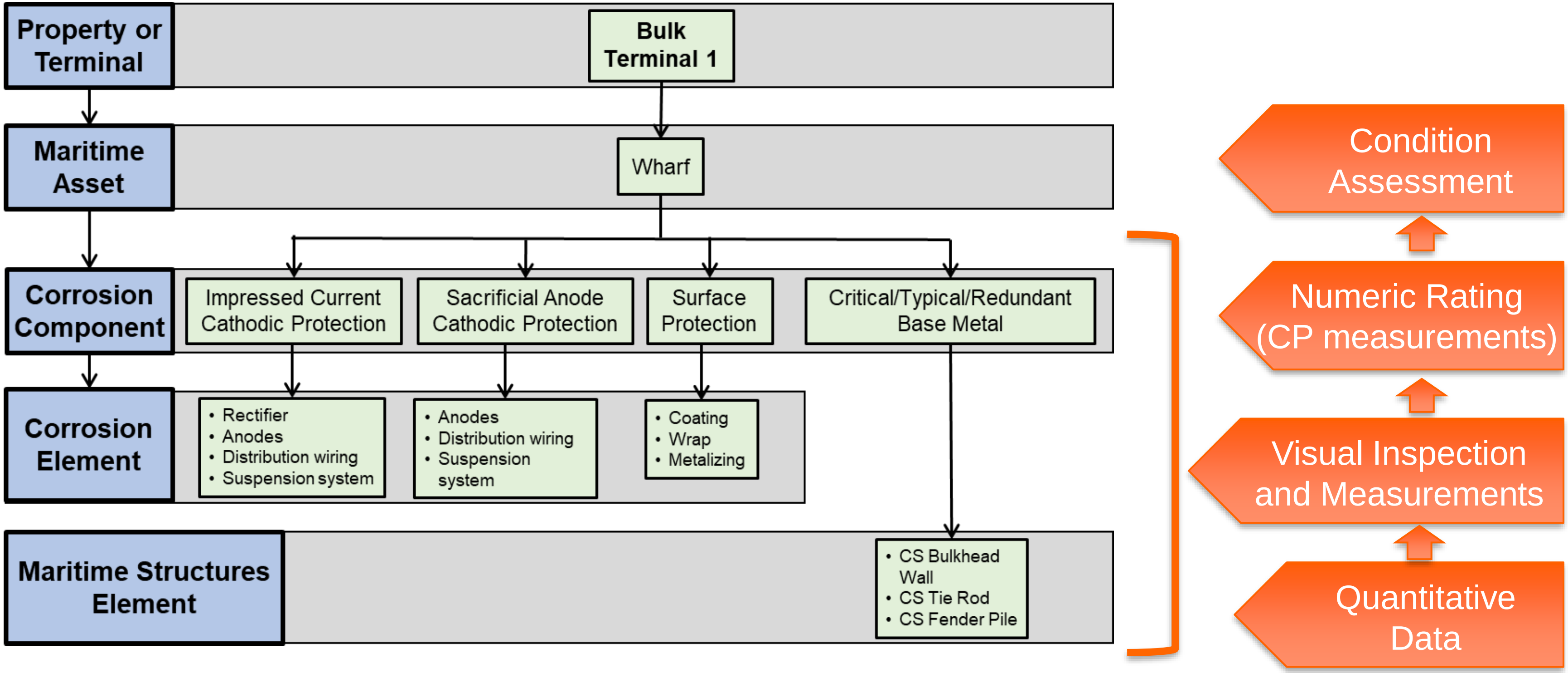
- Chapter 1: Introduction
  - 1.6 Element-Based Inspection and Condition Assessment Approach

Inspection and Assessment Approach

- Element-based inspection and condition assessment approach
- Elements grouped by Component
  - Impressed Current CP
  - Sacrificial Anode CP
  - Surface Protection
  - Base Metal

Elements:
Anodes, Power Supply, Wiring & Protection, Supports…etc.

Corrosion Manual Hierarchy



Inspection and Assessment Approach

- Relies on two equally important factors:
  - Completeness and quality of the documented condition of the asset determined during the inspection
  - Experience and knowledge of the engineer(s) responsible for the assessment

Similarities to Maritime Structures

- Relationship between elements and components remains mostly similar
- General pattern for assessing and providing condition ratings for components and the overall assets
- Documents visual condition of each inspected element

Differences from Maritime Structures

- Additional inspection techniques/ measurements:
  - Document performance of corrosion protection components
  - Estimating the section loss and corrosion rates of base metals
- Base Metal Classification (Critical, Typical, or Redundant)

Module Wrap-Up

- What corrosion protection element characteristics should be recorded to facilitate a credible condition assessment?
  - ☑ Types of elements that may have damage, deterioration, or defects
  - ☑ Type of condition (i.e., damage, deterioration, or defect) observed
  - ☑ Severity of condition observed
  - ☑ Scope or extent of condition observed
  - ☑ Performance of installed systems, often times indicative of multiple elements of the corrosion protection component

Module Wrap-Up, cont'd.

- What base metal element characteristics should be recorded to facilitate a credible condition assessment?
  - ☑ Element type that has a corrosion condition
  - ☑ Type of condition (i.e., corrosion or section loss) observed
  - ☑ Severity of condition observed
  - ☑ Scope or extent of condition observed
  - ☑ Measurement of section loss (facilitate estimate of corrosion rate)

END OF MODULE

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Module 2.1

PHA Asset Types

Corrosion Manual Training Course

Overview

Module 2.1 Learning Outcomes

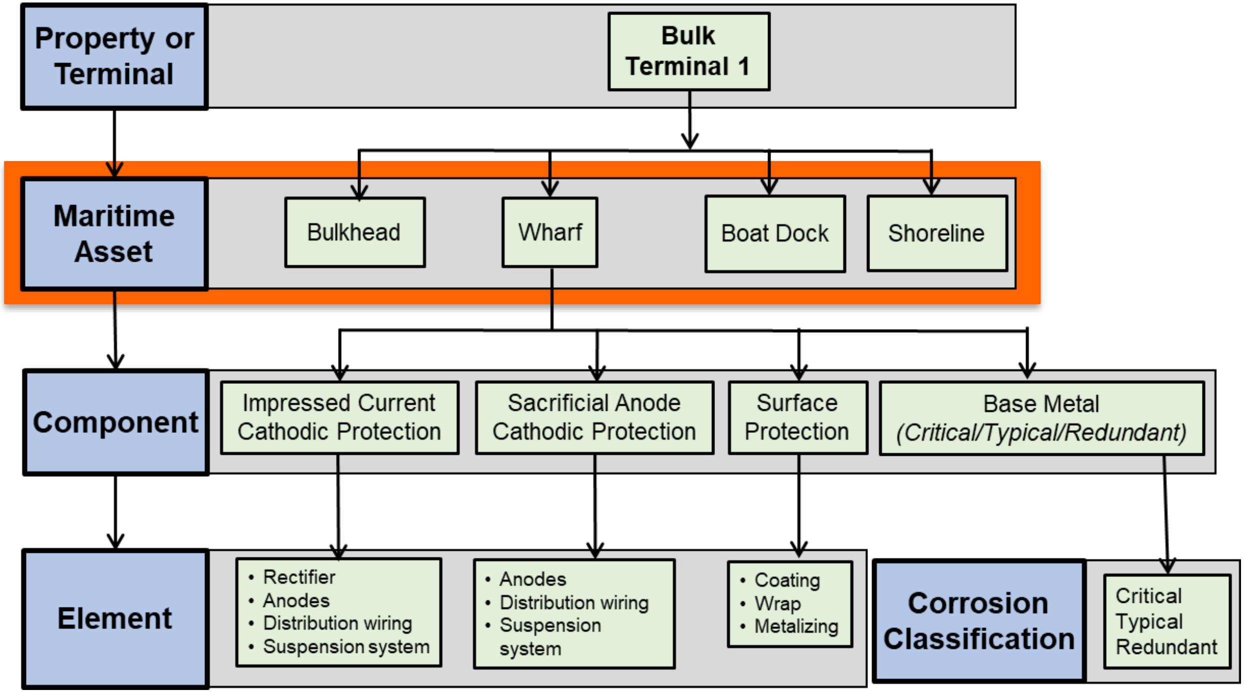
- Identify maritime assets within the PHA inventory.
- Describe the functional purpose of each maritime asset type: wharf, boat dock, and bulkhead, and shorelines.

Module Resources

- Chapter 5: Maritime Asset Types
  - 5.1 Wharves
  - 5.2 Boat Docks
  - 5.3 Bulkheads
  - 5.4 Shoreline
- Appendix A: PHA Maritime Asset List
- Appendix B: Glossary

Maritime Asset

Maritime Asset: A unit of a property or terminal that has a defined boundary and serves a functional purpose



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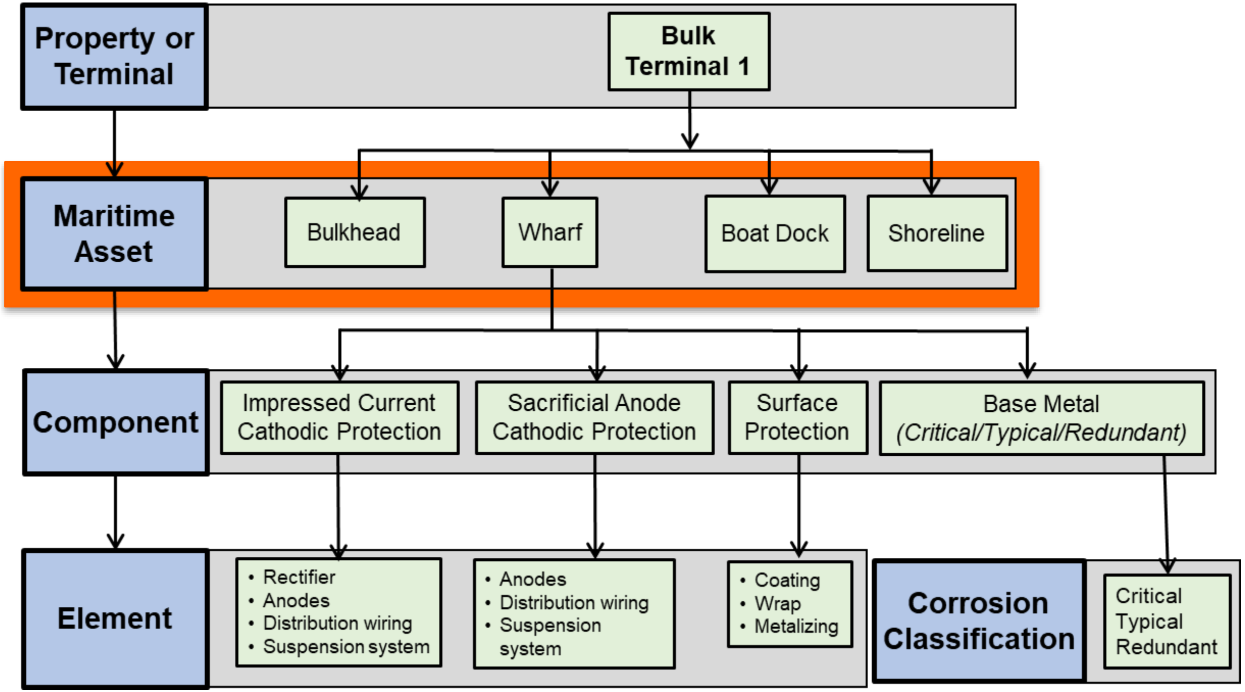
Maritime Asset

Four main types of asset:

1. Wharf
2. Boat Dock
3. Bulkhead
4. Shoreline



Wharf

- Structure oriented parallel to shore for mooring ships

Wharf

- Structure oriented parallel to shore for mooring ships
- Purpose: loading and unloading cargo or personnel from large vessels

Wharf

- Structure oriented parallel to shore for mooring ships
- Purpose: loading and unloading cargo or personnel from large vessels

- Consists of one or more structural systems:
  - Open platform with open structure
  - Open platform with solid structure
  - Solid bulkhead
  - Solid bulkhead with relieving platform

Wharf: Open platform, open structure

- **Open platform**: Water free to move underneath
- **Open structure**: Structure supported over water by piles or drilled shafts

Wharf: Open platform, open structure

- **Open platform**: Water free to move underneath
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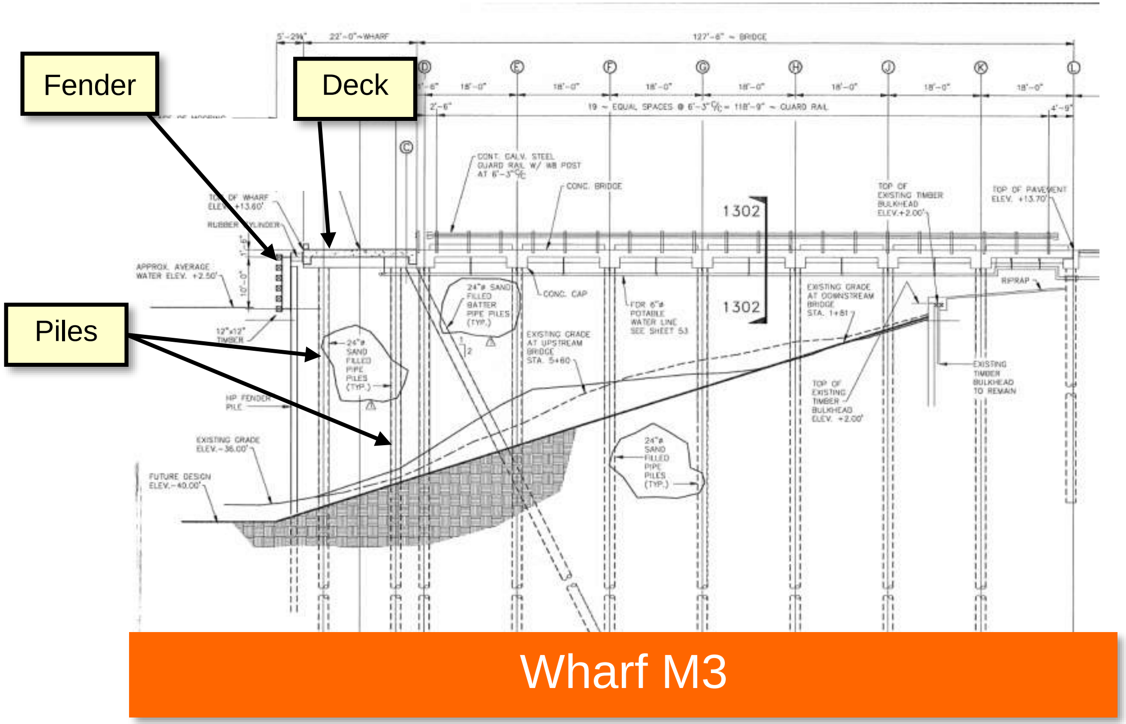

Wharf: Open platform, open structure

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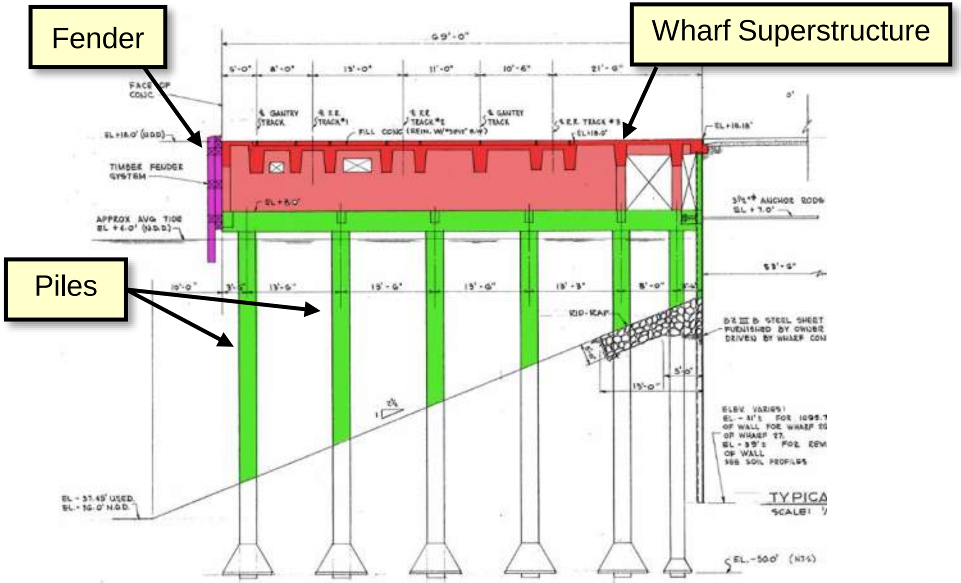

Wharf CD26

Wharf: Open platform, solid structure

- **Open platform**: Water free to move underneath
- **Solid structure**: Deck supported on fill, supported on structural platform slab

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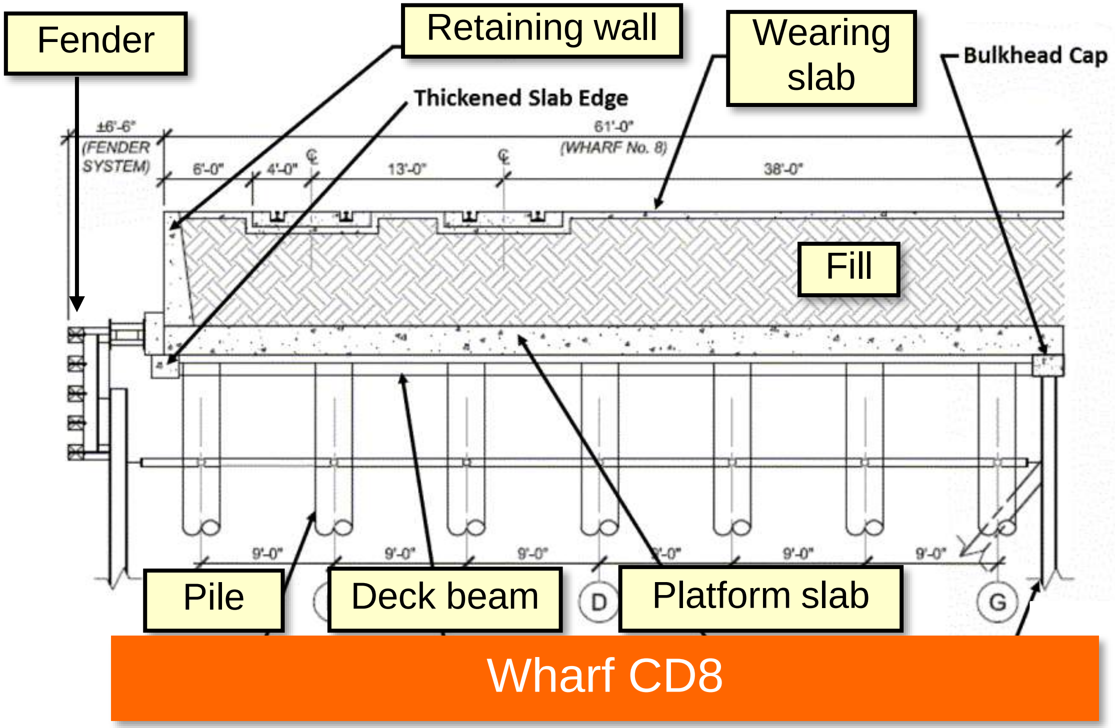

Wharf: Solid bulkhead

- **Solid bulkhead**: Wharf structure supported on fill retained by wall or sheet piles

Wharf: Solid bulkhead, relieving platform

- **Solid bulkhead**: Wharf structure supported on fill retained by wall or sheet pile
- **Relieving platform**: Buried support structure

Wharf: Solid bulkhead, relieving platform

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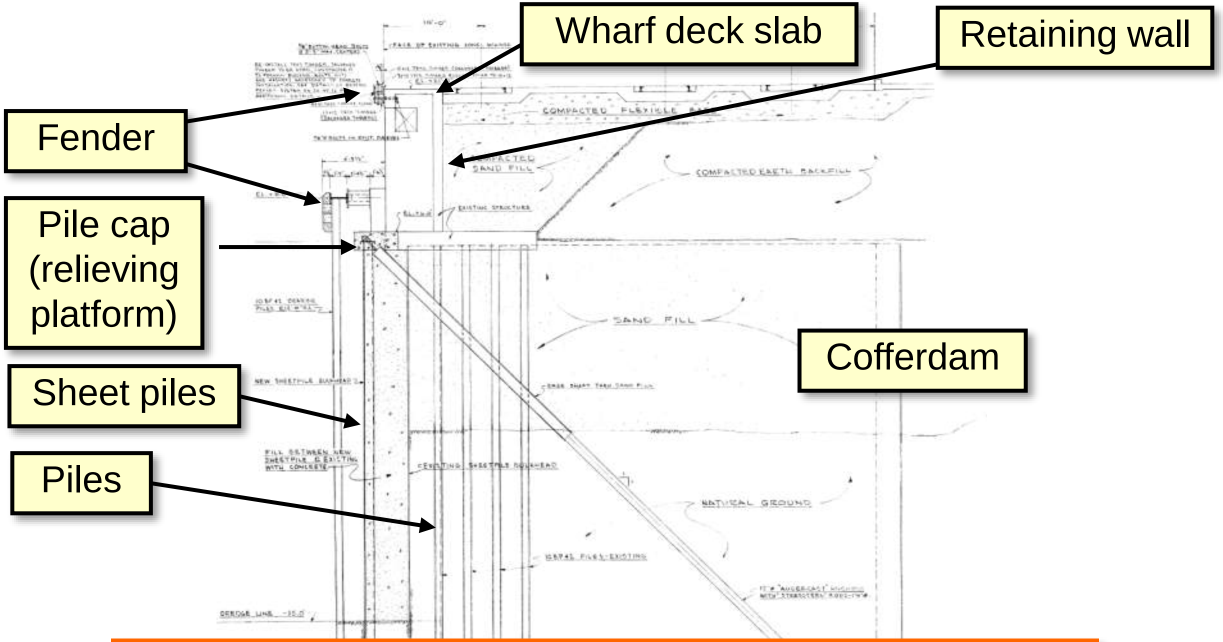


Wharf CD9

Boat Dock

- Similar to wharves, but self-supporting
- **Functional purpose**: loading and unloading cargo or personnel from vessels

Boat Dock

- Similar to wharves, but self-supporting
- **Functional purpose**: loading and unloading cargo or personnel from vessels

- Three general categories:
  - Open platform with open structure
  - Solid bulkhead
  - Floating platform

Bulkhead

- Vertical step in elevation
- **Functional purpose**: separate shoreline from water

Note: A bulkhead is an asset only if it is unassociated with a wharf or boat dock.

Shoreline

- Intersection between land and water
- May be protected or unprotected

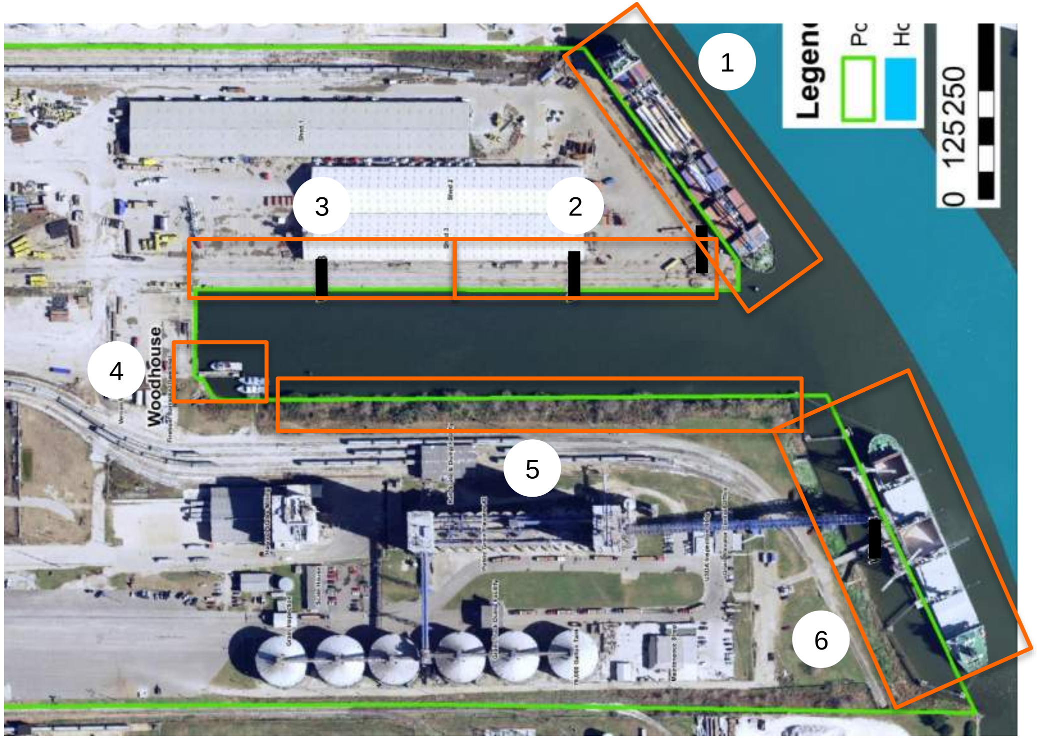
Four Types of Maritime Assets

- Wharf
- Boat dock
- Bulkhead
- Shoreline

Which maritime assets can you identify?

- Woodhouse Terminal
  - Wharves?
  - Boat docks?
  - Bulkheads?
  - Shorelines?

Recall “terminal” = collection of wharves



Which maritime assets can you identify?

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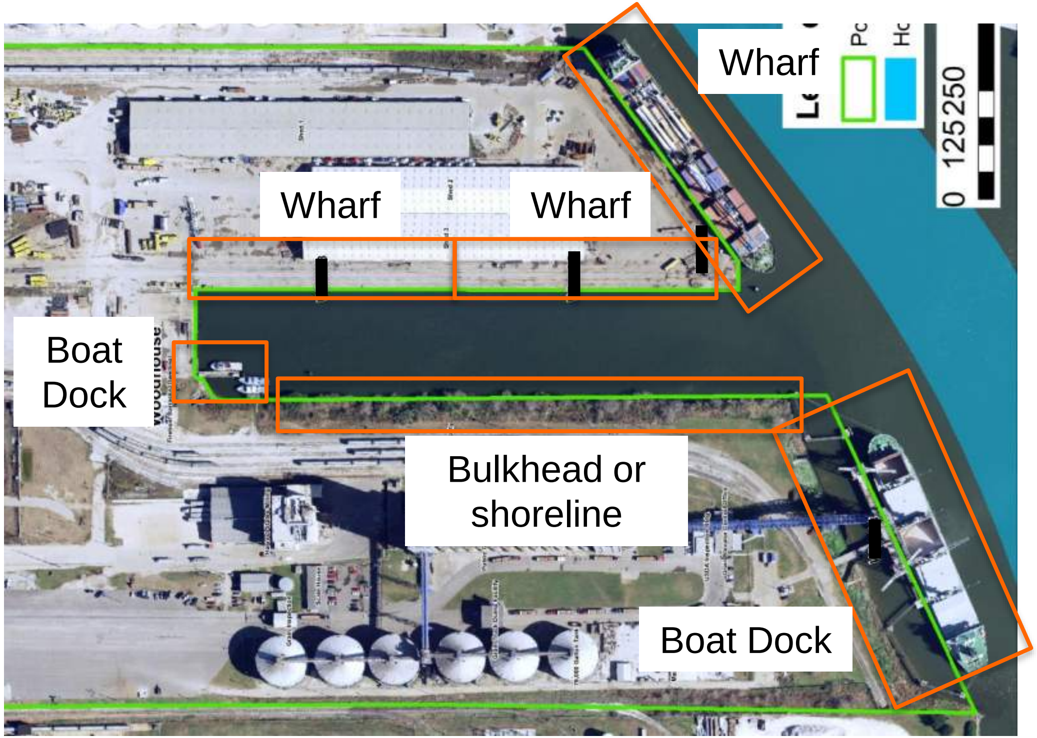

Module Wrap-Up

Module 2.1 Learning Outcomes

1. Identify maritime assets within the PHA inventory.
2. Describe the functional purpose of each maritime asset type:
   a. Wharf
   b. Boat dock
   c. Bulkhead
   d. Shoreline

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END OF MODULE

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Module 2.2

Component Groups

Corrosion Manual Training Course

Overview

Module 2.2 Learning Outcomes

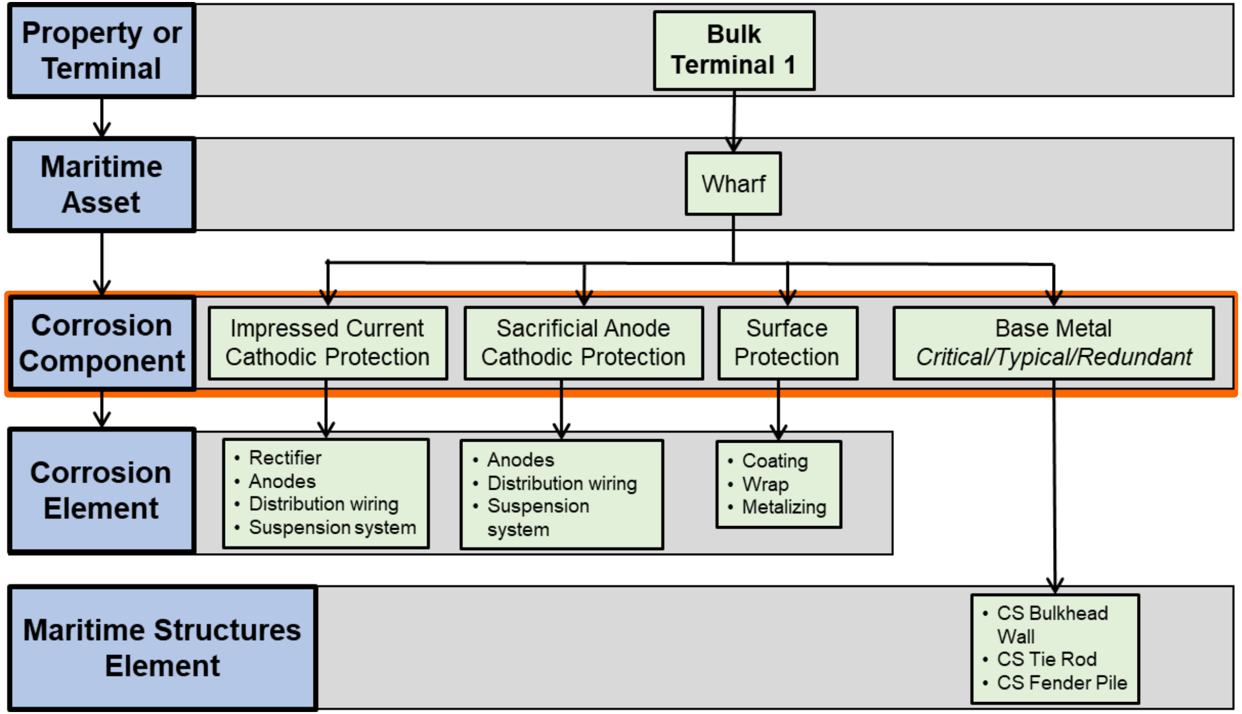
- Identify component types within the PHA CM Inventory.
- Identify elements within each component.
- Differentiate between a component and an element.
- Describe the functional purpose of each component type: impressed current cathodic protection, sacrificial cathodic protection, surface protection, and base metal.

Module Resources

- Chapter 4: Component Types
  - 4.1 General
  - 4.2 Elements Associated with Components
  - 4.3 Link between Corrosion Protection Component and Maritime Structures Elements
- Appendix C

Hierarchy of Terms: Component

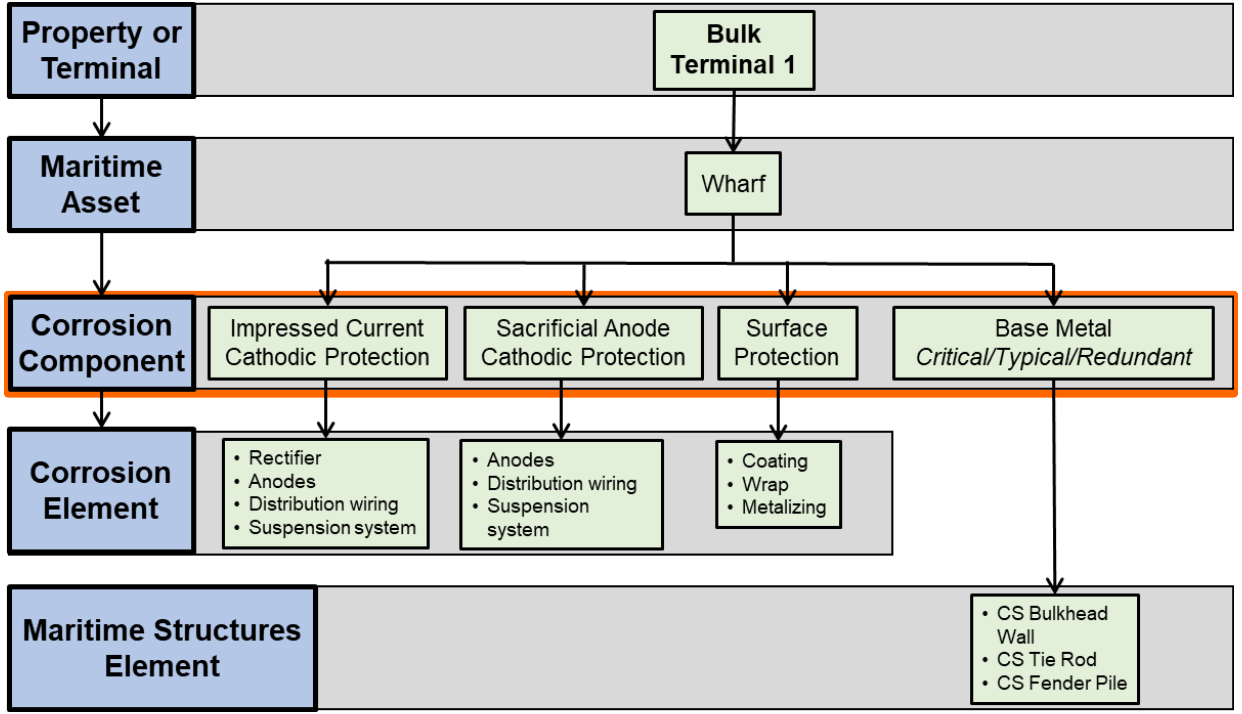
- **Component:** group of elements that make up a particular corrosion protection system or a group of corresponding base metal elements.
- Manual includes four components



Hierarchy of Terms: Component

Four component groups:

1. ICCP
2. SACP
3. Surface Protection
4. Base Metal

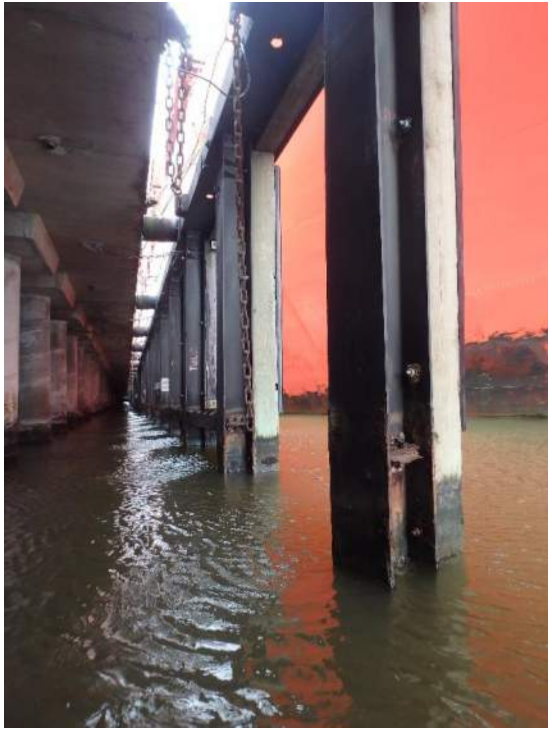


Corrosion Protection Components

- Impressed Current (ICCP) and Sacrificial Anode (SACP) Cathodic Protection Components
  - A group of elements that comprises a ICCP or SACP system for the purpose of protecting structural or functional elements
- Surface Protection Components
  - A group of elements that are applied to the surface of existing structural or functional elements to mitigate or prevent corrosion of the underlying element

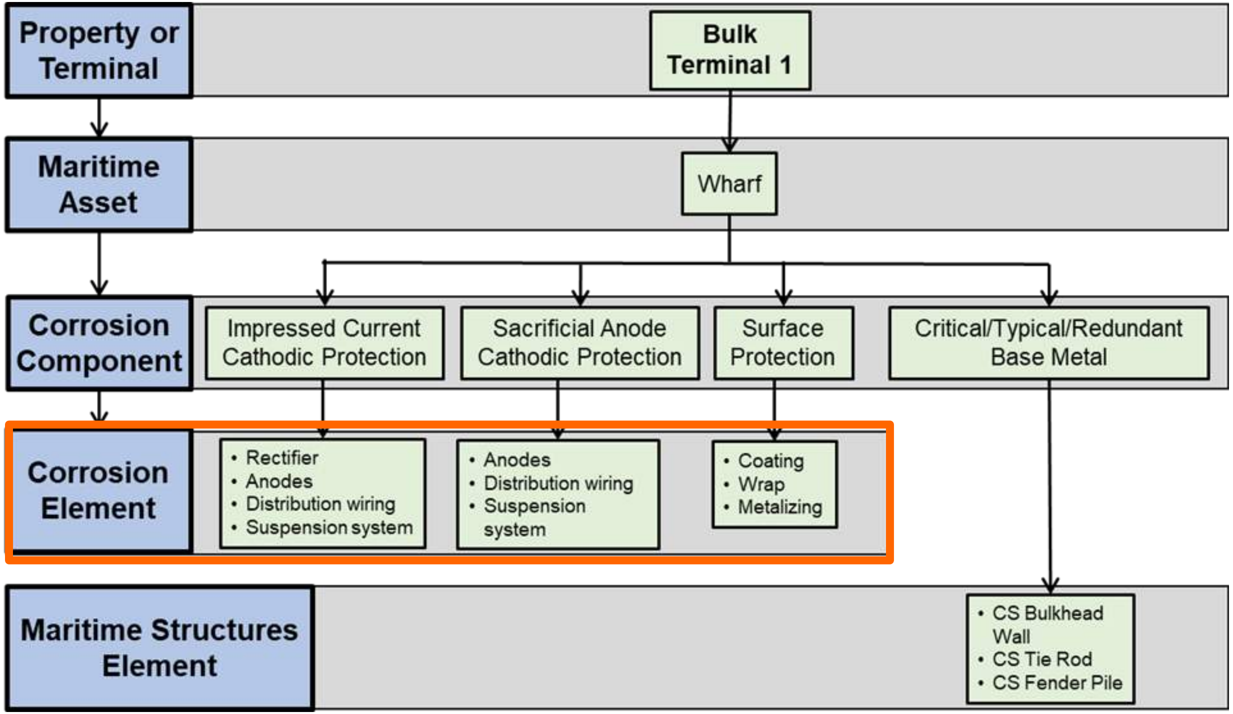
Base Metal Components

- Defined to track the corrosion damage of metal elements
  - Same metal elements exist in Maritime Structures Manual
- Base Metal component is a way to classify elements based on their importance
- Group of elements with the same corrosion classification (Critical, Typical, or Redundant).



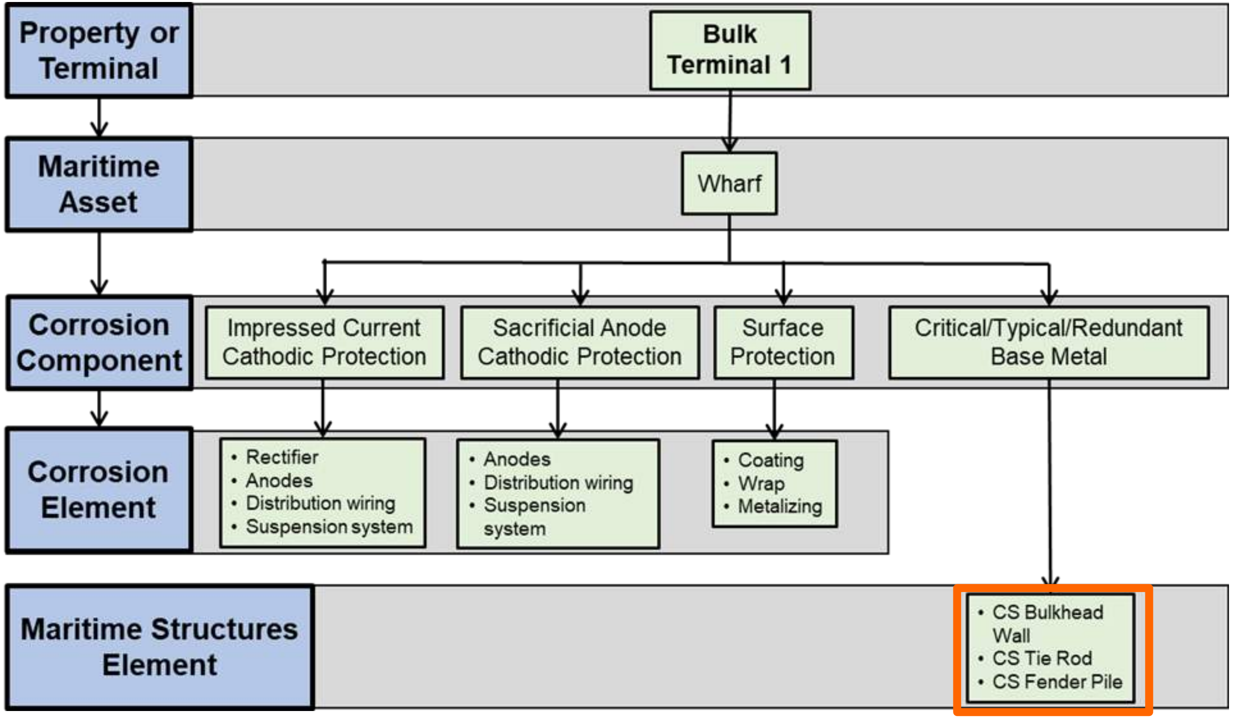
Hierarchy of Terms: Corrosion Element

- **Element:** individual member of a corresponding component
- Defined by components to which it belongs, functional purpose, geometry, and material.



Hierarchy of Terms: Base Metal Element

- **Base Metal Element:** elements that are protected by a corrosion component
- Grouped into one of three Base Metal Corrosion Components
  - Critical
  - Typical
  - Redundant



ICCP Component

Functional Purpose

- Supplies electric current by a device employing external power to protect base metal elements

Example Elements

- Anodes: Inert material (typically) that conducts by oxidation of electrolyte to protect base metal elements
- Supplementary Anode Material: Backfill material for more efficient current distribution
- DC Power Supply: Converts AC to DC for distribution into the system

SACP Component

Functional Purpose

- Supplies CP due to a difference in electric potential between the sacrificial anode and the cathode (base metal)

Example Elements

- Anodes – Sacrificial: A metal that provides sacrificial protection to another metal that is more noble when electrically coupled in an electrolyte
- Wiring, Supports, Monitoring Equipment, Supplementary Anode Materials

Surface Protection Component

- **Functional Purpose**
  - Mitigate or prevent corrosion by providing protection to the external surface
- **Example Elements**
  - Coatings: single or multi-coat systems
  - Metalizing: molten metal sprayed on to surface of metal or concrete
  - Galvanizing: dip base metal in a molten bath of zinc
  - Protective Wraps: provide barrier protection

Base Metal Component

- **Functional Purpose**
  - Groups existing metal elements in the Maritime Structures Manual for purpose of corrosion classification and scoring in the Corrosion Manual
- **Base Metal Component Classification Levels**
  - **Critical (BMC):** Loss will likely significantly compromise the function and/or capacity of the associated component and/or other elements (e.g. bulkhead tie rods)
  - **Typical (BMT):** Loss may reduce the function or capacity of the associated component or asset, but the asset can remain in service (e.g. bulkhead wall)
  - **Redundant (BMR):** Loss will not compromise function of component (e.g. fender support framing)

Base Metal Component

Table C-4 in Appendix C

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[4]
		Critical (BMC)	
TR-CS-BMC TR-GS-BMC	CS Tie Rod GS Tie Rod	A tension-only structural element. Includes elements used as bracing and those used as tie backs for retaining walls. Does not include rods used solely for railing.	EA
DB-CS- BMC DB-GS- BMC	CS Deck Beam GS Deck Beam	A structural element loaded perpendicular to its longitudinal axis that transmits loads directly from the deck to a girder or substructure element.	LF
GI-CS- BMC GI-GS- BMC	CS Girder GS Girder	A structural element loaded perpendicular to its longitudinal axis that transmits loads from a deck beam or stringer to the substructure. May also carry loads directly from a portion of the deck.	LF
GP -CS- BMC GP-WS- BMC	CS Gusset Plate WS Gusset Plate	A structural plate element that provides a connection between other structural elements. Constructed with one or more plates that may be bolted, riveted, or welded.	EA
CO-CS- BMC CO-GS- BMC	CS Column GS Column	A vertical prismatic element that transmits loads (vertical, lateral and/or bending) from the deck or … ubstructure element.	LF
PI-CS- BMC	CS Pile	… tical element that transmits … uperstructure, or substructure … l bearing or friction. Piles are … allation and driven into the … idered deep foundation	EA
PF-CS(S)- BMC PF-CS(C)- BMC	CS Sand-Filled Pile CS Concrete-Filled Pile	A type of pile that consists of a hollow steel pipe driven into the ground and then filled with material. Includes "Raymond Piles", which are concrete-filled pipes with tapered cross-sections.	EA
PC-CS- BMC	CS Pile Cap	A horizontally-oriented structural element that transmits loads from substructure or superstructure elements above to pile elements below.	LF
BG-CS- BMC	CS Closed Web/Box Girder	A hollow, four-sided structural element loaded perpendicular to its longitudinal axis that transmits loads from a deck beam or stringer to the substructure.	LF
BT-CS- BMC BT-GS- BMC	CS Bulkhead Tie Rod GS Bulkhead Tie Rod	A tension-only structural element, used to restrain the top of a bulkhead wall.	EA

Critical
BMC

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[4]
		Typical (BMT)	
AW-CS-BMT	CS Anchor Wall	A continuous buried wall element on the landside of a retaining wall or bulkhead. Used as anchorage for another element.	LF
BW-CS-BMT BW-GS-BMT	CS Bulkhead Wall GS Bulkhead Wall	A structural wall element that functions primarily as an earth retaining structure. Primarily subject to out-of-plane lateral loads. Bulkheads generally separate earth fill from water.	LF
DT-CS- BMT	CS Deck, open Grid	A horizontal, planar structural element that carries and distributes loads to superstructure or substructure elements. Observations specific to topside of element.	SF
SR-CS- BMT SR-GS- BMT	CS Stringer GS Stringer	A structural element loaded perpendicular to its longitudinal axis that transmits loads from the deck to a deck beam	LF
RW-CS- BMT	CS Retaining Wall	A structural wall element that functions primarily to … carry vertical loads from … ning walls are located above	LF
CF-CS- BMT	CS Cofferdam	… ll structural elements used as a … tructure.	EA
BB-CS- BMT	CS Bulkhead Wale Beam	A bulkhead element loaded perpendicular to its longitudinal axis that stiffens a bulkhead and is attached to tie rods or other anchorages.	LF
BC-CS- BMT	CS Bent Cap	A horizontally-oriented structural element that transmits loads from superstructure elements to column elements below.	LF
BR-CS- BMT BR-GS- BMT	CS Brace GS Brace	An element, often diagonally oriented, fastened across pile elements to provide lateral stability.	EA
PB-CS- BMT	CS Battered Pile	A type of pile that is driven at an angle, typically between 30 and 60 degrees from vertical. Battered piles provide lateral stiffness to the structure.	EA
FP-CS- BMT FP-GS- BMT	CS Fender Pile GS Fender Pile	A vertical element that absorbs energy through bending of the member. Fender piles are typically driven into the channel bed and braced at their top to form a propped cantilever.	EA

Typical
BMT

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[4]
		Redundant (BMR)	
SF-CS-BMR SF-GS-BMR	CS Support Framing GS Support Framing	Secondary members generally add to the stability of the fender system and do not distribute berthing and mooring forces, but are lumped together with the primary-load carrying members for inspection purposes.	LF
DU-GS-BMR	GS Deck (stay-in-place form)	A horizontal, planar structural element that carries and distributes loads to superstructure or substructure elements. Observations specific to underside or full-depth of element.	SF
FL-CS-BMR FL-GS-BMR	CS Fender Panel GS Fender Panel	A rectangular element oriented parallel to the fender system that increases the contact area of the fender system against the ship hull.	EA

Redundant
BMT

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Summary of Components

- Components -> Elements
- Corrosion Protection Components
  - ICCP
  - SACP
  - Surface Protection
- Base Metal Components
  - Critical, Typical, Redundant
    - Maritime Structure Metal Elements

Practical Examples

Multiple Choice #1

What corrosion protection component(s) are shown in this photo?

a. SACP

b. ICCP

c. Surface Protection

Multiple Choice #1

What corrosion protection component(s) are shown in this photo?

a. SACP

b. ICCP

c. **Surface Protection**

Multiple Choice #2

What base metal component(s) are shown in this photo?

a. Critical

b. Typical

c. Redundant

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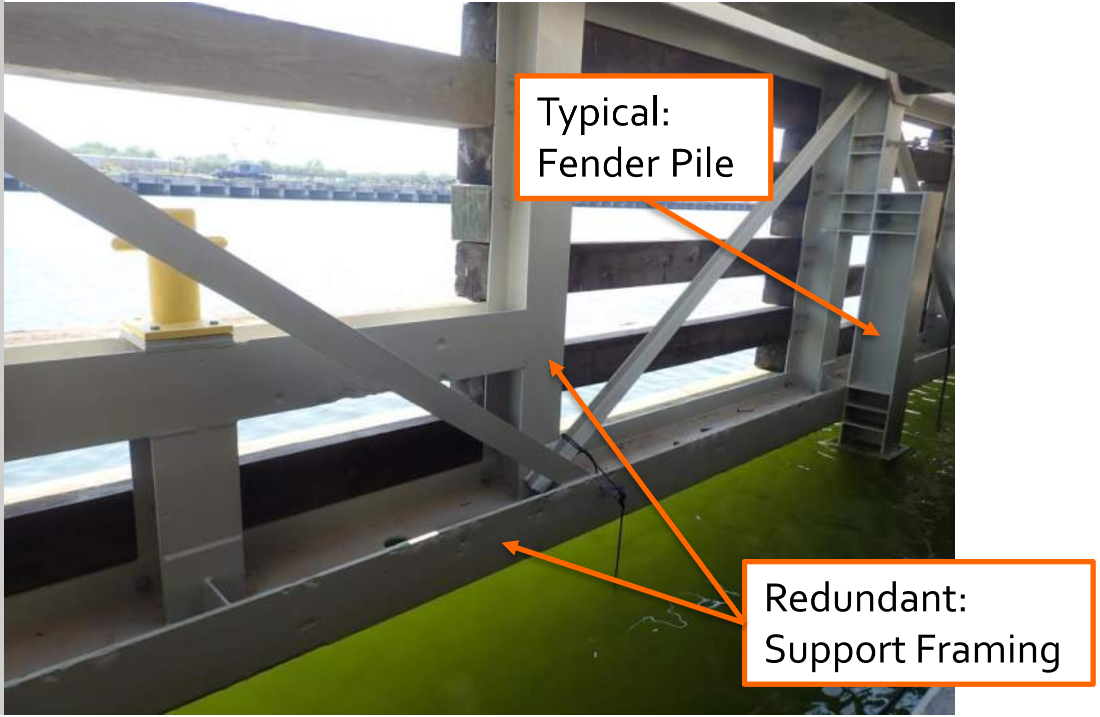
Multiple Choice #2

What base metal component(s) are shown in this photo?

a. Critical
b. **Typical**
c. **Redundant**



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Multiple Choice #3

What corrosion protection component(s) are shown in this photo?

a. SACP

b. ICCP

c. Surface Protection

Multiple Choice #3

What corrosion protection component(s) are shown in this photo?

a. SACP

b. **ICCP**

c. Surface Protection

Multiple Choice #4

What corrosion protection component(s) are shown in this photo?

a. SACP
b. ICCP
c. Surface Protection

Multiple Choice #4

What corrosion protection component(s) are shown in this photo?

a. SACP

b. ICCP

c. **Surface Protection**

Multiple Choice #5

What base metal component(s) are shown in this photo?

a. Critical

b. Typical

c. Redundant

Multiple Choice #5

What base metal component(s) are shown in this photo?

a. Critical

b. **Typical**

c. Redundant

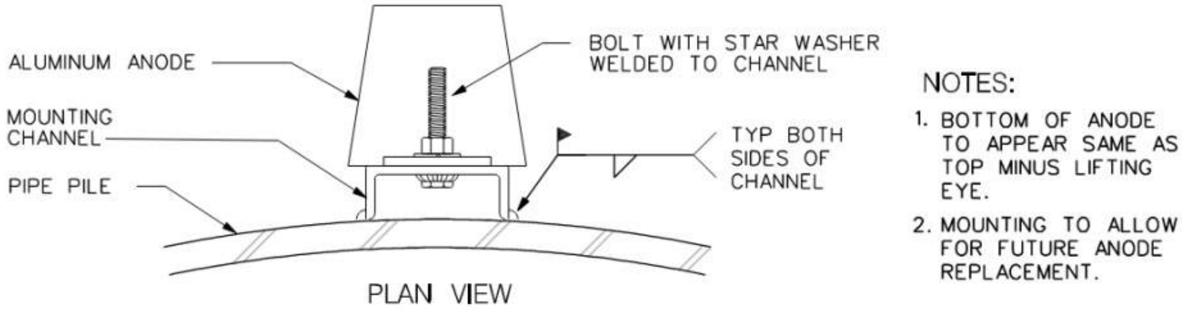
Multiple Choice #5

What corrosion protection component(s) are shown in this photo?

a. SACP

b. ICCP

c. Surface Protection



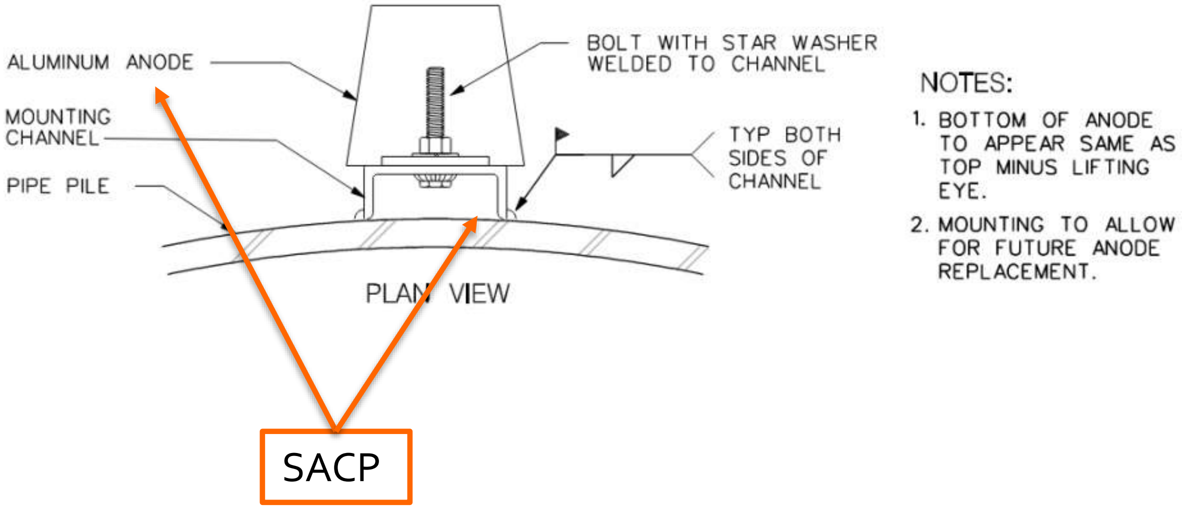
Multiple Choice #5

What corrosion protection component(s) are shown in this photo?

a. SACP

b. ICCP

c. Surface Protection



Module Wrap-up

1. Identify component types within the PHA corrosion inventory.
2. Differentiate between a component and an element
3. Describe the functional purpose of each component type:
   a. ICCP
   b. SACP
   c. Surface Protection
   d. Base Metal

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END OF MODULE

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MODULE 2.3

Elements

Corrosion Manual Training Course

Module Objectives

Module 2.3 Learning Outcomes

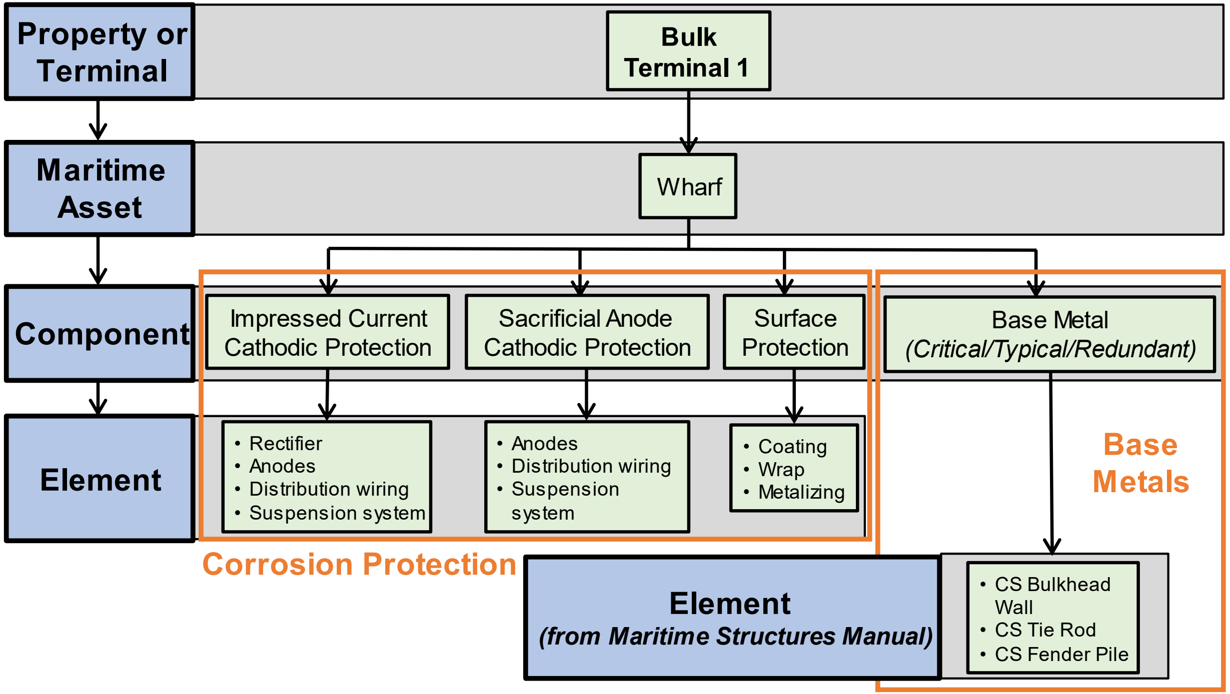
- Describe the hierarchical relationship between an element, a component, and an asset
- Differentiate between corrosion protection and base metal elements within the PHA inventory
- Describe the system used to identify and categorize elements and components
- Complete element codes, IDs, and descriptions for inventory reporting

Module Resources

- Chapter 3, Elements and Element Conditions
  - 3.1 General
  - 3.2 Element Type Descriptions
  - 3.3 Element Conditions and Condition States
- Appendix B: Glossary
- Appendix C: Element Descriptions

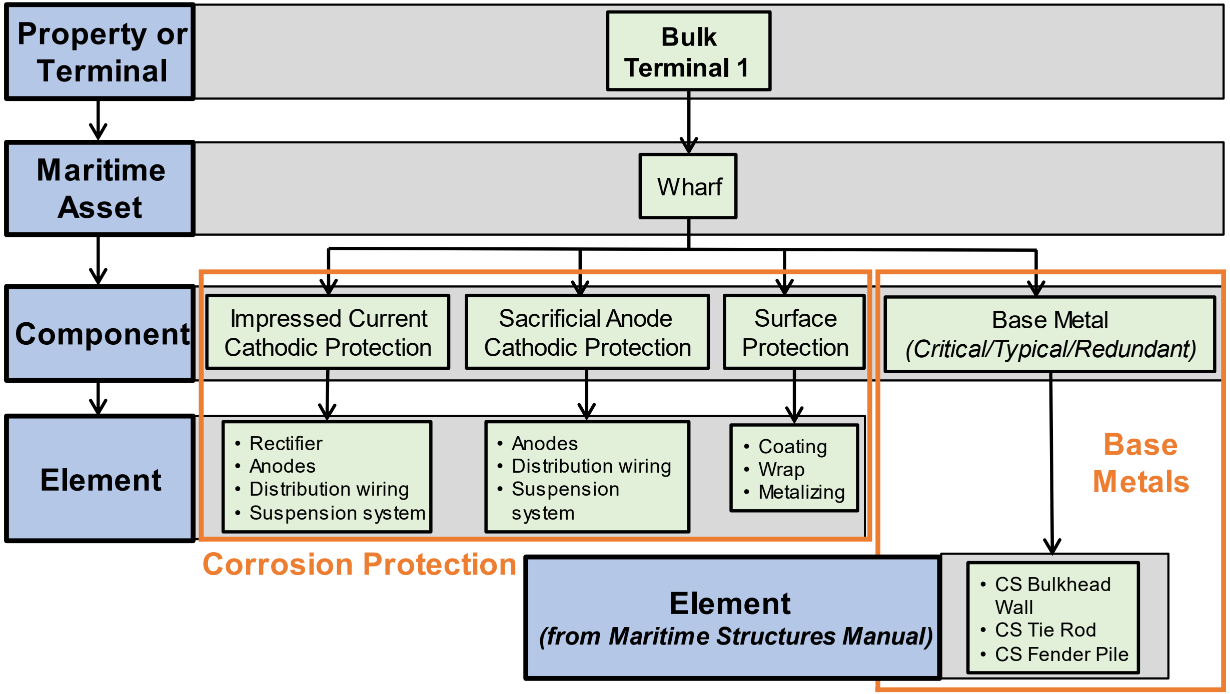
Hierarchy: Corrosion Protection Elements

- **Corrosion Protection Element:** individual member of a corresponding corrosion protection component
- Defined by components to which it belongs, functional purpose, geometry, and material.

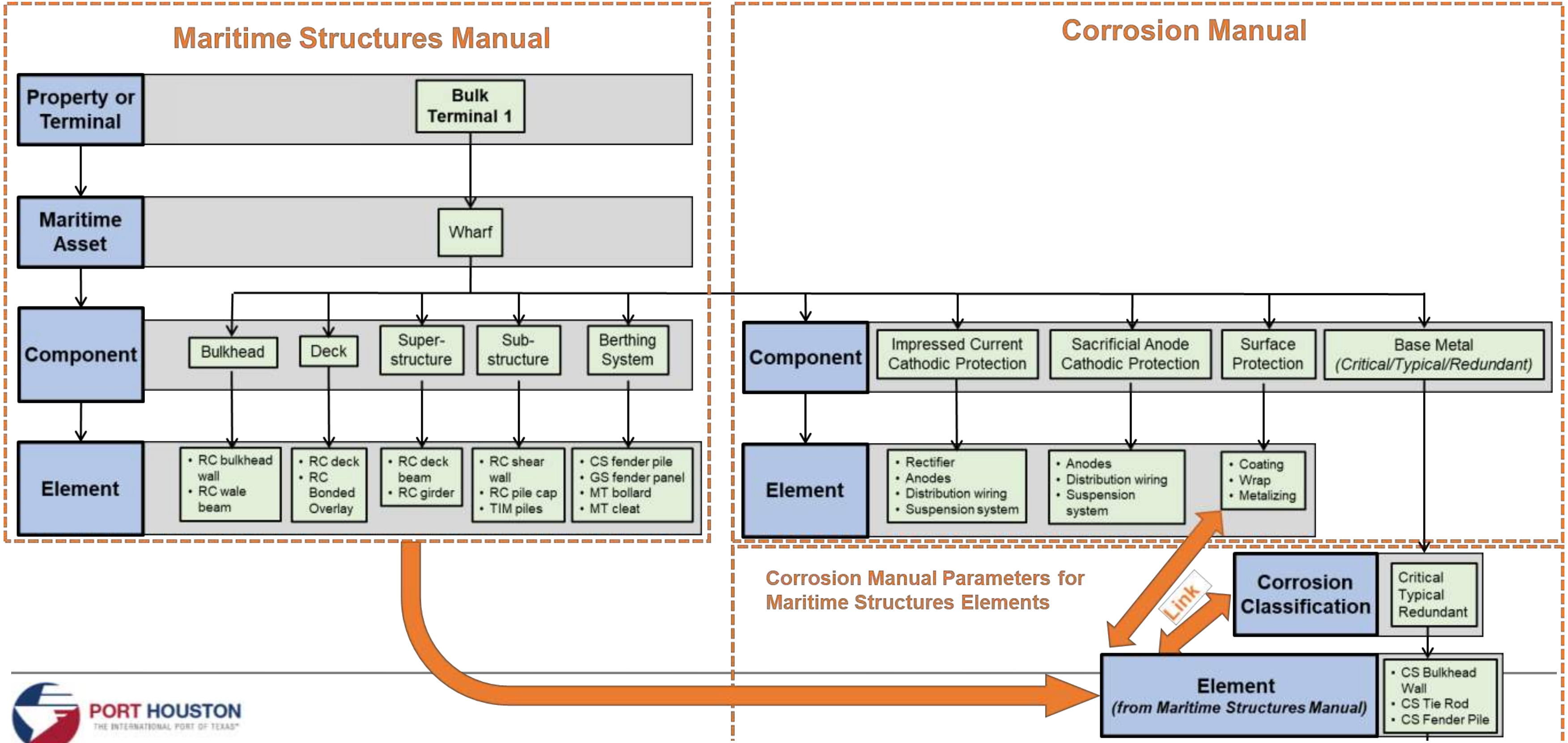


Hierarchy: Base Metal Elements

- **Base Metal Element:** metal elements that are protected by a corrosion protection component
- Classified based on importance to a given component:
  - Critical
  - Typical
  - Redundant



Relationship with Maritime Structures



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Elements

- **Associated Component:** provides the component of which the individual element is a part.
- **Element Code:** indicate the element type and material for ease of documentation
- **Element Descriptor:** A unique name is given for the individual element
- **Element Identification:** The element is described in narrative for identification and categorization by the field inspection personnel
- **Measured units:** measurement basis by which an element's condition state is quantified

Elements

- Elements in PHA inventory are defined in terms of:
  - **Associated component**
  - Element code
  - Element descriptor
  - Element identification
  - Measured units

Table C-3. Surface Protection Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[3]
Coatings, Wraps, and Metalizing (CT, HG, ML, & WP)			
CT-AC CT-EP CT-CE CT-PU CT-OT	AC Coating EP Coating CE Coating PU Coating OT Coating	Coating elements serve to protect steel or concrete elements and may be applied in single-coat or multi-coat systems. Quantity is based on square foot of element.	SF
HG-HDG	HDG Galvanizing	Hot-dip galvanizing provides a sacrificial coating system by dipping the element in a molten bath of zinc during the fabrication process of the steel.	SF
ML-AL ML-ZN ML-AZ ML-AZI ML-TI	AL Metalizing ZN Metalizing AZ Metalizing AZI Metalizing TI Metalizing	Metalizing may be applied to steel or concrete elements and is applied by spraying molten metal on the element. For reinforced concrete elements, connections to the steel reinforcement is required. Quantity is based on square foot of element.	SF

Elements

- Elements in PHA inventory are defined in terms of:
  - Associated component
  - **Element code**
  - **Element descriptor**
  - Element identification
  - Measured units

Table C-3. Surface Protection Component Elements			
Element Code(s)	Element Descriptor	Element Identification	Units[3]
Coatings, Wraps, and Met...			
CT-AC CT-EP CT-CE CT-PU CT-OT	AC Coating EP Coating CE Coating PU Coating OT Coating	Coa... con... coa... squ...	F
HG-HDG	HDG Galvanizing	Hot... coa... mo... pro... of the steel	F
ML-AL ML-ZN ML-AZ ML-AZI ML-TI	AL Metalizing ZN Metalizing AZ Metalizing AZI Metalizing TI Metalizing	Me... ele... met... ele... is r... ele...	F

Element code:

CT-EP

Element type
- CT: Coating

Element material
- EP: Epoxy

Element code (base metals):

BW-CS-BMT

Critical (BMC), Typical (BMT), Redundant (BMR)

Appendix C

Element Type Descriptors

- Elements in PHA inventory are defined in terms of:
  - Associated component
  - **Element code**
  - **Element descriptor**
  - Element identification
  - Measured units

Table 3.1. Materials for Corrosion Protection and Base Metal Elements

Element		Abbreviation	Description
Anodes	Aluminum	AL	Aluminum alloy anodes are used primarily in seawater application and can be produced in a variety of alloys.
	Cast Iron	CI	Cast iron anodes can be used in fresh water, seawater, or underground applications. High-silicon cast iron is a commonly used alloy containing silicon, chromium, and iron.
	Dual	DL	Dual galvanic anodes can be made with a highly active anode metal casing (e.g. magnesium) and a less active core (e.g. zinc). These anodes are designed to provide a high initial current density to achieve initial cathodic polarization.
	Graphite	GP	Graphite anodes are used in soils, flowing seawater, and mud and are typically impregnated with a sealer to prevent failure from gas evolution in pores. Oftentimes used within anode wells.
	Magnesium	MG	Magnesium anodes are available as high-potential or low-potential alloys and are normally used in soils and fresh water.
	Zinc	ZN	Zinc anodes are available in two alloys; one for use in soils and the other for seawater application. Can be manufactured as a bulk anode or a mesh.

Corrosion Elements

- Elements in PHA inventory are defined in terms of:
  - Associated component
  - Element code
  - Element descriptor
  - **Element identification**
  - Measured units

Table C-3. Surface Protection Component Elements			
Element Code(s)	**Element Descriptor**	**Element Identification**	**Units[3]**
Coatings, Wraps, and Metalizing (CT, HG, ML, & WP)			
CT-AC CT-EP CT-CE CT-PU CT-OT	AC Coating EP Coating CE Coating PU Coating OT Coating	Coating elements serve to protect steel or concrete elements and may be applied in single-coat or multi-coat systems. Quantity is based on square foot of element.	SF
HG-HDG	HDG Galvanizing	Hot-dip galvanizing provides a sacrificial coating system by dipping the element in a molten bath of zinc during the fabrication process of the steel.	SF
ML-AL ML-ZN ML-AZ ML-AZI ML-TI	AL Metalizing ZN Metalizing AZ Metalizing AZI Metalizing TI Metalizing	Metalizing may be applied to steel or concrete elements and is applied by spraying molten metal on the element. For reinforced concrete elements, connections to the steel reinforcement is required. Quantity is based on square foot of element.	SF

Corrosion Elements

- Elements in PHA inventory are defined in terms of:
  - Associated component
  - Element code
  - Element descriptor
  - Element identification
  - **Measured units**

Table C-3. Surface Protection Component Elements			
Element Code(s)	Element Descriptor	Element Identification	Units[3]
Coatings, Wraps, and Metalizing (CT, HG, ML, & WP)			
CT-AC CT-EP CT-CE CT-PU CT-OT	AC Coating	Coating elements serve to protect steel or ... may be applied in single- ...ms. Quantity is based on	SF
HG-HDG		...ovides a sacrificial ...ing the element in a ...ing the fabrication	SF
ML-AL ML-ZN ML-AZ ML-AZI ML-TI	TI Metalizing	...lied to steel or concrete ...l by spraying molten ...or reinforced concrete ...o the steel reinforcement is required. Quantity is based on square foot of element.	SF

SF: square foot
LF: linear foot
  Elements whose primary function depends on area (e.g. protective coatings) or length (e.g. deck beam)

EA: each
  Elements that function as a unit (e.g. anodes, DC power supplies)

Practical Example

Practical Example

Impressed Current Cathodic Protection Component

- Which component do these photographs represent?
- Can you identify elements associated with this component?
- Can you identify base metal elements pictured?

Practical Example: PW-TRU

Table 3.1

- DC Power Supply (PW)
- Transformer Rectifier Unit (TRU)

DC Power Supply	Batteries	BAT	Batteries can be used for CP systems that require small output current.
	Electric Circuit Breaker	EB	Circuit breakers are used to disconnect circuits and depower electric equipment. Only circuit breakers directly related to Power Supplies for CP systems (e.g. circuit breakers between AC power supply and transformer-rectifier units that are near the unit).
	Electric Panel	EP	Electric panels, typically operating at 240V or greater, are used to split and distribute AC to multiple transformer-rectifier units.
	Transformer-Rectifier Unit	TRU	Powered by an AC current, TRUs converts AC input to DC output current for use in the CP system.

Table C-1. Impressed Current Cathodic Protection (ICCP) Component Elements			
Element Code(s)	**Element Descriptor**	**Element Identification**	**Units**[1]
DC Power Supply (PW)			
PW-BAT PW-CB PW-EP PW-TRU	BAT DC Power Supply PW DC Power Supply EP DC Power Supply TRU DC Power Supply	Electrical devices used to provide DC power for any impressed current CP system.	EA

Appendix C

Practical Example: BW-CS-BMT

- Carbon Steel Bulkhead Wall
- Typical Base Metal
- BW-CS-BMT

Table 3.1

Metals[1]	Galvanized Steel	GS	Carbon steel that has been hot-dip galvanized with zinc.
	Steel	CS	Carbon steel materials.
	Stainless Steel	SS	Stainless steel materials. Stainless steels have a minimum of 10.5 percent chromium and are available at various grades with varying corrosion resistance.

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[4]
		Typical (BMT)	
AW-CS-BMT	CS Anchor Wall	A continuous buried wall element on the landside of a retaining wall or bulkhead. Used as anchorage for another element.	LF
BW-CS-BMT BW-GS-BMT	CS Bulkhead Wall GS Bulkhead Wall	A structural wall element that functions primarily as an earth retaining structure. Primarily subject to out-of-plane lateral loads. Bulkheads generally separate earth fill from water.	LF

Appendix C

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Element Identification

- Each element is labeled with a unique identification:
  - Element type
  - Location on the asset
  - Same methodology of element identification as FICAP
- Corrosion components may contain several elements having the same element code and material (e.g. PW-BAT)
- Base metal element identification same as previously defined in FICAP

Element Identification

PW3-1

<u>Element Code</u>
PW, ME, WI, etc.

First two letters of element code (material type not included)

<u>Bay Number</u>
1, 2A, 2B, etc.

Numbered sequentially, upstream to downstream

Letters for different structural systems

**Bays same as defined in FICAP Maritime Structures*

<u>Element Number</u>
1, 2, 3, etc.

Numbered sequentially upstream to downstream, water to land, top to bottom

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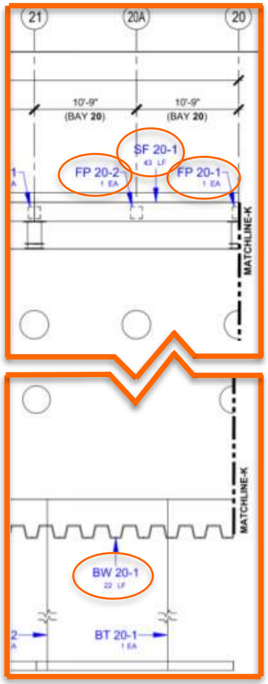
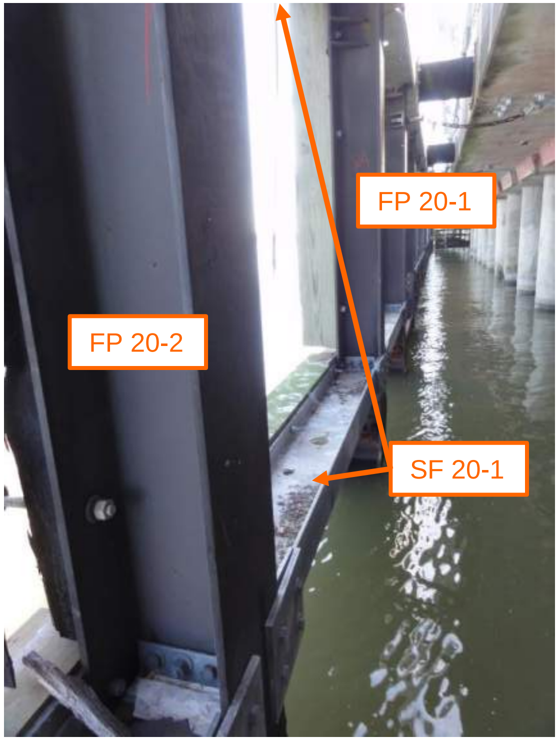
Example: Element IDs

- What are the codes for protective coating elements?
- Protected elements shown:
  - FP20-1
  - SF20-1
  - FP20-2
  - BW20-1

Downstream



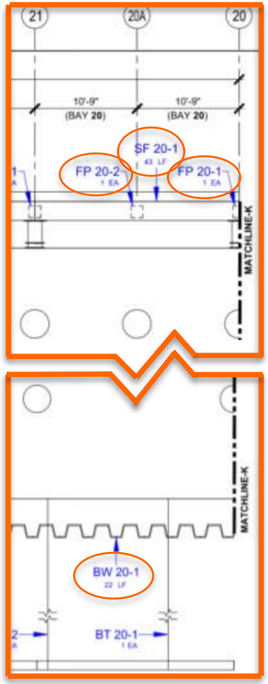
Base Metal Elements



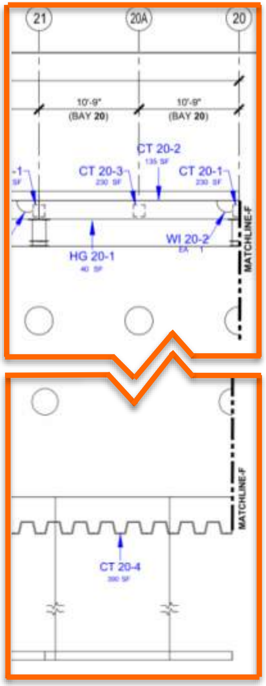
Example: Element IDs

- What are the codes for protective coating elements?
- Protected elements shown:
  - FP20-1
  - SF20-1
  - FP20-2
  - BW20-1

Downstream



Base Metal Elements



Surface Protection Elements

Example from BCT5 Baseline Drawings

Module Wrap-up

Module 2.3 Learning Outcomes

- Describe the hierarchical relationship between an element, a component, and an asset
- Differentiate between corrosion protection and base metal elements within the PHA inventory
- Describe the system used to identify and categorize elements and components
- Complete element codes, IDs, and descriptions for inventory reporting

END OF MODULE

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Module 3.1

Inspection Types and Reports

Corrosion Manual Training Course

Module Objectives

Module 3.1 Learning Outcomes

- List typical objectives, intervals, and scope of each primary inspection type
- Describe relationship between inspection types
- Identify readily accessible elements

Module Resources

- Chapter 2: Inspection Types
- Appendix F: Documentation and Reporting Forms

Inspection Scope and Frequency

- Scope
  - Defines type(s) of inspections
  - Describes the inspection methods and NDE techniques
  - Considers site environmental conditions, rate of damage progression, anticipated design life, etc.
- Frequency
  - Identifies the next inspection intervals for each asset and type of inspection
  - May vary based on inspection findings
  - May be altered between inspections

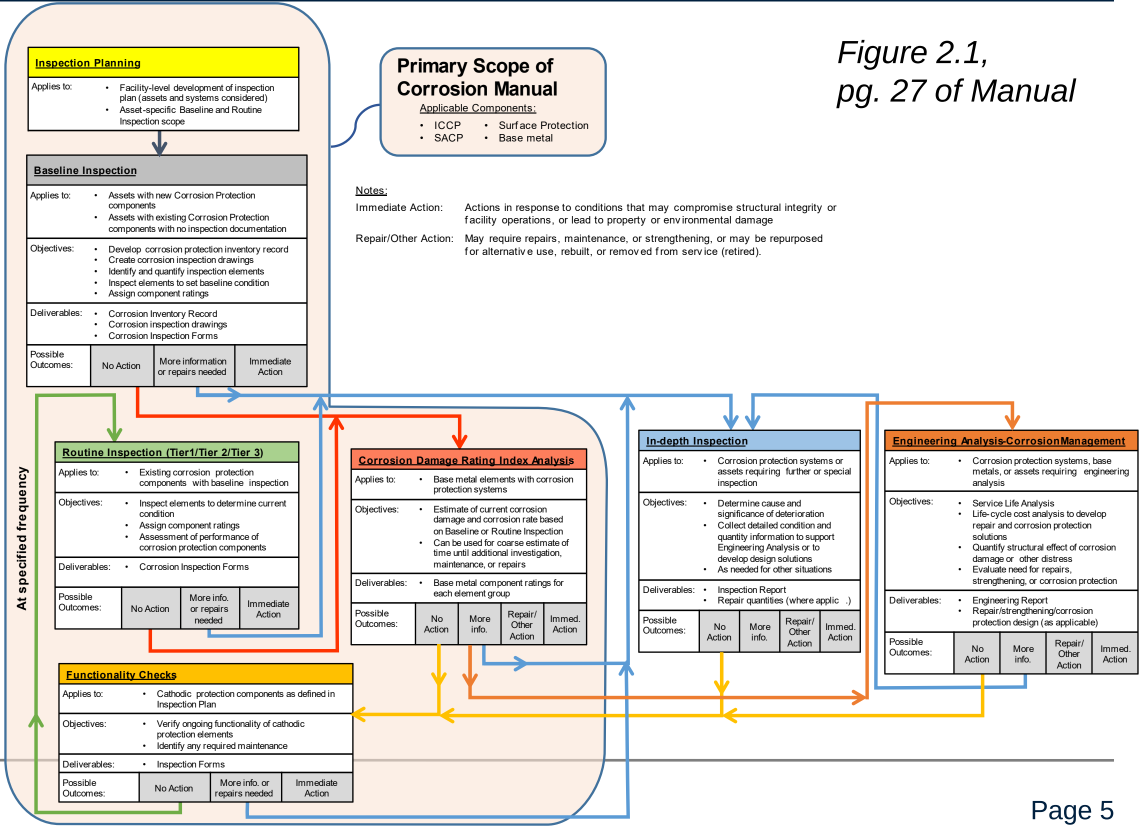
Defined in the Corrosion Inspection Plan

Inspection Types

- Primary Inspection Types
  - Baseline
  - Routine
  - Functionality Checks

**Specific to Corrosion Manual not to Maritime Structures inspections*

Figure 2.1, pg. 27 of Manual

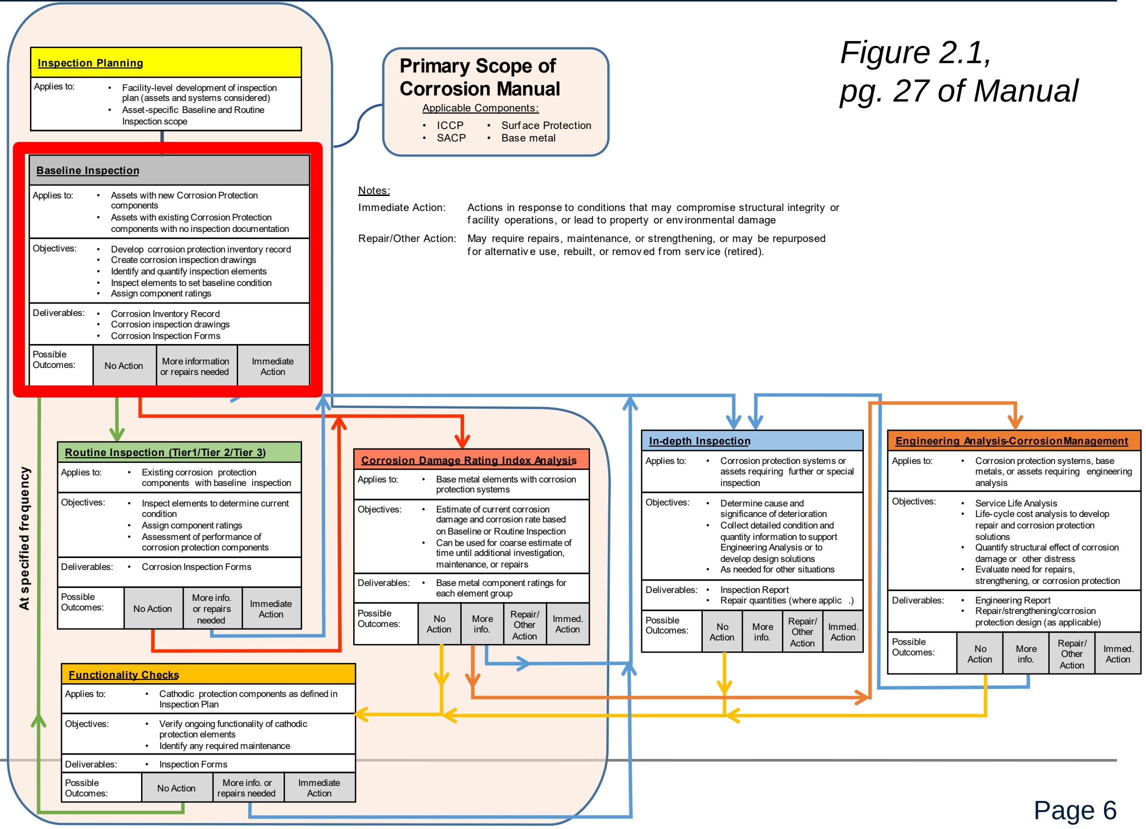


Inspection Types – Baseline Inspection

- New or refurbished asset
- No previous inspection record
- After a change in ownership

"first Routine Inspection"

Figure 2.1, pg. 27 of Manual

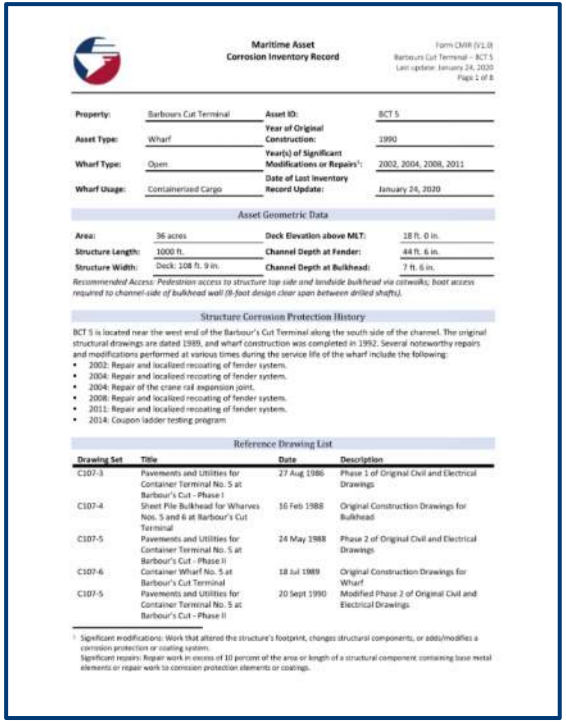


Inspection Types – Baseline Inspection

- Purposes
  - Establish the baseline (initial) corrosion protection system inventory information
  - Develop asset-specific Corrosion Inspection Plan that defines the specific inspection requirements for given asset
  - Determine initial corrosion condition rating
- May involve above-water and underwater inspection

Inspection Types – Baseline Inspection

- Deliverables
  - Corrosion Inventory Record
  - Corrosion Inspection Plan
  - Baseline Inspection Summary
    - – Inspection Data
  - Follow-up Actions Form
  - Inspection History
  - Corrosion Inspection Drawings



Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 1 of 8

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Last Inventory Record Update:**	January 24, 2020

Asset Geometric Data

Area:	36 acres	**Deck Elevation above MLT:**	18 ft. 0 in.
Structure Length:	1000 ft.	**Channel Depth at Fender:**	44 ft. 6 in.
Structure Width:	Deck: 108 ft. 9 in.	**Channel Depth at Bulkhead:**	7 ft. 6 in.

Recommended Access: Pedestrian access to structure top side and landside bulkhead via catwalks; boat access required to channel-side of bulkhead wall (8-foot design clear span between drilled shafts).

Structure Corrosion Protection History

BCT 5 is located near the west end of the Barbour's Cut Terminal along the south side of the channel. The original structural drawings are dated 1989, and wharf construction was completed in 1992. Several noteworthy repairs and modifications performed at various times during the service life of the wharf include the following:

- 2002: Repair and localized recoating of fender system.
- 2004: Repair and localized recoating of fender system.
- 2004: Repair of the crane rail expansion joint.
- 2008: Repair and localized recoating of fender system.
- 2011: Repair and localized recoating of fender system.
- 2014: Coupon ladder testing program

Reference Drawing List

Drawing Set	Title	Date	Description
C107-3	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase I	27 Aug 1986	Phase 1 of Original Civil and Electrical Drawings
C107-4	Sheet Pile Bulkhead for Wharves Nos. 5 and 6 at Barbour's Cut Terminal	16 Feb 1988	Original Construction Drawings for Bulkhead
C107-5	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase II	24 May 1988	Phase 2 of Original Civil and Electrical Drawings
C107-6	Container Wharf No. 5 at Barbour's Cut Terminal	18 Jul 1989	Original Construction Drawings for Wharf
C107-5	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase II	20 Sept 1990	Modified Phase 2 of Original Civil and Electrical Drawings

[1] Significant modifications: Work that altered the structure's footprint, changes structural components, or adds/modifies a corrosion protection or coating system.
Significant repairs: Repair work in excess of 10 percent of the area or length of a structural component containing base metal elements or repair work to corrosion protection elements or coatings.

Inspection Types – Routine Inspection

- At intervals defined in Inspection Plan
- Scope of visual observations and measurements based on Inspection Plan

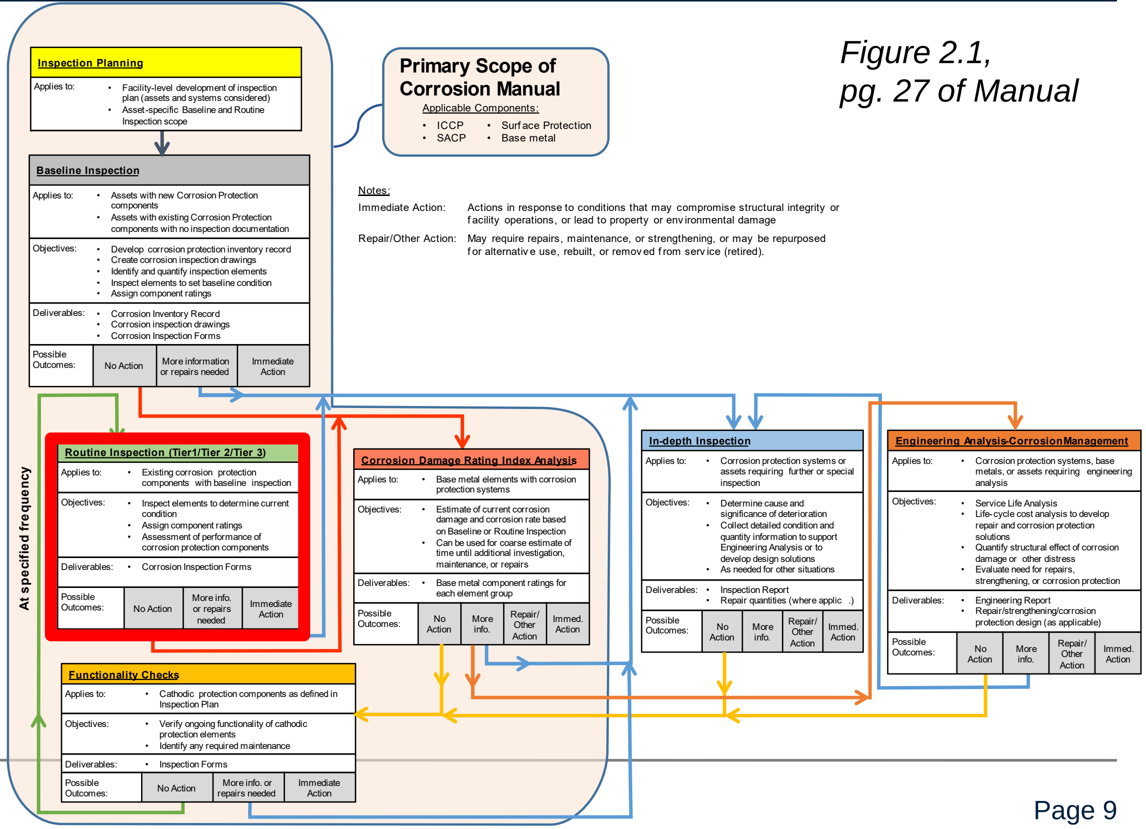


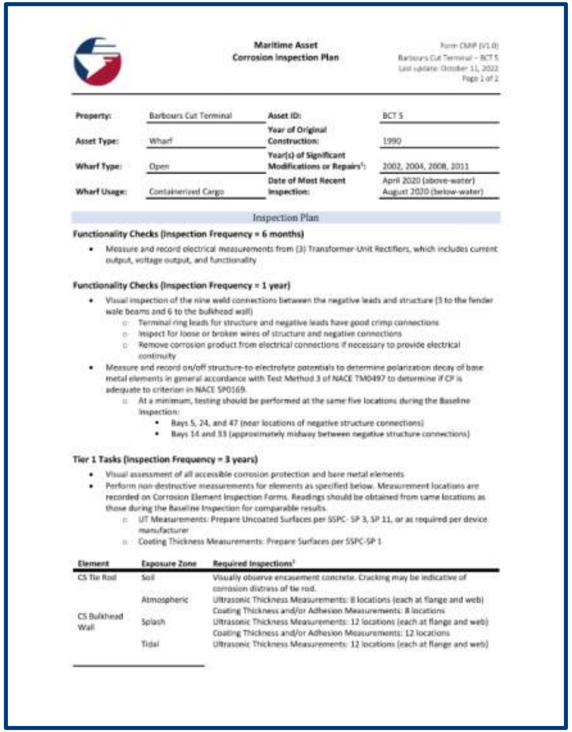
Figure 2.1, pg. 27 of Manual

Inspection Types – Routine Inspection

- Purposes
  - Inspect readily-accessible elements
  - Document change(s) in assets inventory record
  - Update component ratings and asset condition assessment
- May involve above-water and underwater inspection
- May include multiple tasks at different inspection intervals
  - Above water (3 years), underwater (6 years)

Inspection Types – Routine Inspection

- Routine Inspection Deliverables
  - Inspection Summary
    - Inspection Data
  - Follow-up Actions Form
- Modified Baseline Insp. Deliverables
  - Corrosion Inventory Record
  - Corrosion Inspection Plan
  - Inspection History, Drawings



Maritime Asset
Corrosion Inspection Plan

Form CMIP (V1.0)
Barbours Cut Terminal – BCT 5
Last update: October 11, 2022
Page 1 of 2

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	April 2020 (above-water) August 2020 (below-water)

Inspection Plan

Functionality Checks (Inspection Frequency = 6 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

Functionality Checks (Inspection Frequency = 1 year)

- Visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity
- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline inspection:
    - Bays 5, 24, and 47 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Visual assessment of all accessible corrosion protection and bare metal elements
- Perform non-destructive measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline Inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 3, SP 11, or as required per device manufacturer
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[2]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web)

Inspection Types – Functionality Checks

- Intervals defined in Inspection Plan (6 months/ 1year)
- More frequent than Routine Inspections
- Simple checks

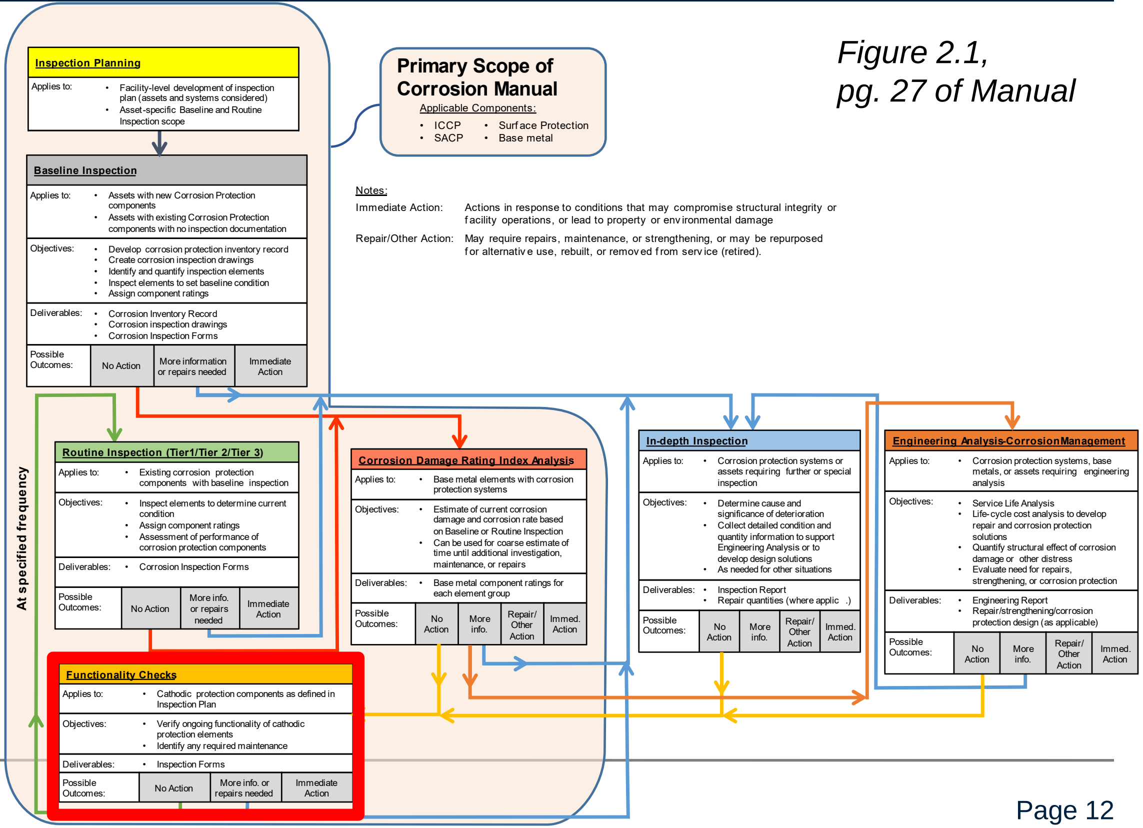


Figure 2.1, pg. 27 of Manual

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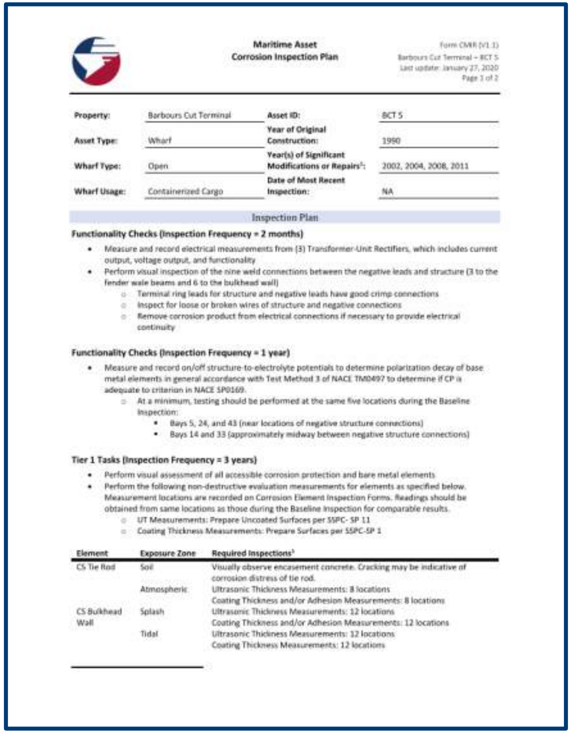
Inspection Types – Functionality Checks

- Purposes
  - Verify functionality of CP systems
    - Six-month or 1-year intervals (or as specified in the inspection plan)
  - Provides quantitative data to monitor performance of CP systems over time
- Does not include underwater inspection
- Does not include visual inspection of every element

Inspection Types – Functionality Checks

- Deliverables
  - Updated Routine Inspection Summary
    - – New Routine Inspection Data, additional functionality checks
  - Updated Inspection History



Maritime Asset
Corrosion Inspection Plan

Form CMIR (V1.1)
Barbours Cut Terminal – BCT 5
Last update: January 27, 2020
Page 1 of 2

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	NA

Inspection Plan

Functionality Checks (Inspection Frequency = 2 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality
- Perform visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity

Functionality Checks (Inspection Frequency = 1 year)

- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline Inspection:
    - Bays 5, 24, and 43 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Perform visual assessment of all accessible corrosion protection and bare metal elements
- Perform the following non-destructive evaluation measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline Inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 11
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
	Atmospheric	Ultrasonic Thickness Measurements: 8 locations Coating Thickness and/or Adhesion Measurements: 8 locations
CS Bulkhead Wall	Splash	Ultrasonic Thickness Measurements: 12 locations Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations Coating Thickness Measurements: 12 locations

Inspection Tasks & Intervals

Table 2.1. Guidelines for Maximum Inspection Intervals

Task Classification	Inspection Interval [Note 2]	Example Inspection Tasks [Note 1]
Functionality Checks [Note 3]	6 months	Verify functionality of ICCP system (current output, frequency, power consumption, shunts, etc.)
	1 year	Measure and record on/off structure-to-electrolyte potentials (and/or decay potentials) for cathodic protection systems
		Verify accessible negative lead-to-structure connections are intact
Tier 1 Routine Inspections	3 years	Perform above water visual assessment
		Obtain above-water thickness measurements of base metal elements
		Obtain above-water coating thickness and/or adhesion measurements
Tier 2 Routine Inspections	6 years	Level I underwater visual inspections of anodes
		Level II underwater cleaning and visual inspection of anodes and base metal elements
		Level III underwater cleaning and remaining thickness/weight measurement of base metal elements, coatings, and anodes
Tier 3 Routine Inspections	As Required [Note 4]	Visual inspection and thickness measurements of buried base metal elements or CP anodes

Inspection Tasks & Intervals

Table 2.2. Recommended Minimum NDE Testing Intervals

Element Classification	Exposure Zone	Test Intervals[Note 1, 2]
Critical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 50 LF or 20% of elements Coating Thickness and/or Adhesion: Every 50 LF or 20%
	Submerged	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Soil	As required
Typical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required
Redundant	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required

Level of Effort

- Corrosion Manual is mostly focused on inspecting and collecting data from readily accessible elements:
  - Exposed to either open water or open atmosphere
  - Do not require removal of overburden or other elements
  - Are not considered confined spaces
  - May be accessed by walking, boat, lift, scaffold, or diving
- Team leader may recommend variations on an asset-specific basis

Inspection Conditions

- Elements obscured by obstructions can be skipped for one inspection cycle if:
  - Total area does not exceed 10% and no significant distress suspected
- Inspections may reveal unserviceable conditions
  - Above-water inspection may be truncated, or underwater inspections deferred
  - PHA approval required, based on observed above-water conditions

Wrap-Up: Three Inspection Types

- Primary Scope of Corrosion Manual:
  - Baseline Inspection
  - Routine Inspections
  - Functionality Checks
- Not Primary Scope of Corrosion Manual :
  - Special Inspections

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END OF MODULE

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Module 3.2

Inspection Documentation

Corrosion Manual Training Course

Module Objectives

Module 3.2 Learning Outcomes

- Describe required documentation for each inspection type
- Outline typical information within each inspection deliverable
- Identify the information required on standard inspection drawings

Module Resources

- Chapter 8: Documentation and Reporting
- Appendix F: Documentation and Reporting Forms
- Appendix G: Corrosion Inspection Drawings
- Appendix H: Reference Information

Inspection Deliverables

Table 8.2. Deliverables for Standard Inspections

Deliverable	**Type of Inspection**	
	Baseline	**Routine**
Corrosion Inventory Record	Yes. Includes initial generation of document.	Revise only if change identified
Corrosion Inspection Plan	Yes. Includes initial generation of document.	Update
Standard Corrosion Inspection Drawing Set	Yes. Includes initial generation of document.	No
Corrosion Element Inspection Forms	Yes. Includes initial generation of document.	Yes. Relies on inspection forms generated by Baseline.
Corrosion Inspection History	Yes. Includes initial generation of document.	Update
Corrosion Inspection Summary	Yes	Yes
Corrosion Inspection Data	Yes	Yes
Follow-Up Action Form	Yes	Yes
Submission into PHA database	Yes	Yes

Corrosion Inventory Record

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 1 of 8

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Last Inventory Record Update:**	January 24, 2020

Asset Geometric Data

Area:	36 acres	**Deck Elevation above MLT:**	18 ft. 0 in.
Structure Length:	1000 ft.	**Channel Depth at Fender:**	44 ft. 6 in.
Structure Width:	Deck: 108 ft. 9 in.	**Channel Depth at Bulkhead:**	7 ft. 6 in.

Recommended Access: Pedestrian access to structure top side and landside bulkhead via catwalks; boat access required to channel-side of bulkhead wall (8-foot design clear span between drilled shafts).

Structure Corrosion Protection History

BCT 5 is located near the west end of the Barbour's Cut Terminal along the south side of the channel. The original structural drawings are dated 1989, and wharf construction was completed in 1992. Several noteworthy repairs and modifications performed at various times during the service life of the wharf include the following:

- 2002: Repair and localized recoating of fender system.
- 2004: Repair and localized recoating of fender system.
- 2004: Repair of the crane rail expansion joint.
- 2008: Repair and localized recoating of fender system.
- 2011: Repair and localized recoating of fender system.
- 2014: Coupon ladder testing program

Reference Drawing List

Drawing Set	Title	Date	Description
C107-3	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase I	27 Aug 1986	Phase 1 of Original Civil and Electrical Drawings
C107-4	Sheet Pile Bulkhead for Wharves Nos. 5 and 6 at Barbour's Cut Terminal	16 Feb 1988	Original Construction Drawings for Bulkhead
C107-5	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase II	24 May 1988	Phase 2 of Original Civil and Electrical Drawings

- Structure Identification and Background/Dates
- Geometric Data
- Corrosion Protection History

Corrosion Inventory Record

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 2 of 8

Drawing Set	Title	Date	Description
C107-12	Repair of Fender System at Wharf No. 5	5 Nov 2002	Fender Repair Drawings
C107-13	Repair of Fender System and Potable Water Line	23 Feb 2004	Fender and Utility Repair Drawings
C160-60	Crane Rail Repair	30 Aug 2004	Crane Rail Expansion Joint Repair Drawings
C60-D02-002	Fender System Maintenance at Barbours Cut Terminal	16 Oct 2008	Fender Repair and Maintenance Drawings
C60-D02-005	Annual Fender System Maintenance at Barbours Cut Terminal 2012	3 Oct 2011	Fender Repair and Maintenance Drawings

Asset Exposure Zones

The following exposure zones have been identified at this site, the specific height of the zones and exposure effects have been estimated based on review of environmental conditions and data.

Exposure Zone	Elevation versus MLLW	Elements
Atmospheric	+3.25 ft. or greater	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Splash	+1.25 to +3.25 ft.	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Tidal	+0 to +1.25 ft.	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Submerged	0 ft. or less	CS Bulkhead Wall, CS Fender Piles
Soil	Below the mudline toward the waterside of the bulkhead and below the pavement on the landward side of the bulkhead	CS Tie Rods, CS Bulkhead Wall, CS Fender Piles

Asset Environmental Conditions

Global Zone	Constituent	Values
Site	Temperature	January: 54°F, February: 57°F, March: 63°F, April: 70°F, May: 77°F, June: 82°F, July: 84°F, August: 84°F, September: 80°F, October: 72°F, November: 63°F, December: 56°F, Annual: 70°F
Site	Relative Humidity	Annual: 74%

- Relevant reference drawings (original, repairs, rehabilitation, etc.)
- Exposure Zones
- Environmental Conditions (reference Appendix H)

Corrosion Inventory Record

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 4 of 8

Impressed Current Corrosion Protection Elements	
Component / Element(s)	**Description**
Anodes	Anodes are installed as part of the ICCP system designed to protect both the fender piles and bulkhead wall.
– OTH Anode	Clusters of two bulk anodes are hung from the deck at approximately 35' to the landside of the fender system at 10' longitudinal spacing, totaling 200 anodes. Anodes are installed at Elev. -3.0 and -12.0'.
DC Power Supply	Three DC power supplies are installed to provide DC power for the ICCP system. Note: drawings indicate five rectifiers, but only three were installed.
– TRU DC Power Supply	Transformer-unit rectifiers are installed approximately 116-feet to the landside of the bulkhead wall adjacent to light poles 8 through 12.
Wiring and Protection	Wiring connects TRU DC Power Supplies with bulk anodes and the structure and is protected by PVC conduit to the landside of the bulkhead wall.
– CU Wiring	No. 6/7 copper wiring connects the corrosion protection system. Positive leads run to the bulk anodes and negative leads are connected to the fender system and bulkhead wall. Negative leads connect the copper conduit to the top fender wale beam and bulkhead wall in three and six locations, respectively.
– PVC Protection	Copper wiring is run through underground PVC conduit from the bulkhead wall to the five transformer-unit rectifiers.

Base Metal Components and Elements	
Component / Element(s)	**Description**
Critical	
– CS Tie Rod	Tie rods, 3-3/4 inch diameter, extending from bulkhead wale beam to dead man, spaced at approximately 15 feet on center and encased in Schedule 40 PVC Casings. • *Installed in 1990, no documented modifications or repairs.* • *Design Cross-Sectional Area = 11.0 in²*
Typical	
– CS Bulkhead Wall	BZ-20 steel sheet piles extending from Elev. +14.65 to -58.00'. Mudline is shown at -5.00'. • *Installed in 1990, no documented modifications or repairs. BZ-20* • *Design Thickness = 0.551 in (flange), 0.394 in (web/wall)*

- List of components and elements
  - Corrosion Protection
    - ICCP
    - SACP
    - Surface Protection
  - Base Metals
    - Design thickness

Corrosion Inventory Record

- Location Map(s)
- Representative Photograph(s)
- Drawings (Partial Plans or Sections)

Figure 1. Asset Location

Figure 2. Aerial view of asset and immediate vicinity.

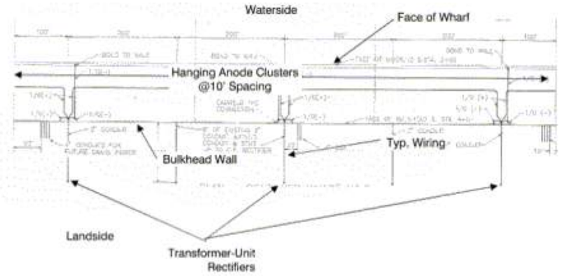


Figure 3. Typical Partial Plan of Structure.

Corrosion Inspection Drawings

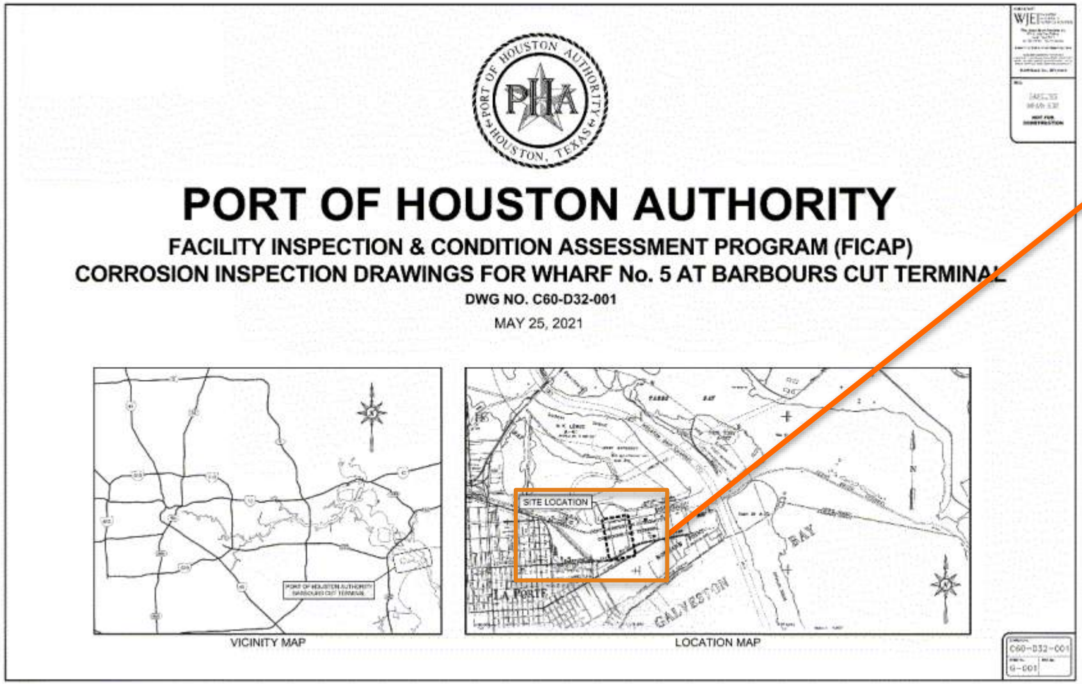
- Provides structure layout, bay labels, locations and IDs of all elements
- As-built of current configuration
- PHA CAD standards
- Plans, Section, and Elevation Views

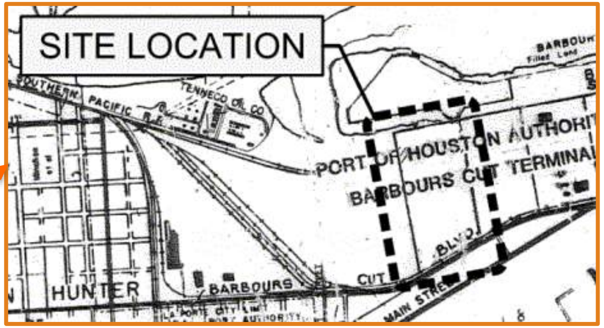
Table 8.1. List of Standard Inspection Drawings

Sheet Number	Sheet Description	Information Included
G-001	Title	Asset name PHA drawing number Date of drawing set Vicinity map Asset location map
G-002	Project Information	Sheet Index Key Plan, referencing asset plan sheets (i.e. G-1XX). The Key Plan should have notes/labels consistent with structure history on Corrosion Inventory Record form (i.e., indicate significant modifications, repairs, expansions, partial demolitions). List of Referenced Historical Drawings Definitions of Symbols Definitions of Abbreviations
G-10(x)	Bay Plan(s)	Plan view of topside of structure. Asset may be broken into multiple pages. Bays outlined and denoted per Corrosion Manual scheme (see Section 8.4.1). Grid lines, based on historic drawings if possible. Overall dimensions of bays. North Arrow Channel Designation
G-11(x)	Corrosion Protection Element Plan(s)	Corrosion Protection elements individually outlined and labeled.* Drawn as plan views. Applicable views may include the superstructure and deck elements cut at the structure topside and/or the substructure and fender elements cut below the deck level. Sheets to be ordered from Upper Plan to Lower Plan.
G-12(x)	Base Metal Element Plan(s)	Base Metal elements individually labeled.* Drawn as plan views. Applicable views may include the superstructure and deck elements cut at the structure topside and/or the substructure and fender elements cut below the deck level. Sheets to be ordered from Upper Plan to Lower Plan.
G-20(x)	Typical Sections	Cross-sections through representative portions of wharf. Include a separate cross-section for significant changes in structure configuration (e.g., change in pile type, arrangement of beams, width of structure, etc.). Provide elevations for Top of Deck; Mean Low Tide. Label typical elements with name and element code (e.g., Polyurethane Coating (CT-PU)).
G-30(x)	Typical Elevations	Elevation view of typical bay(s), as viewed from the channel. Include major corrosion protection and base metal Elements. Label typical elements with name and element code (e.g., Polyurethane Coating (CT-PU)).

* See Section 8.4.2 for Element labeling and identification scheme

Corrosion Inspection Drawings

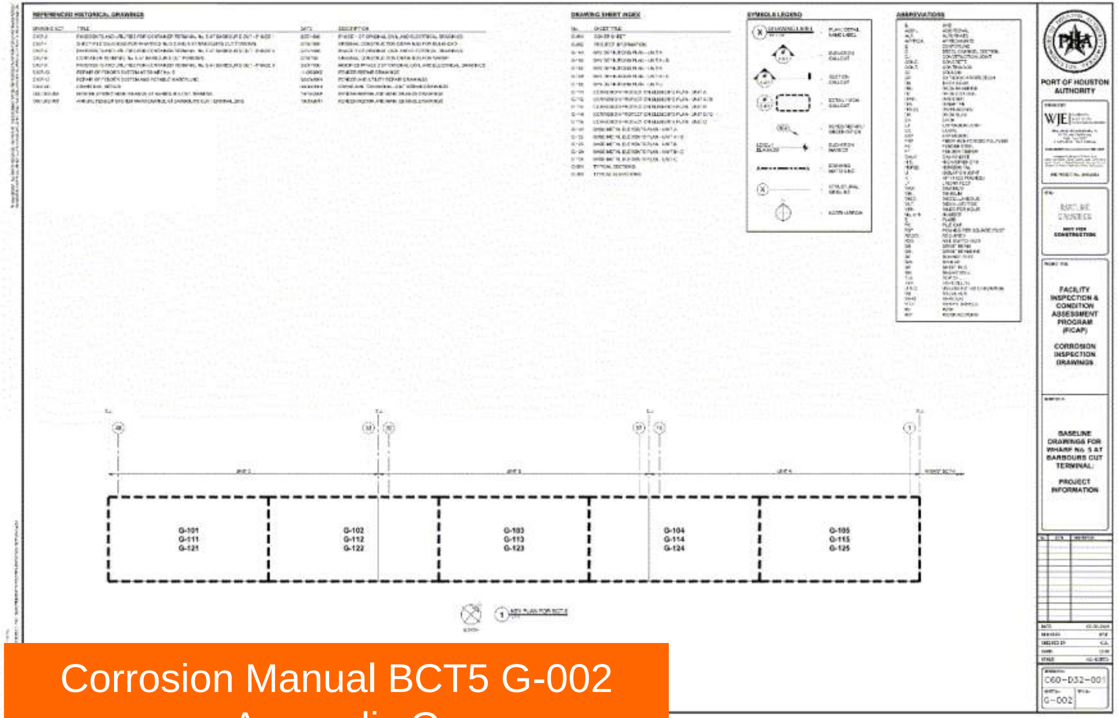




Corrosion Manual BCT5 G-001
Appendix G

Corrosion Inspection Drawings

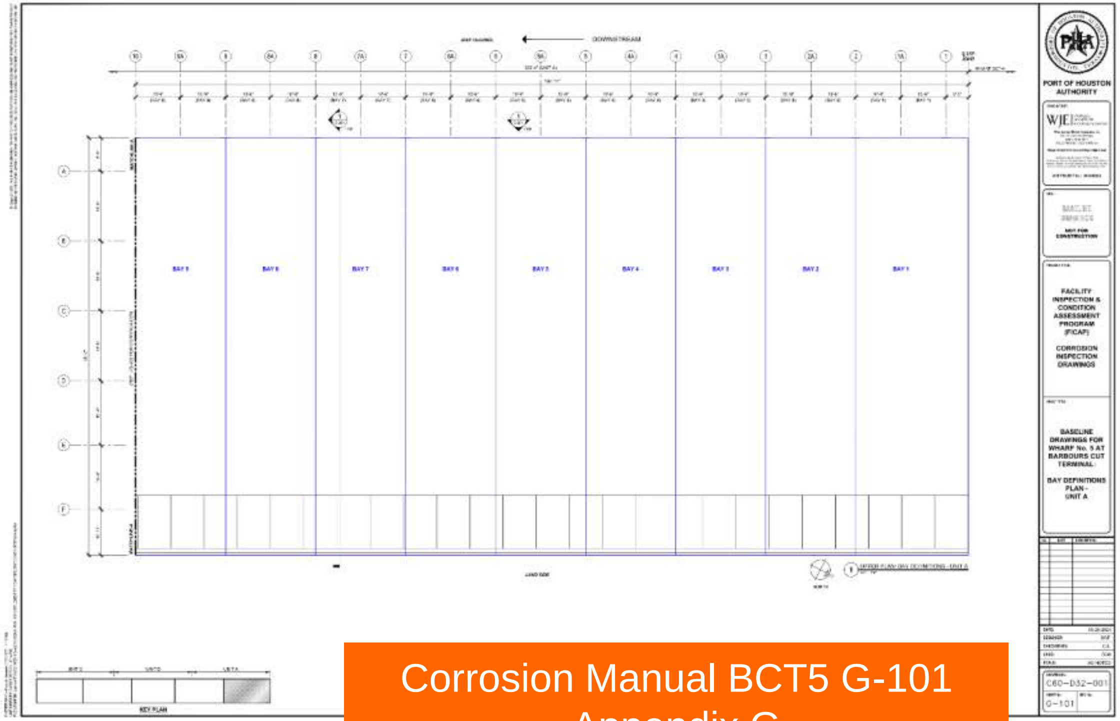
- Key Plan (channel at top)
- Referenced Historical Drawings
- Drawing Sheet Index



Corrosion Manual BCT5 G-002
Appendix G

Corrosion Inspection Drawings

- Bay Definitions
- Bay Numbering
  - Upstream to downstream
  - Letters for differing structural systems



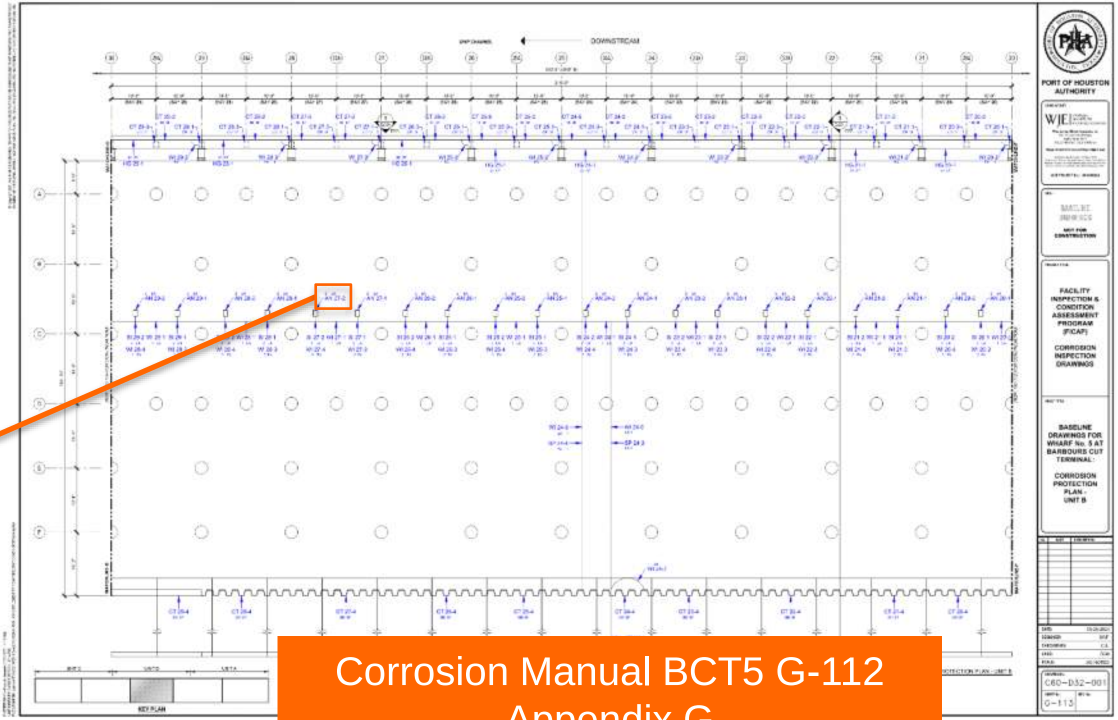
Corrosion Manual BCT5 G-101
Appendix G

Corrosion Inspection Drawings

- Corrosion Protection Plan
- Schematic layout of corrosion elements
- Element IDs labelled

AN 27-2

Element Code	**Bay Number**	**Element Number**
DT, PI, WL, etc.	*1, 2A, 2B, etc.*	*1, 2, 3, etc.*



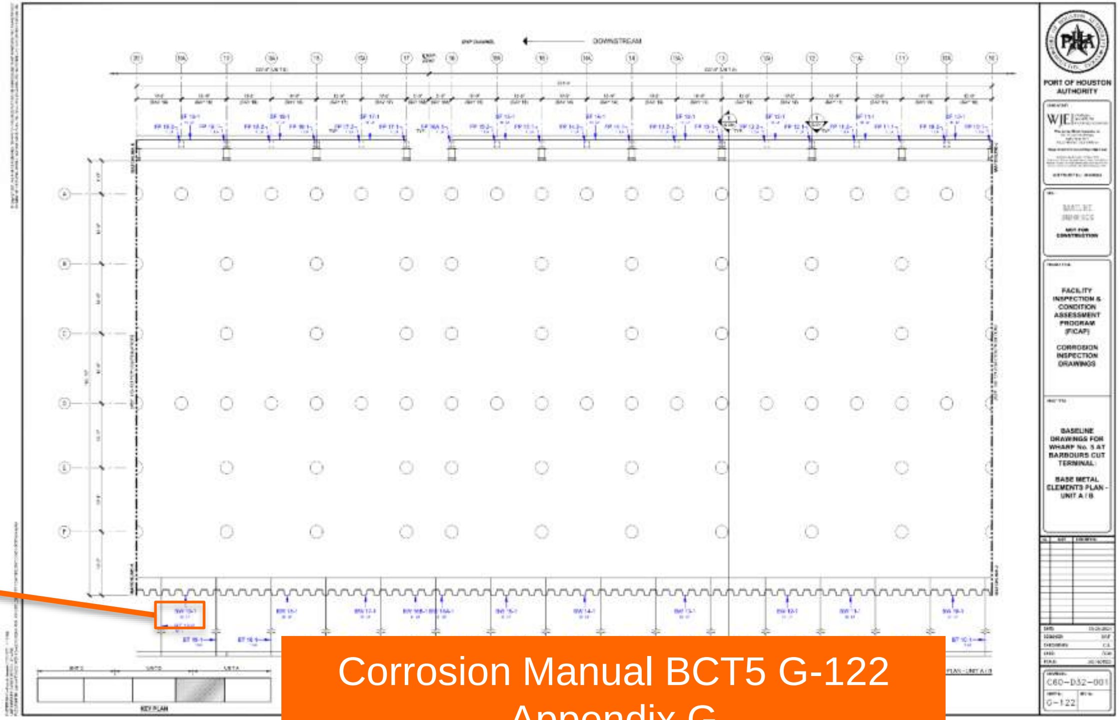
Corrosion Manual BCT5 G-112
Appendix G

Corrosion Inspection Drawings

- Base Metal Elements Plan
- Schematic layout of base metal elements
- Element IDs labelled

BW19-1

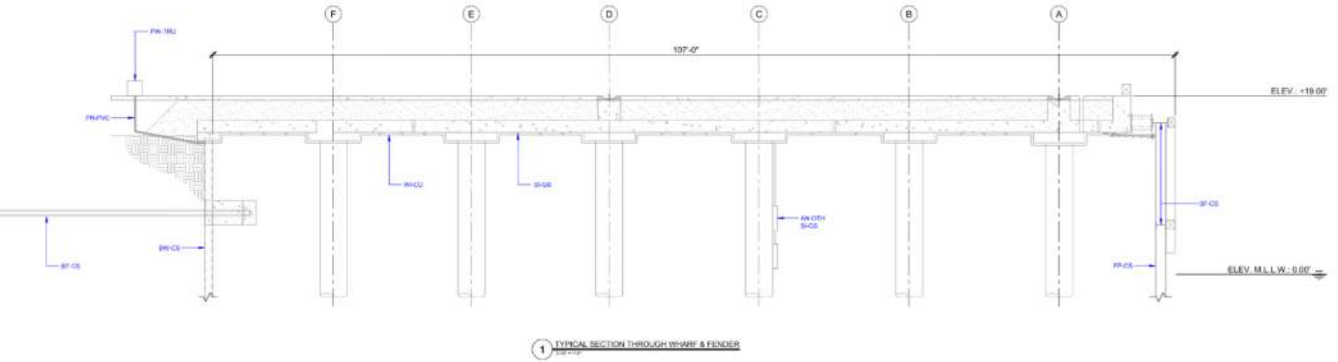
Element Code	Bay Number	Element Number
DT, PI, WL, etc.	*1, 2A, 2B, etc.*	*1, 2, 3, etc.*



Corrosion Manual BCT5 G-122 Appendix G

Corrosion Inspection Drawings

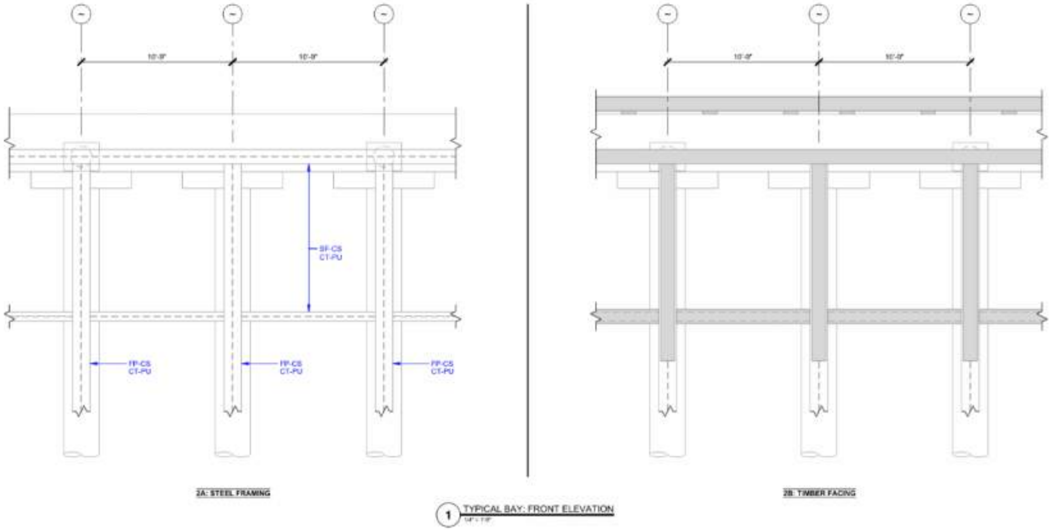
- Typical Sections
- Cross-sectional layout of corrosion and base metal elements
- Does not include element IDs



Corrosion Manual BCT5 G-201
Appendix G

Corrosion Inspection Drawings

- Typical Elevations
- Front view(s) of asset
- Front view layout of corrosion and base metal elements
- Does not include element IDs



Corrosion Manual BCT5 G-301
Appendix G

Corrosion Inspection History

- Log of all inspections
- Includes previous ratings

Maritime Asset Inspection History

Form CMIH (V1.0)
Barbours Cut Terminal – BCT 5
Last updated: January 27, 2020
Page 1 of 1

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Classification:	Wharf	**Year of Original Construction:**	1990
Inspection Frequency:	Ref. Inspection Plan	**Year(s) of Significant Modifications or Repairs:**	2002, 2004, 2008, 2011

Dates of Inspections, Asset, and Component Ratings

Date:	1/24/2020				
Inspection Type:	Baseline				
Inspection Status	Completed				
Inspection Firm: Above Water	WJE				
Inspection Firm: Underwater	Rio				
Corrosion Condition Rating (CCR)	**70**				
Corrosion Protection (CP)	**38**				
ICCP Functionality	4				
ICCP Visual	4				
SA Functionality	NA				
SA Visual	NA				
Surface Protection	3				
Base Metal (BM)	**32**				
Critical	5				
Typical	4				
Redundant	4				

Corrosion Inspection Summary

- Inspection Type
- Scope
- Date
- Team Members
- Seal of Responsible Engineer

Maritime Asset
Corrosion Inspection Summary

Form CMIS (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 1 of 20

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Inspection Type	☒ Baseline ☐ Routine ☐ In-Depth	**Inspection Date(s):**	April 23-24, 2020 (above water) August 4-5, 2020 (under water)
Scope of Inspection	Entire Asset, Above Water and Under Water		
Inspection Firm(s):	**Prime**: Wiss, Janney, Elstner Associates, Inc. **Underwater:** Rio Engineering, Inc. **Other (role):** N/A		
Reported By:	S. Foster, P.E.	**Report Date:**	October 6, 2020
Corrosion Manual Version/Date:	Rev. 0, October 2022	**Variances from CM Procedure:**	N/A

Seal of Responsible Engineer

I hereby certify this inspection was performed under my direct supervision and control and to the best of my professional knowledge complies with the Corrosion Manual and applicable codes.

Signed: ____________________

Name: ____________________

Texas License No.: ____________________

Date: __________ Expires: __________

Seal

Inspection Team Members

Project Manager: Stephen Foster
Inspection Team Leader(s): Stephen Foster
Inspection Team Member(s): Casey Jones, Kyle Myers, Lane Thompson

Underwater Team Leader: Joe Starkey
Underwater Team Member(s):

Corrosion Inspection Summary

- Asset Condition
  - Corrosion Condition Rating
  - CP Rating
  - Base Metal Rating
- Component Ratings by element group and Comments
- Photographs

Maritime Asset
Corrosion Inspection Summary

Form CMIS (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 2 of 20

Overall Asset Condition

Overall, the base metal elements were in fair condition with minor to moderate measured section loss. The estimated corrosion rates for the bulkhead wall, fender piles, and fender support framing were all ranked with a damage index of fair to good. There are, however, several localized areas of distress that should be prepared and recoated to maintain the current condition of the assets.

The corrosion protection systems appeared to be functioning as intended for the bulkhead wall, but not the fender piles. Current output and structure-to-electrolyte potential measurements indicate that the system is operating as intended and providing sufficient cathodic protection to the bulkhead wall. The bond wires to the fender piles were all severed and non functional.

ICF (Functional) Component Rating = 4 (Deduction = 4)
ICV (Visual) Component Rating = 4 (Deduction = 2)
SPR Rating = 3 (Deduction = 8)
CP = 60 - 1.6 x (ICF + ICV + COA) = 60 - 1.6 x (4 + 2 + 8) = 38

CR Rating = 5 (Deduction = 3)
TYP Rating = 4 (Deduction = 3)
RED Rating = 4 (Deduction = 2)
BM = 40 - (CR + TYP + RED) = 40 - (3 +3 + 2) = 32

CCR = CP + BM = 38 + 32 = 70

The overall corrosion condition rating (CCR) for BCT 5 is 70.

Impressed Current Corrosion Protection Elements

Element(s)	Rating	Comments
Anodes	**4**	Limited moderate marine growth or section loss. Most elements and their attachment are sound and functional purpose/use of the component is not affected.
– OTH Bulk Anode	4	
DC Power Supply	**4 (Functional)** **4 (Visual)**	All three rectifiers are functional, proper gage readings and DC outputs were verified. PW5-1 was turned off upon arrival of the inspector, however, it was deemed functional when turned on.
– TRU DC Power Supply	4 (Funct) 4 (Visual)	All six "on" potentials of the bulkhead wall were measured as more negative than -850 mV vs. CSE. All of the "Instant off" potentials were measured as more negative than -850mV vs. CSE and more positive than -1250 mV. Measured potentials at the fender did not meet any established criteria due to disconnection of the bond wires.
Wiring and Protection	**3**	Wiring and protection was in satisfactory condition.
– CU Wiring	3	Negative lead wiring from the bulkhead wall appeared to be in satisfactory condition with minor corrosion at the connections. Positive lead wiring to the anodes exhibited

Corrosion Inspection Summary

- Base Metal Ratings
  - Section Loss
  - Estimated Corrosion Rate
- Figures
  - Representative Conditions

Base Metal Components and Elements

Element(s)	Rating	Comments
Critical	**NA**	Inaccessible. Rated as 5 for scoring purposes due to age.
– CS Tie Rod	NA	
Typical	**4**	
– CS Bulkhead Wall	5	The bulkhead wall was in satisfactory condition with minor corrosion at the seams and minimal general section loss, mostly in the splash and tidal zone. In 30 years of service, the average section loss was approximately 5 to 6%. *Section loss: (>2% to ≤ 10% satisfactory)* *Estimated Corrosion Rate: (Satisfactory <2mpy)*
– CS Fender Piles	4	Impact damage and corrosion of piles was observed near the waterline, with an average section loss of approximately 27% near the ends of the flanges. Webs typically have minimal section loss apart from stiffeners Overall, fair amount of section loss with estimated corrosion rate between 6 and 11 mpy. *Section loss: (Fair <10%)* *Estimated Corrosion Rate: (Fair, 6 < x ≤ 11 mpy)*
Redundant	**4**	
– CS Support Framing	4	Impact damage and corrosion of framing was observed near the waterline, particularly at connections. *Section loss: (>2% to ≤ 10%, Fair)* *Estimated Corrosion Rate: (2 < x ≤ 6 mpy, Fair)*

Figure 7. Connection bond from the bulk head wall to the fender piles, no major visible signs of corrosion or distress.

Figure 8. Negative wire connection from rectifier to bulkhead wall, showing visible signs of corrosion at connection point.

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Follow-Up Action Form

- Priority
  - High Priority
  - Routine
- Component/Element
- Condition
- Reason for Action
- Recommended Action

Maritime Asset
Follow-up Actions

Form CMFA (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 1 of 5

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Inspection Type:	☒Baseline ☐Routine ☐ Special	**Inspection Date:**	April 21-22, 2020 (abovewater) August 4-5, 2020 (underwater)
Scope of Inspection	Entire Asset, Above Water and Under Water		
Inspection Firm(s):	**Prime:** Wiss, Janney, Elstner Associates, Inc. (WJE)		
	Underwater: Rio Engineering, Inc.		
	Other (role): N/A		
Reported By:	C. Jones, WJE	**Report Date:**	October 6, 2020

Follow-up Actions

Item No.:	1	**Priority:**	☒Priority ☐Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	Rectifier was turned off when the cover was initially opened. The time duration for which the rectifier was turned off is unknown.		
Reason for action:	ICCP system cannot function with rectifiers turned off.		
Recommended Action:	Routinely check rectifiers are turned on and functioning. NOTE: The rectifier was turned on and left running after completion of the inspection.		

Figure 1. As-found power switch of the landside rectifier in Bay 5 was turned off.

Follow-Up Action Form

- Follow-Up Actions Log
  - Summary of items
  - Responsible party

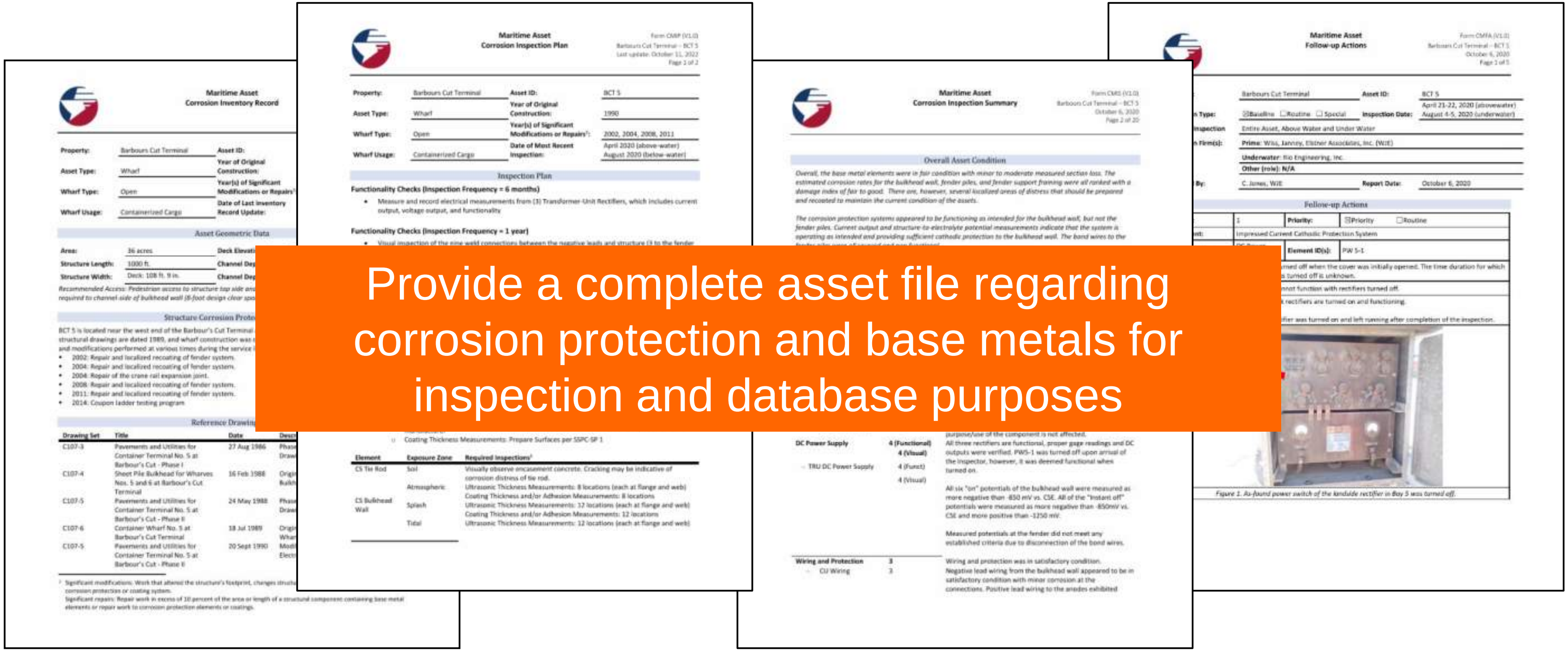
Maritime Asset
Follow-up Actions

Form MSFA (V1.1)
Northside Turning Basin – CD 25
July 30, 2021
Page 5 of 5

Follow-up Actions Log

Item No.	Priority	Recommended Action	Assigned To	Assigned By	Date
1	Priority	Replace anodes and adjust rectifier current outputs to provide adequate CP of base metal elements	PHA	WJE	July 30, 2021
2	Routine	Repair electrical bond wires between fender piles and support framing	PHA	WJE	July 30, 2021
3	Routine	Clean and coat fender pile and support framing elements in the tidal and splash zone.	PHA	WJE	July 30, 2021
4	Routine	Monitor coating defects of bulkhead wall in future inspections.	PHA	WJE	July 30, 2021

Baseline Inspection Deliverables



Provide a complete asset file regarding corrosion protection and base metals for inspection and database purposes

Routine Inspection Deliverables

- Update Baseline Inspection forms
- New Inspection Summary & Data & Follow-Up Action Form

Table 8.2. Deliverables for Standard Inspections

Deliverable	Type of Inspection	
	Baseline	Routine
Corrosion Inventory Record	Yes. Includes initial generation of document.	Revise only if change identified
Corrosion Inspection Plan	Yes. Includes initial generation of document.	Update
Standard Corrosion Inspection Drawing Set	Yes. Includes initial generation of document.	No
Corrosion Element Inspection Forms	Yes. Includes initial generation of document.	Yes. Relies on inspection forms generated by Baseline.
Corrosion Inspection History	Yes. Includes initial generation of document.	Update
Corrosion Inspection Summary	Yes	Yes
Corrosion Inspection Data	Yes	Yes
Follow-Up Action Form	Yes	Yes
Submission into PHA database	Yes	Yes

Routine Inspection

- 3-year or 6-year cycle
- Inspect readily-accessible elements
- Perform repeatable measurements
- Document change in asset's inventory record
- Update component ratings and asset condition assessment

Useful in Providing Trends for Asset Management

Routine Inspection Deliverables

- Updated Inventory Record or Drawings (if needed)
- Updated Inspection Plan (if needed)
- (New) Inspection Summary
- (New) Inspection Data
- (New) Follow Up Actions

Maritime Asset
Corrosion Inventory Record and Inspection Plan

Form CMIR (V1.1)
Barbours Cut Terminal – BCT 5
Last update: May 23, 2019
Page 1 of 11

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Last Inventory Record Update:**	May 23, 2019

Asset Geometric Data

Area:	36 acres	**Deck Elevation above MLT:**	18 ft. 0 in.
Structure Length:	1000 ft.	**Channel Depth at Fender:**	44 ft. 6 in.
Structure Width:	Deck: 108 ft. 9 in.	**Channel Depth at Bulkhead:**	7 ft. 6 in.

Recommended Access: Pedestrian access to structure top side and landside bulkhead via catwalks; boat access required to channel-side of bulkhead wall (8-foot design clear span between drilled shafts).

Structure Corrosion Protection History

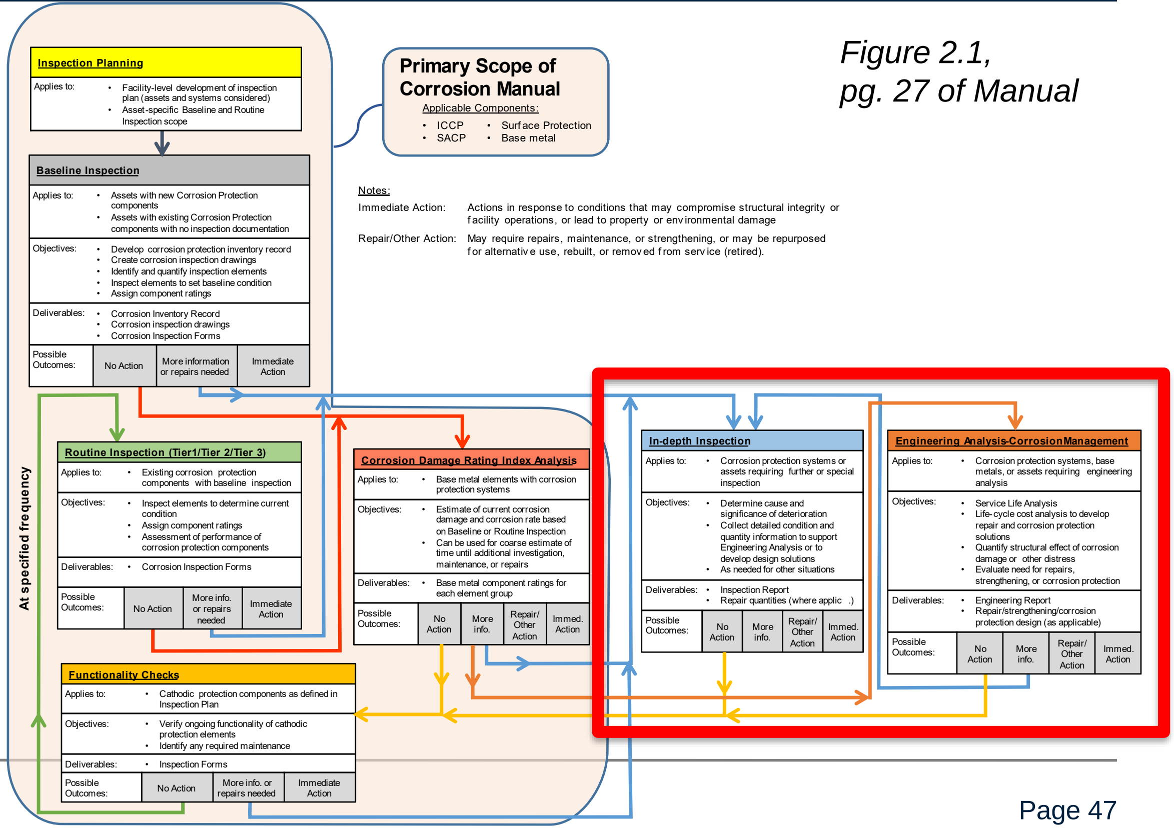
BCT 5 is located near the west end of the Barbour's Cut Terminal along the south side of the channel. The original structural drawings are dated 1989, and wharf construction was completed in 1992. Several noteworthy repairs and modifications performed at various times during the service life of the wharf include the following:

- 2002: Repair and localized recoating of fender system.
- 2004: Repair and localized recoating of fender system.
- 2004: Repair of the crane rail expansion joint.
- 2008: Repair and localized recoating of fender system.
- 2011: Repair and localized recoating of fender system.

Special Inspections / Refined Analysis

1. Objective and Scope
2. Methodology
3. Record of observations/ data
4. Interpretation of observations/data
5. Recommendations
6. Summary
7. Seal of Responsible Professional

Figure 2.1, pg. 27 of Manual



Review Quiz

Question #1

- Which type of an inspection best describes acquiring typical corrosion related information for tracking of corrosion performance over time? Select the best answer
  - Baseline
  - **Routine Inspection**
  - Special

Question #2

- What are the required unique deliverables for a Routine Inspection?
  - Inventory Record
  - Inspection Plan
  - Inspection Drawing Set
  - Element Inspection Forms
  - Inspection History
  - Inspection Summary
  - Inspection Data
  - Follow Up Action Form
  - Submission to PHA Database

Question #3

- On which form can you find the information regarding Exposure Zones and Environmental Conditions?
  - Follow-Up Action Form
  - Inspection Drawing Set
  - Inspection Summary
  - **Inventory Record**

Question #4

- On the standard inspection drawings, the asset is to be oriented so that the channel is on which side of the sheet?
  - **Top**
  - Bottom
  - Left
  - Right

END OF MODULE

Module 4.1

Element Condition Codes and Condition States

Corrosion Manual Training Course

Module Objectives

Module 4.1 Learning Outcomes

- Identify and quantify damage and deterioration conditions in corrosion protection and base metal elements
- Characterize severity of damage for corrosion and base metal elements using the four predefined condition states
- Understand use of visual and quantitative data for determining element conditions

Module References

- Chapter 3: Elements and Element Conditions
- Chapter 8: Documentation and Reporting
- Appendix F: Documentation and Reporting Forms

Element Condition Codes

- Listed by
  - Component
  - Element
  - Material
  - Condition
- Appendix E

Impressed Current Cathodic Protection (ICCP) Component Elements

DC Power Supply

Code	Condition Name
ACIN	Error in AC Input
BATT	Condition of Battery
DISP	Error in Output Display Panels
ELEC	Condition of Electrical Components
LABL	Condition of Labels
MISS	Missing
OUTP	Error in DC Output
VAND	Environmental / Vandalism

Sacrificial Anode Cathodic Protection (SACP) Component Elements

Cathodic Protection Jackets

Code	Condition Name
ABWJ	Abrasion/ wear
CRKJ	Cracking
DISJ	Jacket Distortion
IMPT	Impact Damage
MISS	Missing

Surface Protection Component Elements

Coatings, Wraps, and Metalizing

Code	Condition Name
ADHS	Adhesion
CHLK*	Chalking
GALV*	Galvanized Zinc Coating
FRPW*	Fiber-reinforced polymer / plastic wraps
PEEL*	Peeling/ bubbling/ cracking
THCK	Thickness
WEAR*	Wear
WETH*	Weathering Steel Patina

* Repeated from FICAP Maritime Structures Manual

Base Metal Component

Metal Material

Code	Condition Name
CORR	Corrosion (visual / qualitative)
SXLS	Section loss

ICCP and/or SACP Component Elements

Anodes

Code	Condition Name
CNSM	Consumption
CONW	Condition of Thermite Weld
MARG	Marine Growth
MISS	Missing
PASS	Passivation
PROT	Protection or Sleeve

Supplementary Anode Materials

Code	Condition Name
BSTL	Backfill Settlement
CNSM	Consumption
CONW	Condition of Thermite Weld
MISS	Missing
VENT	Condition of Well Vent

Monitoring Equipment

Code	Condition Name
ELEC	Condition of Electrical Components
LABL	Condition of Labels
LEAD	Condition of Leads
MISS	Missing
REFE	Condition of Reference Electrode
VAND	Environmental / Vandalism

Wiring and Protection

Code	Condition Name
CNSP	Connection / Splice Distress
CRKP	Cracking of Conduit
INSU	Condition of Insulation
MISS	Missing
WIRE	Condition of Wiring

CP Supports

Code	Condition Name
BASK	Condition of Submerged Anode Baskets
CONS	Connection Distress to Structure
MISS	Missing
SUPP	Condition of Support Elements

CM pg E.1

Element Condition Codes

- Four letter code, describes type of:
  - Damage
  - Deterioration
  - Defect
- Specific to each individual element
- Similar to FICAP Structures

By Component

By Element or Material Type

CM pg E.1

Sacrificial Anode Cathodic Protection (SACP) Component Elements

Cathodic Protection Jackets

Code	Condition Name
ABWJ	Abrasion/ wear
CRKJ	Cracking
DISJ	Jacket Distortion
IMPT	Impact Damage
MISS	Missing

ICCP and/or SACP Component Elements

Anodes

Code	Condition Name
CNSM	Consumption
CONW	Condition of Thermite Weld
MARG	Marine Growth
MISS	Missing
PASS	Passivation
PROT	Protection or Sleeve

Supplementary Anode Materials

Code	Condition Name
BSTL	Backfill Settlement
CNSM	Consumption
CONW	Condition of Thermite Weld
MISS	Missing
VENT	Condition of Well Vent

Monitoring Equipment

Code	Condition Name
ELEC	Condition of Electrical Components
LABL	Condition of Labels
[illegible]	[illegible] Leads
[illegible]	[illegible]
[illegible]	[illegible] Reference Electrode
VAND	Environmental / Vandalism

Element Condition States

- Four Condition States
  - CS1 (Good)
  - CS2 (Fair)
  - CS3 (Poor)
  - CS4 (Severe)
- Similar to FICAP Structures

Type	Code	Condition Name	Condition Definition	Condition States: CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Supplementary Anode Materials	BSTL	Backfill Settlement	Settlement or improper compaction of anode well backfill.	No visible settlement.	Minor settlement observed.	Minor to moderate settlement or poor consolidation observed.	Moderate to major settlement or poor consolidation observed, affecting localized resistivity of the anode bed/well.
	CNSM	Consumption	Consumption of anode	<10% consumed by weight	10-50% consumed by weight	51-75% consumed by weight	>75% consumed by weight
	CONW	Condition of Thermite Weld	Condition of thermite weld connecting anode to the wiring.	No connection distress; connection is in place and functioning as intended.	Minor distress without distortion is present, but connection is in place and functioning as intended.	Cracked weld; assessment has determined electrical connection has not been compromised.	Cracked weld resulting in electrical isolation of the anode.
	MISS	Missing	Element intended to be in place is missing. Does not apply to elements that have been intentionally removed as part of a modification.	Element is present.	Parts of an element are missing, however does not affect functionality.	Element is missing but assessment has determined element is not needed for functionality.	Element is missing.
	VENT	Condition of Well Vent	Distress or damage to anode well vent.	No distress.	Minor distress to vent.	Minor or moderate distress that may affect the ability of the pipe to vent gases properly.	Vent is damaged and/or filled so that immediate functionality has been compromised.

Detailed Descriptions CM pg E.2-10

Element Condition States

- Some condition states based on quantitative data / measurements
- Units for measurement are different than units for element (ex: mass vs. Ea., mils vs SF)

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Anodes	CNSM	Consumption	Consumption of anode.	<10% consumed by weight	10-50% consumed by weight	51-75% consumed by weight	>75% consumed by weight
	CONA	Condition of Connection	Condition of thermite weld connecting anode to the wiring.	No connection distress; connection is in place and functioning as intended.	Minor distress without distortion is present, but connection is in place and functioning as intended.	Cracked weld or damaged connection; assessment has determined electrical connection has not been compromised.	Cracked weld or failed connection resulting in electrical isolation of the anode.
	MARG	Marine Growth	Organic growth on bulk and/or ribbon anodes.	No marine growth present.	Minor marine growth on anode.	Moderate marine growth on anode that may affect functionality.	Significant marine growth on anode affecting functionality.
	MISS	Missing	Element intended to be in place is missing. Does not apply to elements that have been intentionally remo as part of a modificatio	Element is present.	Parts of an element are missing, however does not affect functionality	Element is missing but assessment has determined element is	Element is missing.
	PASS	Passivation	Passivation of anode.				
	PROT	Protection or Sleeve	Condition of Anode Protection or Sleeve				

Detailed D

Table C-2. Sacrificial Anode Cathodic Protection (SACP) Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[2]
Cathodic Protection Jackets (JA)			
JA-FG JA-PVC	FG Cathodic Protection Jacket PVC Cathodic Protection Jacket	Systems serving to encase a structural or functional element, typically in conjunction with a galvanic cathodic protection system, such as underlying zinc mesh or an attached bulk anode.	EA
Anodes - Sacrificial (AS)			
AS-AL AS-CI AS-DL AS-GP AS-MG AS-ZN AS-MMO AS-SCI AS-OTH	AL Anode CI Anode DL Anode GP Anode MG Anode ZN Anode MMO Anode SCI Anode OTH Anode	Anodes are installed as part of a sacrificial CP system. Galvanic anodes are more active metals with respect to the structure being protected and are designed to preferentially corrode. Anodes are typically installed in anode wells, soil, or underwater.	EA

Element Condition States

- Some condition states based on quantitative data
- Units for measurement are different than units for element (ex: % loss vs. LF)

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Metal Material	WETH	Weathering Steel Patina [See Table Note 1]	Condition of weathering steel patina (oxide film).	Uniform color pattern, dark brown with some lighter reddish- or purple-brown spots. Patina is adhered.	Dark brown but with minor color variation. Small loose flakes on surface but underlying patina is adhered.	Dark brown with black blotches, non-uniform texture. Medium (up to 1 inch) sized flakes.	Dark brown, black patina with widespread blotchiness. Laminar sheets or large flakes. Patina is no longer effective.
Metal Material	CORR	Corrosion	Corrosion of metal and other material elements, excluding connections.	No corrosion observed.	Freckled rust or light pitting present; section loss is not evident.	Section loss is evident or pack rust is present, but assessment has determined element's functionality or capacity is not compromised.	Section loss is significant enough to affect element's immediate functionality or capacity Pack rust is causing element instability or prevents elements from functioning as intended.
Metal Material	SXLS	Section loss	Section loss of base metal elements based on measured thickness during inspection.	≤ 2% section loss	>2% to ≤ 10% section loss	>10% to ≤ 30% section loss	>30% section loss

Detailed Descriptions CM PG E.2-10

Element Condition States

- Some condition states based on quantitative data / measurements
- Units for measurement are different than units for element (ex: mils vs. SF)

Type	Code	Condition Name	Condition Definition	CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Coatings, Wraps, and Metalizing	ADHS	Adhesion	Adhesion of protective coating on base metals based on measured inspection data, using ASTM D4541 or D3359 or equivalent.	Typical pull off testing values ≥200 psi. Adhesion test result classification of 5B.	Typical pull off testing values between 100 and 200 psi. Adhesion test result classification of 4B or 3B.	Typical pull off testing values between 50 and 100 psi. Adhesion test result classification of 2B or 1B.	Typical pull off testing values less than 50 psi. Adhesion test result classification of 0B.
	CHLK	Chalking	Chalking in metal protective coatings	No chalking.	Surface dulling.	Loss of pigment.	Loss of adhesion to structure resulting in disbondment of coating, structure becomes susceptible to corrosion.
	FRPW	Fiber-reinforced polymer wrap	Condition of fiber-reinforced (Glass, Carbon, or other material) polymer permanently bonded to a member. Also may apply to unbonded plastic wrap, such as for piles.	No visible distress.	Minor bubbles or blisters. Minor abrasion to surface layer.	Delamination, gouges, holes, tears, or splits in material but assessment has determined capacity or functionality of wrap is not compromised.	Delamination, gouges, holes, tears, or splits in material that affects capacity or functionality of wrap.
	GALV	Galvanized zinc coating	Condition of galvanized zinc patina on steel elements.	No white or red corrosion products. Surface may be bright and shiny, spangled, or matte gray.	White rust (zinc oxide) is visible on surface.	Red rust is visible through coating on less than 5 percent of the local area.	Red rust exceeds 5 percent of the local area.
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking.	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.
	THCK	Thickness	Thickness of protective coating on base metals based on measured inspection data.	≥ 18 mils	≥10 mils to < 18 mils	≥ 5 mils to < 10 mils	<5 mils
	WEAR	Wear	Wear of protective coating. Includes wear from abrasion	No wear.	Substrate not exposed, coating showing wear or	Substrate is partially exposed; thickness of	Substrate exposed; protective coating is no

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Summary

- Characterization of corrosion and base metal elements using the four predefined condition states.
  - Based on element and/or material
- Quantitative data obtained as part of Corrosion Manual
  - Provide specific condition ratings for elements

Practical Examples

Practical Example #1: Rectifier

Practical Example #1: Rectifier

Given

- Rectifier appears to be functioning
- DC output amperage measured at 45 amps
- Ammeter reads DC output amperage at 0 amps

Practical Example #1: Rectifier

Review

- What component is this element a part of?
  - ICCP
- What element do the photographs refer to?
  - TRU DC Power Supply
  - PW-TRU

Practical Example #1: Rectifier

Questions

- Condition code would you use?
  - DISP – Error in Output Display Panels
- What condition state and quantity would you assign to this element?
  - **CS4 (1 EA)**

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
DC Power Supply	ACIN	Error in AC Input	Incorrect AC input readings.	N/A	N/A	Error in AC input frequency.	No AC input voltage.
	BATT	Condition of Battery	Condition of CP battery.	No distress and proper output voltage measured.	Distress to battery and/or terminals that does not affect output voltage.	Distress to battery and/or terminals that reduces output voltage. May also include typical usage of battery.	Zero voltage output.
	DISP	Error in Output Display Panels	Accuracy of rectifier output panels.	<5% measured error in current and/or voltage display panels	5 to 10% measured error in current and/or voltage display panels.	>10% measured error in current and/or voltage display panels.	Current and/or voltage display panels nonfunctional.
	ELEC	Condition of Electrical Parts	Visual and functional condition of electrical components, including shunts, breakers, fuses, diodes…etc.	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress observed but functionality intact.	Moderate to major distress observed with possibly impacted functionality.
	LABL	Condition of Labels	Condition of labels unit and leads.	Easily legible.	Worn but legible.	Limited or no legible label information.	Labels for leads incorrectly labelled.
	MISS	Missing	Element intended to be in place is missing. Does not apply to elements that have been intentionally removed as part of a modification.	Element is present	Parts of an element are missing, however does not affect functionality.	Element is missing and has negatively impacted functionality or capacity.	Element is missing and is preventing any functionality or capacity.
	OUTP	DC Output	DC output readings.	DC output voltage and current.	N/A	Zero DC output current with DC output voltage	Zero DC output current and zero DC output voltage.
	VAND	Environmental / Vandalism	Deliberate or undeliberate destruction of PHA property by persons or environmental conditions.	No damage present	Potentially detrimental environmental conditions not yet resulting in damage (e.g. buildup of flammable material near electrical equipment).	Damage to equipment but functionality has not been diminished.	Damage to equipment resulting in reduced or eliminated functionality.

Practical Example #2: Wiring

Given

- Bond wire connecting fender pile and support framing
- Corrosion at connection resulted in disbonded wire

Practical Example #2: Wiring

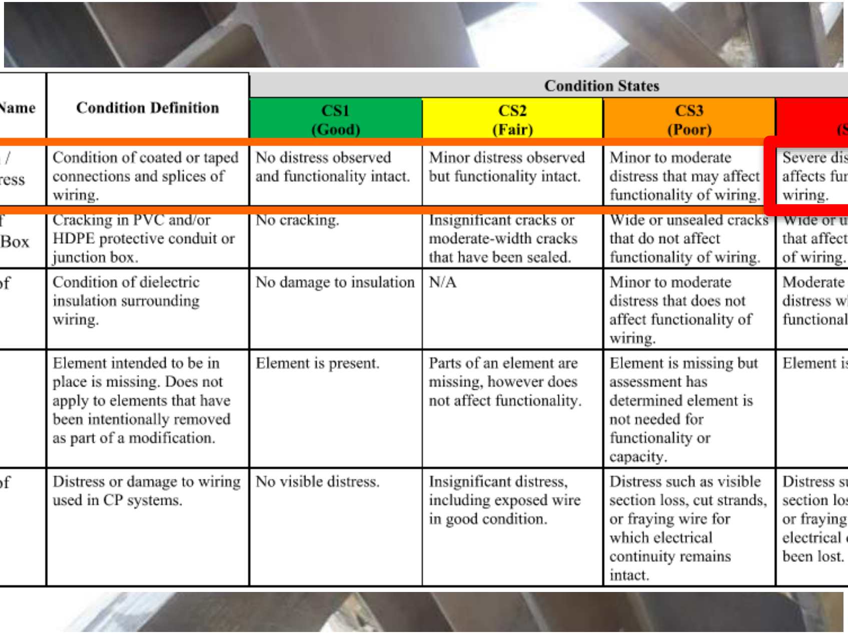
Review

- What component is this element a part of?
  - ICCP
- What element do the photographs refer to?
  - Wiring and Protection
  - WI-CU

Practical Example #2: Wiring

Questions

- What condition code would you use?
  - CNSP – Connection / Splice Distress
- What condition state and quantity would you assign?
  - CS4 (1 EA)



Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Wiring and Protection	CNSP	Connection / Splice Distress	Condition of coated or taped connections and splices of wiring.	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress that may affect functionality of wiring.	Severe distress which affects functionality of wiring.
	CRKP	Cracking of Conduit or Box	Cracking in PVC and/or HDPE protective conduit or junction box.	No cracking.	Insignificant cracks or moderate-width cracks that have been sealed.	Wide or unsealed cracks that do not affect functionality of wiring.	Wide or unsealed cracks that affect functionality of wiring.
	INSU	Condition of Insulation	Condition of dielectric insulation surrounding wiring.	No damage to insulation	N/A	Minor to moderate distress that does not affect functionality of wiring.	Moderate to severe distress which may affect functionality of wiring.
	MISS	Missing	Element intended to be in place is missing. Does not apply to elements that have been intentionally removed as part of a modification.	Element is present.	Parts of an element are missing, however does not affect functionality.	Element is missing but assessment has determined element is not needed for functionality or capacity.	Element is missing.
	WIRE	Condition of Wiring	Distress or damage to wiring used in CP systems.	No visible distress.	Insignificant distress, including exposed wire in good condition.	Distress such as visible section loss, cut strands, or fraying wire for which electrical continuity remains intact.	Distress such as visible section loss, cut strands, or fraying wire for which electrical continuity has been lost.

Practical Example #2: Wiring

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	CNSP	Connection / Splice Distress	Condition of coated or taped connections and splices of wiring.	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress that may affect functionality of wiring.	Severe distress which affects functionality of wiring.
	CRKP	Cracking of Conduit or Box	Cracking in PVC and/or HDPE protective conduit or	No cracking.	Insignificant cracks or moderate-width cracks	Wide or unsealed cracks that do not affect	Wide or unsealed cracks that affect functionality

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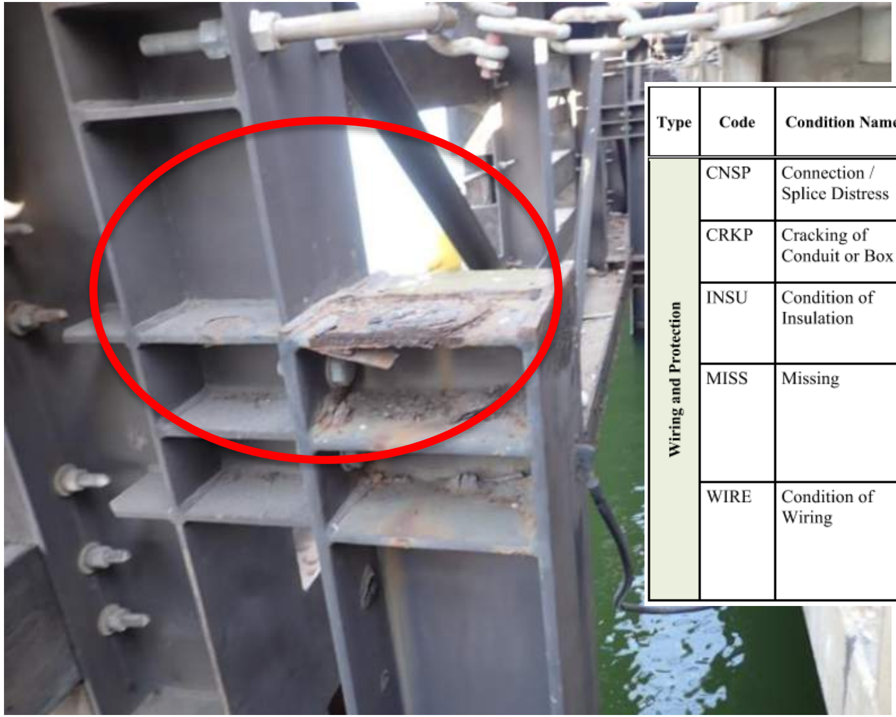
Practical Example #2: Wiring



Type	Code	Condition Name	Condition Definition	Condition States: CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Wiring and Protection	CNSP	Connection / Splice Distress	Condition of coated or taped connections and splices of wiring.	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress that may affect functionality of wiring.	Severe distress which affects functionality of wiring.
	CRKP	Cracking of Conduit or Box	Cracking in PVC and/or HDPE protective conduit or junction box.	No cracking.	Insignificant cracks or moderate-width cracks that have been sealed.	Wide or unsealed cracks that do not affect functionality of wiring.	Wide or unsealed cracks that affect functionality of wiring.
	INSU	Condition of Insulation	Condition of dielectric insulation surrounding wiring.	No damage to insulation	N/A	Minor to moderate distress that does not affect functionality of wiring.	Moderate to severe distress which may affect functionality of wiring.
	MISS	Missing	Element intended to be in place is missing. Does not apply to elements that have been intentionally removed as part of a modification.	Element is present.	Parts of an element are missing, however does not affect functionality.	Element is missing but assessment has determined element is not needed for functionality or capacity.	Element is missing.
	WIRE	Condition of Wiring	Distress or damage to wiring used in CP systems.	No visible distress.	Insignificant distress, including exposed wire in good condition.	Distress such as visible section loss, cut strands, or fraying wire for which electrical continuity remains intact.	Distress such as visible section loss, cut strands, or fraying wire for which electrical continuity has been lost.

Practical Example #3: Wall Coating

Given

- Coating at bulkhead wall
- Exposed portion in mostly good condition
- Area where full coating system is peeling/cracked and substrate is exposed

Practical Example #3: Wall Coating

Questions

- What condition code would you use?
  - PEEL – Peeling/ bubbling/ cracking
- What condition state and quantity would you assign?
  - **CS4 (3 SF)**

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Coatings, Wraps, and Metalizing	ADHS	Adhesion	Adhesion of protective coating on base metals based on measured inspection data, using ASTM D4541 or D3359 or equivalent.	Typical pull off testing values ≥200 psi. Adhesion test result classification of 5B.	Typical pull off testing values between 100 and 200 psi. Adhesion test result classification of 4B or 3B.	Typical pull off testing values between 50 and 100 psi. Adhesion test result classification of 2B or 1B.	Typical pull off testing values less than 50 psi. Adhesion test result classification of 0B.
	CHLK	Chalking	Chalking in metal protective coatings	No chalking.	Surface dulling.	Loss of pigment.	Loss of adhesion to structure resulting in disbondment of coating, structure becomes susceptible to corrosion.
	FRPW	Fiber-reinforced polymer wrap	Condition of fiber-reinforced (Glass, Carbon, or other material) polymer permanently bonded to a member. Also may apply to unbonded plastic wrap, such as for piles.	No visible distress.	Minor bubbles or blisters. Minor abrasion to surface layer.	Delamination, gouges, holes, tears, or splits in material but assessment has determined capacity or functionality of wrap is not compromised.	Delamination, gouges, holes, tears, or splits in material that affects capacity or functionality of wrap.
	GALV	Galvanized zinc coating	Condition of galvanized zinc patina on steel elements.	No white or red corrosion products. Surface may be bright and shiny, spangled, or matte gray.	White rust (zinc oxide) is visible on surface.	Red rust is visible through coating on less than 5 percent of the local area.	Red rust exceeds 5 percent of the local area.
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking.	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.
	THCK	Thickness	Thickness of protective coating on base metals based on measured inspection data.	≥ 18 mils	≥10 mils to < 18 mils	≥ 5 mils to < 10 mils	<5 mils
	WEAR	Wear	Wear of protective coating. Includes wear from abrasion or weathering.	No wear.	Substrate not exposed, coating showing wear or abrasion.	Substrate is partially exposed; thickness of the coating is reduced.	Substrate exposed; protective coating is no longer effective.

Practical Example #4: Pile Coating

Given

- Coating at fender pile
- Atmospheric portion in mostly good condition
- Splash zone area where substrate is exposed
- Coating is peeling

Practical Example #4: Pile Coating

Questions

- What condition code would you use?
  - PEEL – Peeling/ bubbling/ cracking
- What condition state and quantity would you assign?
  - **CS2 (1SF)**
  - **CS4 (2 SF)**

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking.	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.

Practical Example #5: Measurements

Given

- Bulkhead Wall (Base Metal)
    - Metal Thickness at Flange
    - Design: 0.551 inches
    - Thickness: 0.539 inches (average)
- Wall Coating
    - Thickness: 29.6 mils (average)

Practical Example #5: Measurements

Questions

- Base Metal - What condition code?
  - SXLS – Section loss based on measurements
- What condition state and quantity?
  - **CS2**
  - 25 LF

Type	Code	Condition Name	Condition Definition	Condition States: CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Metal Material	WETH	Weathering Steel Patina [See Table Note 1]	Condition of weathering steel patina (oxide film).	Uniform color pattern, dark brown with some lighter reddish- or purple-brown spots. Patina is adhered.	Dark brown but with minor color variation. Small loose flakes on surface but underlying	Dark brown with black blotches, non-uniform texture. Medium (up to 1 inch) sized flakes.	Dark brown, black patina with widespread blotchiness. Laminar sheets or large flakes.
	CORR	Corrosion	Corrosion of metal and other	No corrosion observ			... functioning as intended.
	SXLS	Section loss	Section loss of base metal elements based on measured thickness during inspection.	≤ 2% section loss	>2% to ≤ 10% section loss	>10% to ≤ 30% section loss	>30% section loss

0.539/0.551 = 97.8%
→2.2% section loss

Representative of full length of wall (25 LF) in that exposure zone (4 ft)

Practical Example #5: Measurements

Questions

- Coating- What condition code?
  - THCK – Thickness of coating based on measurements
- What condition state and quantity?
  - **CS1**
  - 100 SF

Representative of full length of wall (25 LF) in that exposure zone (4 ft)

Average: 29.6 mils

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking.	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.
	THCK	Thickness	Thickness of protective coating on base metals based on measured inspection data.	≥ 18 mils	≥10 mils to < 18 mils	≥ 5 mils to < 10 mils	<5 mils
	WEAR	Wear	Wear of protective coating. Includes wear from abrasion or weathering.	No wear.	Substrate not exposed, coating showing wear or abrasion.	Substrate is partially exposed; thickness of the coating is reduced.	Substrate exposed; protective coating is no longer effective.

END OF MODULE

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Module 4.2

Documenting Element Condition States

Corrosion Manual Training Course

Module Objectives

Module 4.2 Learning Outcomes

- Document an element's condition state using an Element Inspection Form
- Understand required elemental input for database submission

Documenting Element Condition States

- Characterize **<u>and quantify</u>** any observable conditions exhibited by an individual element
- An element may experience **multiple conditions**, even in the same location
  - Record condition and quantity
  - Some quantities **not counted** if multiple conditions exist in a given area
  - Not counted quantities identified in **brackets or separate column in database**

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity [counted with other CS])			
					CS1	CS2	CS3	CS4
CT 40-1	CT-EP	SF	230	165	0	35	30	0
	– PEEL	*SF*	*30*				*30*	*0*
	– CHLK	*SF*	*25*			*35 [25]*		
CT 40-2	CT-EP	SF	175	0	35	60	40	40
	– PEEL	*SF*	*80*				*40*	*40*
	– CHLK	*SF*	*85*			*60 [25]*		
Coating Subtotal	**CT-EP**	**SF**	**405**	**165**	**35**	**95**	**70**	**40**

Documenting Element Condition States

- Provided by Inspection Plan:
  - Element Location ID
  - Element Codes
  - Units & Quantities
- Documented during Inspection:
  - Condition Codes
  - Condition States
  - Quantities
  - Inaccessible areas

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity [counted with other CS])			
					CS1	CS2	CS3	CS4
CT 40-1	CT-EP	SF	230	165	0	35	30	0
	– PEEL	*SF*	*30*				*30*	*0*
	– CHLK	*SF*	*35*			*35 [25]*		
CT 40-2	CT-EP	SF	175	0	35	60	40	40
	– PEEL	*SF*	*80*				*40*	*40*
	– CHLK	*SF*	*60*			*60 [25]*		
Coating Subtotal	**CT-EP**	**SF**	**405**	**165**	**35**	**95**	**70**	**40**

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Example: Coating Element

- CT 40-2
  - Epoxy coating
  - 175 SF total
- Visual Observations
  - Peeling, chalking of varying degrees

- Area 1
  - 40 SF CS4 PEEL
- Area 2
  - 40 SF CS3 PEEL
  - 25 SF CS2 CHLK
- Area 3
  - 60 SF CS2 CHLK

Example: Coating Element CT40-2

Pg 30 of CM

- Area 1
  - 40 SF CS4 PEEL
- Area 2
  - 40 SF CS3 PEEL
  - 25 SF CS2 CHLK
- Area 3
  - 60 SF CS2 CHLK
- Remaining CS1

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity [counted with other CS])			
					CS1	CS2	CS3	CS4
CT 40-1	CT-EP	SF	230	165	0	35	30	0
	– PEEL	*SF*	*30*				*30*	*0*
	– CHLK	*SF*	*35*			*35 [25]*		
CT 40-2	CT-EP	SF	175	0	35	60	40	40
	– PEEL	*SF*	*80*				*40*	*40*
	– CHLK	*SF*	*60*			*60 [25]*		
Coating Subtotal	**CT-EP**	**SF**	**405**	**165**	**35**	**95**	**70**	**40**

Documenting Condition States & Quantities

- Elemental inspection data on reporting forms
- Brackets or separate columns for quantity data not counted

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity [counted with other CS])			
					CS1	CS2	CS3	CS4
CT 40-1	CT-EP	SF	230	165	0	35	30	0
	– PEEL	*SF*	*30*				*30*	*0*
	– CHLK	*SF*	*35*			*35 [25]*		
CT 40-2	CT-EP	SF	175	0	35	60	40	40
	– PEEL	*SF*	*80*				*40*	*40*
	– CHLK	*SF*	*60*			*60 [25]*		
Coating Subtotal	**CT-EP**	**SF**	**405**	**165**	**35**	**95**	**70**	**40**

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity)					
					CS1	CS2	CS2NC	CS3	CS3NC	CS4
CT 40-1	CT-EP	SF	230	165	0	35	25	30	0	0
	– PEEL	*SF*	*30*					*30*		*0*
	– CHLK	*SF*	*35*			*35*	*25*			
CT 40-2	CT-EP	SF	175	0	35	60	25	40	0	40
	– PEEL	*SF*	*80*					*40*		*40*
	– CHLK	*SF*	*60*			*60*	25			
Coating Subtotal	**CT-EP**	**SF**	**405**	**165**	**35**	**95**	**50**	**70**	**0**	**40**

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Documenting Element Condition States

- Elemental condition states and quantities entered in the PHA Database
- Separate column for Not Counted quantities

Surface Protection

CT 1-1	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-1	Baseline	100	0	100	0	0	0	0	0	0
CT 1-1	ADHS		0	0	30	0	0	0	0	0
CT 1-1	PEEL		0	0	0	0	0	0	15	0

CT 1-2	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-2	Baseline	400	0	400	0	0	0	0	0	0
CT 1-2	PEEL		0	0	0	0	0	0	115	0
CT 1-2	ADHS		0	0	240	0	0	0	0	0

CT 1-3	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-3	Baseline	134	0	134	0	0	0	0	0	0
CT 1-3	PEEL		0	0	0	0	10	0	15	0

CT 2-1	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 2-1	Baseline	100	0	100	0	0	0	0	0	0
CT 2-1	PEEL		0	0	0	0	0	0	12	0

CT 2-2	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 2-2	Baseline	400	0	400	0	0	0	0	0	0
CT 2-2	PEEL		0	0	0	0	0	0	105	0

Documenting Element Condition States

- Database provides Summary of Elemental Condition State
  - Sorted by Component
  - Summary of Quantities

Surface Protection

CT-CE	Total Qty.	Not Accessible	CS1	CS2	CS2NC	CS3	CS3NC	CS4
ADHS		0	0	405	135	60	0	30
Baseline	15819	0	13350	0	0	0	0	0
PEEL		0	0	0	0	128	0	1482
THCK		0	0	364	170	0	10	0
Total CT-CE	15819	0	13350	769	305	188	10	1512

CT-EP	Total Qty.	Not Accessible	CS1	CS2	CS2NC	CS3	CS3NC	CS4
ADHS		0	0	336	0	0	0	0
Baseline	7796.5	0	7008	0	0	0	0	0
PEEL		0	0	127	0	37	0	57
THCK		0	0	231.5	245	0	0	0
Total CT-EP	7796.5	0	7008	694.5	245	37	0	57

HG-HDG	Total Qty.	Not Accessible	CS1	CS2	CS2NC	CS3	CS3NC	CS4
Baseline	234	0	210	0	0	0	0	0
GALV		0	0	24	0	0	0	0
Total HG-HDG	234	0	210	24	0	0	0	0

Documenting Element Condition States

- Photographs
  - Anything with follow-up action
  - Representative of conditions
  - Submit to database
    - – JPEG
    - – 2048 pixels on longest edge
  - Example Photo Naming
    - – CD29_CT10-3_Baseline_3-22-2021_001.jpg

Practical Examples

Practical Example #1: Bulkhead Wall

- Given Information:
  - Component: Base Metal
  - Element: Bulkhead Wall (Typical)
  - Design Thickness: 0.5 in.
  - Average Measured UT: 0.435 in.
- What Condition Code(s), State(s), and est. quantities are appropriate?
  - Condition Code: SXLS
  - Condition State: **CS3**
  - Quantity: 3 LF

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	SXLS	Section loss	Section loss of base metal elements based on measured thickness during inspection.	≤ 2% section loss	>2% to ≤ 10% section loss	>10% to ≤ 30% section loss	>30% section loss

Practical Example #2: Coating

- Given
  - Component: Surface Protection
  - Element: Coal Tar Epoxy Coating
  - Pull-off Testing: 150 psi average in 200 SF atmospheric/exposed zone
  - Visual observations→
- What Condition Code(s), State(s), and est. quantities are appropriate?
  - PEEL **CS4**, 15 SF
  - ADHS **CS2**, 185 SF

Practical Example #3: Wiring Protection

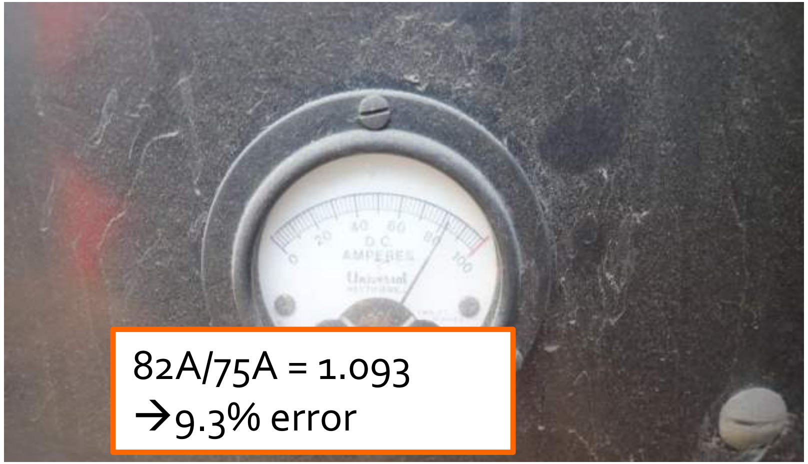
- Given Information:
  - Component: Impress
  - Element: PR-HDPE
  - Broken conduit, wirir

Type	Code	Condition Name	Condition Definition	Condition States: CS1 (Good)	Condition States: CS2 (Fair)	Condition States: CS3 (Poor)	Condition States: CS4 (Severe)
Protection	CNSP	Connection / Splice Distress	Condition of coated or taped connections and splices of wiring.	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress that may affect functionality of wiring.	Severe distress which affects functionality of wiring.
	CRKP	Cracking of Conduit or Box	Cracking in PVC and/or HDPE protective conduit or junction box.	No cracking.	Insignificant cracks or moderate-width cracks that have been sealed.	Wide or unsealed cracks that do not affect functionality of wiring.	Wide or unsealed cracks that affect functionality of wiring.
	INSU	Condition of Insulation	Condition of dielectric insulation surrounding wiring.	No damage to insulation	N/A	Minor to moderate distress that does not affect functionality of wiring.	Moderate to severe distress which may affect functionality of wiring.

- What Condition Code(s), State(s), and est. quantities are appropriate?
  - Condition Code: CRKP
  - Condition State: **CS3**
  - Quantity: 1 EA

Practical Example #4: Rectifier

- Given Information:
  - Component: ICCP
  - Element: Transformer-Rectifier Unit
  - Measured D.C. Current Output: 75 amps
- What Condition Code(s), State(s), and est. quantities are appropriate?
  - Condition Code: DISP
  - Condition State: **CS2**
  - Quantity: 1 EA



Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	ACIN	Error in AC Input	Incorrect AC input readings.	N/A	N/A	Error in AC input frequency.	No AC input voltage.
	BATT	Condition of Battery	Condition of CP battery.	No distress and proper output voltage measured.	Distress to battery and/or terminals that does not affect output voltage.	Distress to battery and/or terminals that reduces output voltage. May also include typical usage of battery.	Zero voltage output.
	DISP	Error in Output Display Panels	Accuracy of rectifier output panels.	<5% measured error in current and/or voltage display panels	5 to 10% measured error in current and/or voltage display panels.	>10% measured error in current and/or voltage display panels.	Current and/or voltage display panels nonfunctional.
	ELEC	Condition of Electrical Parts	Visual and functional condition of electrical components, including	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress observed but functionality intact	Moderate to major distress observed with possibly impacted

Practical Example #4: Rectifier

DISP, CS2, 1 EA

- What if the shunt is also not functional?
  - ELEC
  - **CS4, 1 EA**
- Record on inspection form/ database?

Type	Code	Condition Name	Condition Definition	Condition States: CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Power Supply	ACIN	Error in AC Input	Incorrect AC input readings.	N/A	N/A	Error in AC input frequency.	No AC input voltage.
	BATT	Condition of Battery	Condition of CP battery.	No distress and proper output voltage measured.	Distress to battery and/or terminals that does not affect output voltage.	Distress to battery and/or terminals that reduces output voltage. May also include typical usage of battery.	Zero voltage output.
	DISP	Error in Output Display Panels	Accuracy of rectifier output panels.	<5% measured error in current and/or voltage display panels.	5 to 10% measured error in current and/or voltage display panels.	>10% measured error in current and/or voltage display panels.	Current and/or voltage display panels nonfunctional.
	ELEC	Condition of Electrical Parts	Visual and functional condition of electrical components, including shunts, breakers, fuses, diodes…etc.	No distress observed and functionality intact.	Minor distress observed but functionality intact.	Minor to moderate distress observed but functionality intact.	Moderate to major distress observed with possibly impacted functionality.
	LABL	Condition of Labels	Condition of labels unit and leads.	Easily legible.	Worn but legible.	Limited or no legible label information.	Labels for leads incorrectly labelled.

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity): CS1	CS2	CS2NC	CS3	CS3NC	CS4
PW 1-1	PW-TRU	EA	1	0	0	0	1	0	0	1
	– DISP	*SF*	*0*				*1*			
	– ELEC	*SF*	*1*							*1*

Practical Example #5: Wall Coating

Given

- Coating 300 SF total quantity
    - 100 SF Atmospheric
    - 50 SF Splash
    - 150 SF Submerged
- Mostly good condition
- Area where full coating is peeling/ cracked and substrate is exposed

Practical Example #5: Wall Coating

Questions

- What condition code would you use?
  - PEEL – Peeling/ bubbling/ cracking
- What condition state and quantity would you assign?
  - **CS4 (3 SF)**

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Coatings, Wraps, and Metalizing	ADHS	Adhesion	Adhesion of protective coating on base metals based on measured inspection data, using ASTM D4541 or D3359 or equivalent.	Typical pull off testing values ≥200 psi. Adhesion test result classification of 5B.	Typical pull off testing values between 100 and 200 psi. Adhesion test result classification of 4B or 3B.	Typical pull off testing values between 50 and 100 psi. Adhesion test result classification of 2B or 1B.	Typical pull off testing values less than 50 psi. Adhesion test result classification of 0B.
	CHLK	Chalking	Chalking in metal protective coatings	No chalking.	Surface dulling.	Loss of pigment.	Loss of adhesion to structure resulting in disbondment of coating, structure becomes susceptible to corrosion.
	FRPW	Fiber-reinforced polymer wrap	Condition of fiber-reinforced (Glass, Carbon, or other material) polymer permanently bonded to a member. Also may apply to unbonded plastic wrap, such as for piles.	No visible distress.	Minor bubbles or blisters. Minor abrasion to surface layer.	Delamination, gouges, holes, tears, or splits in material but assessment has determined capacity or functionality of wrap is not compromised.	Delamination, gouges, holes, tears, or splits in material that affects capacity or functionality of wrap.
	GALV	Galvanized zinc coating	Condition of galvanized zinc patina on steel elements.	No white or red corrosion products. Surface may be bright and shiny, spangled, or matte gray.	White rust (zinc oxide) is visible on surface.	Red rust is visible through coating on less than 5 percent of the local area.	Red rust exceeds 5 percent of the local area.
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking.	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.
	THCK	Thickness	Thickness of protective coating on base metals based on measured inspection data.	≥ 18 mils	≥10 mils to < 18 mils	≥ 5 mils to < 10 mils	<5 mils
	WEAR	Wear	Wear of protective coating. Includes wear from abrasion or weathering.	No wear.	Substrate not exposed, coating showing wear or abrasion.	Substrate is partially exposed; thickness of the coating is reduced.	Substrate exposed; protective coating is no longer effective.

Practical Example #5: Wall Coating

Given

- Testing in atmospheric zone (25 LF x 4 FT exposure = 100 SF)
- Adhesion Testing
  - 150 psi average
- Thickness Testing
  - Average 17.5 mils

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	ADHS	Adhesion	Adhesion of protective coating on base metals based on measured inspection data, using ASTM D4541 or D3359 or equivalent	Typical pull off testing values ≥200 psi. Adhesion test result classification of 5B.	Typical pull off testing values between 100 and 200 psi. Adhesion test result classification of 4B or 3B	Typical pull off testing values between 50 and 100 psi. Adhesion test result classification of 2B or 1B	Typical pull off testing values less than 50 psi. Adhesion test result classification of 0B.

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.
	THCK	Thickness	Thickness of protective coating on base metals based on measured inspection data.	≥ 18 mils	≥10 mils to < 18 mils	≥ 5 mils to < 10 mils	<5 mils
	WEAR	Wear	Wear of protective coating. Includes wear from abrasion or weathering.	No wear.	Substrate not exposed, coating showing wear or abrasion.	Substrate is partially exposed; thickness of the coating is reduced.	Substrate exposed; protective coating is no longer effective.

Practical Example #5: Wall Coating

- Inspection Results
  - CS4 PEEL 3 SF
  - CS2 ADHS 97 SF
  - CS2 THCK 100 SF Not Counted

- Coating 300 SF total quantity
  - 100 SF Atmospheric
  - 50 SF Splash
  - 150 SF Submerged (Not accessed)

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity)					
					CS1	CS2	CS2NC	CS3	CS3NC	CS4
CT 1-1	CT-EP	SF	300	150	50	97	100	0	0	3
	--PEEL	SF	3							3
	--ADHS	SF	97			97				
	--THCK	SF	0				100			

Practical Example #5: Wall Coating

- What if we measured 9 mils coating thickness?
  - ~~CS2 THCK 100 SF Not Counted~~
  - CS3 THCK 100 SF

Type	Code	Condition Name	Condition Definition	Condition States			
				CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
	PEEL	Peeling/ bubbling/ cracking	Peeling, bubbling, or cracking in protective coatings or wraps	No peeling, bubbling, or cracking.	Finish coat exhibits peeling, bubbling, or cracking.	Finish and primer coats exhibit peeling, bubbling, or cracking.	Substrate is exposed.
	THCK	Thickness	Thickness of protective coating on base metals based on measured inspection data.	≥ 18 mils	≥10 mils to < 18 mils	≥ 5 mils to < 10 mils	<5 mils
	WEAR	Wear	Wear of protective coating. Includes wear from abrasion or weathering.	No wear.	Substrate not exposed, coating showing wear or abrasion.	Substrate is partially exposed; thickness of the coating is reduced.	Substrate exposed; protective coating is no longer effective.

Element Location ID	Element / Condition Code	Units	Total Quantity	In-accessible	Condition States (quantity)					
					CS1	CS2	CS2NC	CS3	CS3NC	CS4
CT 1-1	CT-EP	SF	300	150	50	0	97	97	3	3
	--PEEL	SF	*3*							*3*
	--ADHS	SF	*0*			~~*97*~~	*97*			
	--THCK	SF	*97*				~~*100*~~	*97*	*3*	

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Module Wrap-Up

- Identify damage and deterioration found in PHA elements using **condition codes**
- Characterize severity using the four predefined **condition states**
- Record **quantity** of damage and deterioration conditions found in PHA elements
- **Document** an element's condition state using an Element Inspection Form and PHA database

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END OF MODULE

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Module 5.1

Baseline Inspection Planning

Corrosion Manual Training Course

Module Objectives

Module 5.1 Learning Outcomes

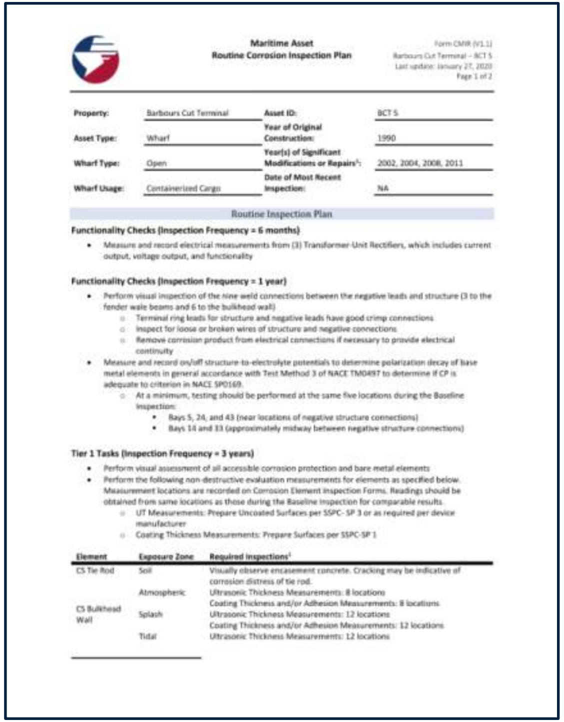
- Identify components and associated elements in corrosion inspection
- Classify importance of base metal elements
- Characterize exposure zones of elements
- Identify appropriate inspection procedures for corrosion protection and base metal elements
- Develop a Baseline Corrosion Inspection Plan

Module References

- Chapter 2: Inspection Types
- Chapter 8: Documentation and Reporting
- Appendix F: Documentation and Reporting Forms

Asset-Specific Inspection Plan

- Considers the following:
  - Specific components/elements to be inspected
  - Current age and expected design life
  - Nature/severity of environmental conditions and exposure
  - Types of corrosion mechanisms
  - Classification of base metals
  - Current conditions



Maritime Asset
Routine Corrosion Inspection Plan

Form CMIR (V1.1)
Barbours Cut Terminal – BCT 5
Last update: January 27, 2020
Page 1 of 2

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	NA

Routine Inspection Plan

Functionality Checks (Inspection Frequency = 6 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

Functionality Checks (Inspection Frequency = 1 year)

- Perform visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity
- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline inspection:
    - Bays 5, 24, and 43 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Perform visual assessment of all accessible corrosion protection and bare metal elements
- Perform the following non-destructive evaluation measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 3 or as required per device manufacturer
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations

PORT HOUSTON
THE INTERNATIONAL PORT OF TEXAS

Inspection Plan Goals

- Primary goals of an inspection plan:
  - Define the type(s) of inspection procedures needed
  - Identify the frequency for each inspection type
  - Describe the inspection methods and NDE techniques
  - Describe the extent and locations of inspection and NDE
  - Identify any surface cleaning requirements that may be needed for each type of inspection
  - Describe access requirements to perform the inspections

Types of Inspections

- Visual inspection
- NDE techniques
- Coating thickness and/or adhesion testing
- Anode mass measurement
- CP system electrical measurements

Baseline Inspection Planning

1. **Develop Corrosion Inventory Record**
    - Identify components and elements
    - Classify importance and design thickness for base metals
    - Characterize exposure zone for each element group
    - Characterize environmental conditions of asset
2. **Develop Corrosion Drawings**
    - Shows all elements (labels and quantities)
3. **Develop Corrosion Inspection Plan**
    - Defines specific tasks, locations, and frequencies

Inventory Record: Corrosion Protection

- Corrosion Protection Components
  - Identify all corrosion protection components
  - Identify elements and materials associated with each component
  - Review design intent of each installed system
  - Identify current age(s)

Task performed by document review.

Impressed Current Corrosion Protection Elements

Component / Element(s)	Description
Bulk Anode	Bulk anodes are installed as part of the ICCP system designed to protect both the fender piles and bulkhead wall.
– OTH Bulk Anode	Clusters of two bulk anodes are hung from the deck at approximately 35' to the landside of the fender system at 10' longitudinal spacing, totaling 200 anodes. Anodes are installed at Elev. -3.0 and -12.0'.
DC Power Supply	Three DC power supplies are installed to provide DC power for the ICCP system. Note: drawings indicate five rectifiers, but only three were installed.
– TRU DC Power Supply	Transformer-unit rectifiers are installed approximately 116-feet to the landside of the bulkhead wall adjacent to light poles 8 through 12.

Sacrificial Anode Corrosion Protection Elements

None.

Common Corrosion Protection Elements

Component / Element(s)	Description
Wiring and Protection	Wiring connects TRU DC Power Supplies with bulk anodes and the structure and is protected by PVC conduit to the landside of the bulkhead wall.
– CU Wiring	No. 6/7 copper wiring connects the corrosion protection system. Positive leads run to the bulk anodes and negative leads are connected to the fender system and bulkhead wall. Negative leads connect the copper conduit to the top fender wale beam and bulkhead wall in three and six locations, respectively.
– PVC Protection	Copper wiring is run through underground PVC conduit from the bulkhead wall to the five transformer-unit rectifiers.

Surface Protection Elements

Component / Element(s)	Description
Surface Protection	Coatings are used in conjunction with the ICCP system for protection of the bulkhead wall and fender system.
– PU Coatings	A three-coat system is used for protection of the fender system (Epoxy Low and Intermediate Coat with an Acrylic Urethane Topcoat).
– EP Coatings	An epoxy coating system is used for protection of the bulkhead wall (details unknown).

Inventory Record: Base Metals

- Base Metal Components
  - Identify base metal elements and materials
  - Classify importance (Critical, Typical, Redundant)
  - Define exposure zones
  - Identify current age(s) and design metal thicknesses

Task performed by document review.

Base Metal Components and Elements

Component / Element(s)	Description
Critical	
– CS Tie Rod	Tie rods, 3-3/4 inch diameter, extending from bulkhead wale beam to dead man, spaced at approximately 15 feet on center and encased in Schedule 40 PVC Casings. • *Installed in 1990, no documented modifications or repairs.* • *Design Cross-Sectional Area = 11.0 in²*
Typical	
– CS Bulkhead Wall	Steel sheet piles extending from Elev. +14.65 to -58.00'. Mudline is shown at -5.00'. • *Installed in 1990, no documented modifications or repairs.* • *Design Thickness = 0.5 in*
– CS Fender Piles	HP117 piles are extend from Elev. +16.0 to -69.0' and are spaced at 10'-9" on center. • *Installed in 1990, no documented modifications or repairs.* • *Design Web/Flange Thickness = 0.805 in*
Redundant	
– CS Support Framing	Structural steel framing used to support the timber facing consisting of W21x111 top wales and W14x43 bottom wales. *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Design Thickness: W14x43-- web = 0.305 in, flange= 0.530 in W21x111-- web = 0.550 in, flange = 0.875 in*

**Base Metal Components and Elements identified with FICAP labelling scheme*

Asset Exposure Zones

The following exposure zones have been identified at this site, the specific height of the zones and exposure effects have been estimated based on review of environmental conditions and data.

Exposure Zone	Elevation versus MLLW	Elements
Atmospheric	+3.25 ft. or greater	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Splash	+1.25 to +3.25 ft.	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Tidal	+0 to +1.25 ft.	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Submerged	0 ft. or less	CS Bulkhead Wall, CS Fender Piles
Soil	Below the mudline toward the waterside of the bulkhead and below the pavement on the landward side of the bulkhead	CS Tie Rods, CS Bulkhead Wall, CS Fender Piles

Inventory Record: Base Metals

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[1]
Critical (BMC)			
TR-CS-BMC TR-GS-BMC	CS Tie Rod GS Tie Rod	A tension-only structural element. Includes elements used as bracing and those used as tie backs for retaining walls. Does not include rods used solely for railing.	EA
DB-CS- BMC DB-GS- BMC	CS Deck Beam GS Deck Beam	A structural element loaded perpendicular to its longitudinal axis that transmits loads directly from the deck to a girder or substructure element.	LF
GI-CS- BMC GI-GS- BMC	CS Girder GS Girder	A structural element loaded perpendicular to its longitudinal axis that transmits loads from a deck beam or stringer to the substructure. May also carry loads directly from a portion of the deck.	LF
GP -CS- BMC GP-WS- BMC	CS Gusset Plate WS Gusset Plate	A structural plate element that provides a connection between other structural elements. Constructed with one or more plates that may be bolted, riveted, or welded.	EA
CO-CS- BMC CO-GS- BMC	CS Column GS Column	A vertical prismatic element that transmits loads (vertical, lateral and/or bending) from the deck or ...ubstructure element.	LF
PI-CS- BMC	CS Pile	...tical element that transmits ...uperstructure, or substructure ...d bearing or friction. Piles are ...allation and driven into the ...idered deep foundation	EA
PF-CS(S)- BMC PF-CS(C)- BMC	CS Sand-Filled Pile CS Concrete-Filled Pile	A type of pile that consists of a hollow steel pipe driven into the ground and then filled with material. Includes "Raymond Piles", which are concrete-filled pipes with tapered cross-sections.	EA
PC-CS- BMC	CS Pile Cap	A horizontally-oriented structural element that transmits loads from substructure or superstructure elements above to pile elements below.	LF
BG-CS- BMC	CS Closed Web/Box Girder	A hollow, four-sided structural element loaded perpendicular to its longitudinal axis that transmits loads from a deck beam or stringer to the substructure.	LF
BT-CS- BMC BT-GS- BMC	CS Bulkhead Tie Rod GS Bulkhead Tie Rod	A tension-only structural element, used to restrain the top of a bulkhead wall.	EA

Critical
BMC

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[1]
Typical (BMT)			
AW-CS-BMT	CS Anchor Wall	A continuous buried wall element on the landside of a retaining wall or bulkhead. Used as anchorage for another element.	LF
BW-CS-BMT BW-GS-BMT	CS Bulkhead Wall GS Bulkhead Wall	A structural wall element that functions primarily as an earth retaining structure. Primarily subject to out-of-plane lateral loads. Bulkheads generally separate earth fill from water.	LF
DT-CS- BMT	CS Deck, open Grid	A horizontal, planar structural element that carries and distributes loads to superstructure or substructure elements. Observations specific to topside of element.	SF
SR-CS- BMT SR-GS- BMT	CS Stringer GS Stringer	A structural element loaded perpendicular to its longitudinal axis that transmits loads from the deck to a deck beam	LF
RW-CS- BMT	CS Retaining Wall	A structural wall element that functions primarily to ... carry vertical loads from ...ning walls are located above	LF
CF-CS- BMT	CS Cofferdam	...ll structural elements used as a ...ructure.	EA
BB-CS- BMT	CS Bulkhead Wale Beam	A bulkhead element loaded perpendicular to its longitudinal axis that stiffens a bulkhead and is attached to tie rods or other anchorages.	LF
BC-CS- BMT	CS Bent Cap	A horizontally-oriented structural element that transmits loads from superstructure elements to column elements below.	LF
BR-CS- BMT BR-GS- BMT	CS Brace GS Brace	An element, often diagonally oriented, fastened across pile elements to provide lateral stability.	EA
PB-CS- BMT	CS Battered Pile	A type of pile that is driven at an angle, typically between 30 and 60 degrees from vertical. Battered piles provide lateral stiffness to the structure.	EA
FP-CS- BMT FP-GS- BMT	CS Fender Pile GS Fender Pile	A vertical element that absorbs energy through bending of the member. Fender piles are typically driven into the channel bed and braced at their top to form a propped cantilever.	EA

Typical
BMT

Table C-4. Base Metal Component Elements

Element Code(s)	Element Descriptor	Element Identification	Units[1]
Redundant (BMR)			
SF-CS-BMR SF-GS-BMR	CS Support Framing GS Support Framing	Secondary members generally add to the stability of the fender system and do not distribute berthing and mooring forces, but are lumped together with the primary-load carrying members for inspection purposes.	LF
DU-GS-BMR	GS Deck (stay-in-place form)	A horizontal, planar structural element that carries and distributes loads to superstructure or substructure elements. Observations specific to underside or full-depth of element.	SF
FL-CS-BMR FL-GS-BMR	CS Fender Panel GS Fender Panel	A rectangular element oriented parallel to the fender system that increases the contact area of the fender system against the ship hull.	EA

Redundant
BMT

Table C-4 in Appendix C

PORT HOUSTON
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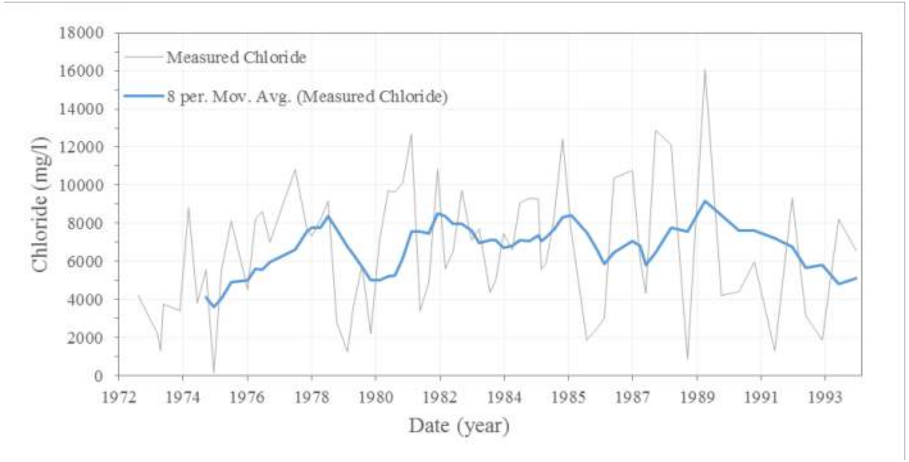
Inventory Record: Environmental

- Environmental Conditions
  - **Site** –temperature, relative humidity, airborne chloride content
  - **Water** –temperature, chloride content, nutrients, microbial activity, and flow velocity
  - **Soil** – resistivity, sulfate and chloride content, and pH



Chloride Content in Ship Channel- Barbour's Cut
(Source: TCEQ, water quality data from 1974 to 1993)

Inventory Record: Exposure Zones

- **Atmospheric** - oxygen, UV, high humidity
- **Splash** – wet/dry cycles, increased ion concentration, highest corrosion rates
- **Tidal** – low drying, variable oxygen, lower corrosion rates compared to splash
- **Submerged** –lower oxygen availability, lower corrosion rates
- **Soils** – depends on solids, water, gaseous constituents, groundwater, and resistivity

Baseline Inspection Planning

- Which components / elements are present?
  Inventory Record
- Which inspection procedures and scopes are applicable to the asset?
  Inspection Plan
  - Use guidelines in Chapter 2 to develop plan
  - Adjust based on engineering judgement and PHA approval

Corrosion Manual Guidelines for Intervals

Inspection Frequency

Table 2.1. Guidelines for Maximum Inspection Intervals

Task Classification	Inspection Interval[Note 2]	Example Inspection Tasks [Note 1]
Functionality Checks [Note 3]	6 months	Verify functionality of ICCP system (current output, frequency, power consumption, shunts, etc.)
	1 year	Measure and record on/off structure-to-electrolyte potentials (and/or decay potentials) for cathodic protection systems
		Verify accessible negative lead-to-structure connections are intact
Tier 1 Routine Inspections	3 years	Perform above water visual assessment
		Obtain above-water thickness measurements of base metal elements
		Obtain above-water coating thickness and/or adhesion measurements
Tier 2 Routine Inspections	6 years	Level I underwater visual inspections of anodes
		Level II underwater cleaning and visual inspection of anodes and base metal elements
		Level III underwater cleaning and remaining thickness/weight measurement of base metal elements, coatings, and anodes
Tier 3 Routine Inspections	As Required[Note 4]	Visual inspection and thickness measurements of buried base metal elements or CP anodes

Note 1: Underwater inspection levels per ASCE 101

Note 2: Inspection interval for a particular asset is defined in the Inspection Plan. Interval may be reduced for assets with significant deterioration or where dictated by the type or priority of use. Interval may be increased for newly constructed assets or other assets at the discretion of the PHA.

Note 3: Typical functionality checks are as described in NACE SP0169 and SP0176. Note the frequency for Functionality checks has been modified from the referenced standards to meet the needs and desires of PHA.

Note 4: Inspection of buried elements will be as defined in the Inspection Plan. Initial inspection interval will be based on the age and visual condition of associated elements. The need and frequency of inspection for buried elements will be established based on subsequent inspections.

NDE Testing Intervals

Table 2.2. Recommended Minimum NDE Testing Intervals

Element Classification	Exposure Zone	Test Intervals[Note 1, 2]
Critical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 50 LF or 20% of elements Coating Thickness and/or Adhesion: Every 50 LF or 20%
	Submerged	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Soil	As required
Typical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required
Redundant	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required

Note 1: Individual repeated elements, such as piles, sampled on percentage basis. Large, solid-faced elements, such as bulkhead walls, measured based on plan length (linear foot = LF)

Note 2: A minimum of three test locations should be obtained for each element classification within each exposure zone, with a minimum of three individual readings at a given location (approximately 1 sq. ft.).

Example Inspection Plan: BCT 5

- Define inspection procedures
  - Applicable standards
  - Specific test locations
  - Based on element and exposure zone

Maritime Asset
Corrosion Inspection Plan

Form CMIP (V1.0)
Barbours Cut Terminal – BCT 5
Last update: October 11, 2022
Page 1 of 2

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	April 2020 (above-water) August 2020 (below-water)

Inspection Plan

Functionality Checks (Inspection Frequency = 6 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

Functionality Checks (Inspection Frequency = 1 year)

- Visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity
- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline Inspection:
    - Bays 5, 24, and 47 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Visual assessment of all accessible corrosion protection and bare metal elements
- Perform non-destructive measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline Inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 3, SP 11, or as required per device manufacturer
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web)

Maritime Asset
Corrosion Inspection Plan

Form CMIP (V1.0)
Barbours Cut Terminal – BCT 5
Last update: October 11, 2022
Page 2 of 2

Element	Exposure Zone	Required Inspections[1]
		Coating Thickness Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Fender Piles	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Support Framing	Atmospheric	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
	Splash	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness Measurements: 8 locations
	Tidal	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations

[1]Test locations shall be representative of the condition of the given element within the entire bay. Unless specific conditions were noted during the visual survey or FICAP inspection that warrant acquiring data for specific bays, bays where data is to be acquired are listed below:

- 5 Locations: Bays 5, 14, 24, 33, and 43
- 8 Locations: Bays 3, 9, 15, 22, 29, 35, 41, and 47
- 12 Locations: Bays 1, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, and 46

Tier 2 Tasks (Inspection Frequency = 6 years)

- Level I underwater diving inspection of anodes as defined in ASCE 101
  - 100 percent verification of anode placement and connection of positive lead to each anode
- Level II underwater cleaning and inspection of anodes at 10% of anodes:
  - Bays 5, 14, 24, 33, and 43
- Level III underwater thickness and weight measurements of anodes:
  - Bays 5, 24, and 43
- Level III underwater thickness and weight measurements of base metal elements and coatings (shown in Table above)
  - Bays 5, 14, 24, 33, and 43

Tier 3 Tasks

- No planned Tier 3 inspections of buried tie rods unless warranted during future inspections.

Revision History

Rev. No.	Developed by	Date	Verified by	Date	Comments
0	C. Jones	01/27/2020	S. Foster	01/27/2020	Baseline
1	C. Jones	NA	S. Foster	NA	Routine inspection developed
2	S. Foster	10/11/2022		10/11/2022	Updated for 100% Manual

Appendix F

BCT 5 Inventory Record

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 1 of 8

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Last Inventory Record Update:**	January 24, 2020

Asset Geometric Data

Area:	36 acres	**Deck Elevation above MLT:**	18 ft. 0 in.
Structure Length:	1000 ft.	**Channel Depth at Fender:**	44 ft. 6 in.
Structure Width:	Deck: 108 ft. 9 in.	**Channel Depth at Bulkhead:**	7 ft. 6 in.

Recommended Access: Pedestrian access to structure top side and landside bulkhead via catwalks; boat access required to channel-side of bulkhead wall (8-foot design clear span between drilled shafts).

Structure Corrosion Protection History

BCT 5 is located near the west end of the Barbour's Cut Terminal along the south side of the channel. The original structural drawings are dated 1989, and wharf construction was completed in 1992. Several noteworthy repairs and modifications performed at various times during the service life of the wharf include the following:

- 2002: Repair and localized recoating of fender system.
- 2004: Repair and localized recoating of fender system.
- 2004: Repair of the crane rail expansion joint.
- 2008: Repair and localized recoating of fender system.
- 2011: Repair and localized recoating of fender system.
- 2014: Coupon ladder testing program

Reference Drawing List

Drawing Set	Title	Date	Description
C107-3	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase I	27 Aug 1986	Phase 1 of Original Civil and Electrical Drawings
C107-4	Sheet Pile Bulkhead for Wharves Nos. 5 and 6 at Barbour's Cut Terminal	16 Feb 1988	Original Construction Drawings for Bulkhead
C107-5	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase II	24 May 1988	Phase 2 of Original Civil and Electrical Drawings
C107-6	Container Wharf No. 5 at Barbour's Cut Terminal	18 Jul 1989	Original Construction Drawings for Wharf
C107-5	Pavements and Utilities for Container Terminal No. 5 at Barbour's Cut - Phase II	20 Sept 1990	Modified Phase 2 of Original Civil and Electrical Drawings

[1] Significant modifications: Work that altered the structure's footprint, changes structural components, or adds/modifies a corrosion protection or coating system.
Significant repairs: Repair work in excess of 10 percent of the area or length of a structural component containing base metal elements or repair work to corrosion protection elements or coatings.

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 2 of 8

Drawing Set	Title	Date	Description
C107-12	Repair of Fender System at Wharf No. 5	5 Nov 2002	Fender Repair Drawings
C107-13	Repair of Fender System and Potable Water Line	23 Feb 2004	Fender and Utility Repair Drawings
C160-60	Crane Rail Repair	30 Aug 2004	Crane Rail Expansion Joint Repair Drawings
C60-D02-002	Fender System Maintenance at Barbours Cut Terminal	16 Oct 2008	Fender Repair and Maintenance Drawings
C60-D02-005	Annual Fender System Maintenance at Barbours Cut Terminal 2012	3 Oct 2011	Fender Repair and Maintenance Drawings

Asset Exposure Zones

The following exposure zones have been identified at this site, the specific height of the zones and exposure effects have been estimated based on review of environmental conditions and data.

Exposure Zone	Elevation versus MLLW	Elements
Atmospheric	+3.25 ft. or greater	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Splash	+1.25 to +3.25 ft.	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Tidal	+0 to +1.25 ft.	CS Bulkhead Wall, CS Fender Piles, CS Support Framing
Submerged	0 ft. or less	CS Bulkhead Wall, CS Fender Piles
Soil	Below the mudline toward the waterside of the bulkhead and below the pavement on the landward side of the bulkhead	CS Tie Rods, CS Bulkhead Wall, CS Fender Piles

Asset Environmental Conditions

Global Zone	Constituent	Values
Site	Temperature	January: 54°F, February: 57°F, March: 63°F, April: 70°F, May: 77°F, June: 82°F, July: 84°F, August: 84°F, September: 80°F, October: 72°F, November: 63°F, December: 56°F, Annual: 70°F
Site	Relative Humidity	Annual: 74%
Site	Atmospheric Chloride Concentration	5 to 10 kg / ha/ year
Water	Temperature	54°F - 86°F
Water	Chloride Concentration	4,000 - 6,000 ppm
Water	Additional Nutrients	Nitrite Plus Nitrate: 0 - 0.3 ppm, Sulfate: 0 - 1200 ppm
Water	Resistivity	No Data
Water	Microbial Activity	Negligible PCB Congener #52 and #191
Water	Flow Velocity	No Data
Soil	Resistivity	No Data
Soil	Sulfate Content	No Data
Soil	Chloride Concentration	No Data

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 3 of 8

Sources:

Consultant / Source	Title	Date	Description
National Atmospheric Deposition Program	Annual Precipitation - Weighted Mean Concentrations	Accessed 21 May 2019	Compiled Annual Data for Testing of Precipitation
National Weather Service	Houston Hobby Extremes, Normals, and Annual Summaries	Accessed 21 May 2019	Summary of Mean, Avg. High, and Avg. Low Temperatures for Houston
Texas Commission on Environmental Quality	Water Summary Report for Segment 2436 (Barbours Cut)	Various Dates	Summary of Water Testing Data for Barbour's Cut
Weatherbase	Monthly - Weather Averages Summary	Accessed 21 May 2019	Summary of Average Temperatures, Precipitation, and Humidity

BCT 5 Inventory Record

Impressed Current Corrosion Protection Elements

Component / Element(s)	Description
Bulk Anode	Bulk anodes are installed as part of the ICCP system designed to protect both the fender piles and bulkhead wall.
– OTH Bulk Anode	Clusters of two bulk anodes are hung from the deck at approximately 35' to the landside of the fender system at 10' longitudinal spacing, totaling 200 anodes. Anodes are installed at Elev. -3.0 and -12.0'.
DC Power Supply	Three DC power supplies are installed to provide DC power for the ICCP system. Note: drawings indicate five rectifiers, but only three were installed.
– TRU DC Power Supply	Transformer-unit rectifiers are installed approximately 116-feet to the landside of the bulkhead wall adjacent to light poles 8 through 12.
Wiring and Protection	Wiring connects TRU DC Power Supplies with bulk anodes and the structure and is protected by PVC conduit to the landside of the bulkhead wall.
– CU Wiring	No. 6/7 copper wiring connects the corrosion protection system. Positive leads run to the bulk anodes and negative leads are connected to the fender system and bulkhead wall. Negative leads connect the copper conduit to the top fender wale beam and bulkhead wall in three and six locations, respectively.
– PVC Protection	Copper wiring is run through underground PVC conduit from the bulkhead wall to the five transformer-unit rectifiers.

Surface Protection Elements

Component / Element(s)	Description
Surface Protection	Coatings are used in conjunction with the ICCP system for protection of the bulkhead wall and fender system.
– PU Coatings	A three-coat system is used for protection of the fender system (Epoxy Low and Intermediate Coat with an Acrylic Urethane Topcoat).
– EP Coatings	An epoxy coating system is used for protection of the bulkhead wall (details unknown).

Base Metal Components and Elements

Component / Element(s)	Description
Critical	
– CS Tie Rod	Tie rods, 3-3/4 inch diameter, extending from bulkhead wale beam to dead man, spaced at approximately 15 feet on center and encased in Schedule 40 PVC Casings. • *Installed in 1990, no documented modifications or repairs.* • *Design Cross-Sectional Area = 11.0 in^2*
Typical	
– CS Bulkhead Wall	BZ-20 steel sheet piles extending from Elev. +14.65 to -58.00'. Mudline is shown at -5.00'. • *Installed in 1990, no documented modifications or repairs. BZ-20* • *Design Thickness = 0.551 in (flange), 0.394 in (web/wall)*
– CS Fender Piles	HP14x117 piles are extend from Elev. +16.0 to -69.0' and are spaced at 10'-9" on center. • *Installed in 1990, no documented modifications or repairs.* • *Design Web/Flange Thickness = 0.805 in*
Redundant	
– CS Support Framing	Structural steel framing used to support the timber facing consisting of W21x111 top wales and W14x43 bottom wales. *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Design Thickness: W14x43 (bottom)- web = 0.305 in, flange= 0.530 in W21x111(top)- web = 0.550 in, flange = 0.875 in HP14x117 (replacements) - web/flange = 0.805 in*

**Base Metal Components and Elements identified with FICAP labelling scheme*

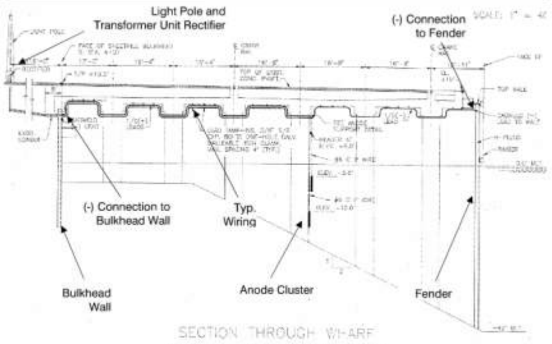
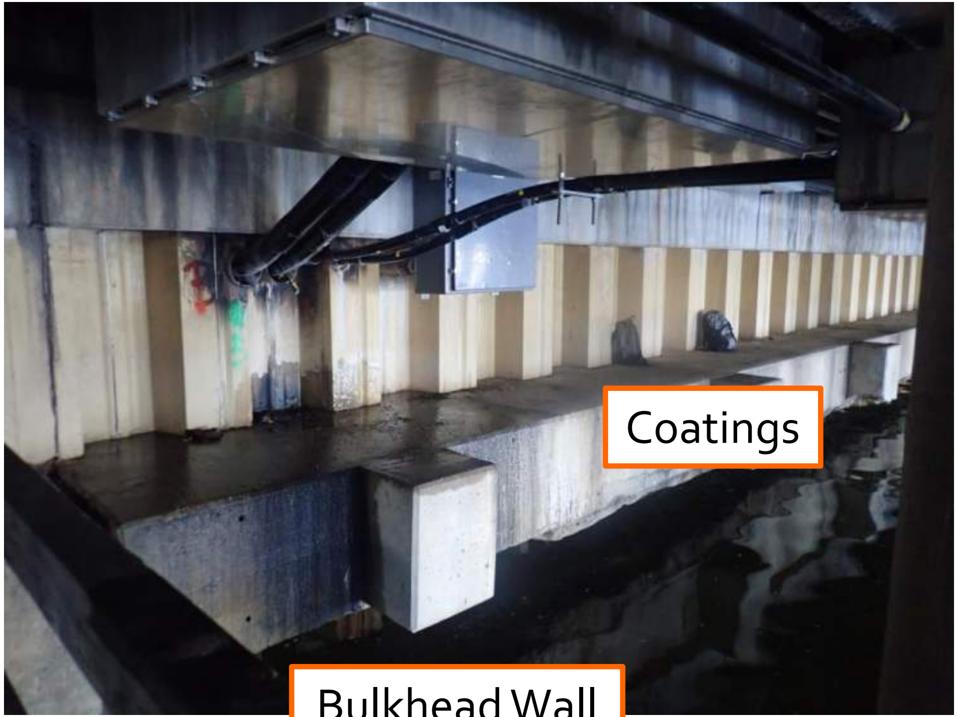


Figure 4. Typical Section through Structure.

Revision History

Rev. No.	Reported by:	Date	Verified by	Date	Comments
0	C. Jones	01/24/2020	S. Foster	01/24/2020	Baseline

BCT 5 Inventory Record

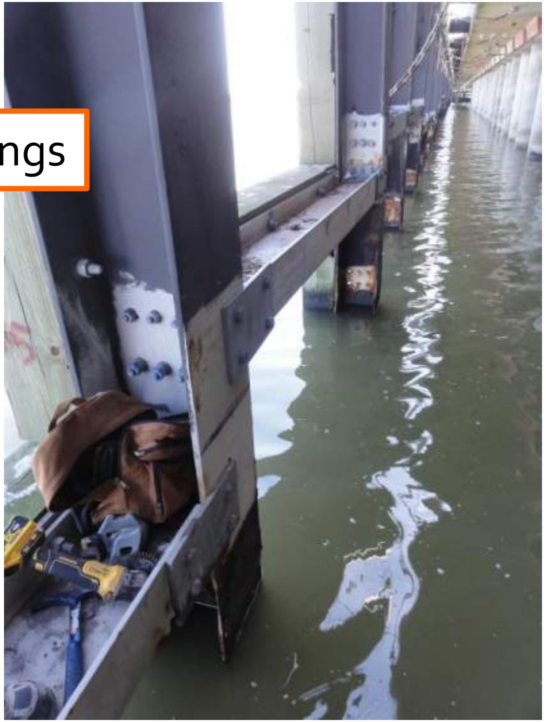


Coatings

Bulkhead Wall

ICCP

BCT 5 Inventory Record



Coatings

Fender Piles and Support Framing

BCT 5 Inventory Record

Impressed Current Corrosion Protection Elements	
Component / Element(s)	**Description**
Bulk Anode	Bulk anodes are installed as part of the ICCP system designed to protect both the fender piles and bulkhead wall.
– OTH Bulk Anode	Clusters of two bulk anodes are hung from the deck at approximately 35' to the landside of the fender system at 10' longitudinal spacing, totaling 200 anodes. Anodes are installed at Elev. -3.0 and -12.0'.
DC Power Supply	Three DC power supplies are installed to provide DC power for the ICCP system. Note: drawings indicate five rectifiers, but only three were installed.
– TRU DC Power Supply	Transformer-unit rectifiers are installed approximately 116-feet to the landside of the bulkhead wall adjacent to light poles 8 through 12.
Wiring and Protection	Wiring connects TRU DC Power Supplies with bulk anodes and the structure and is protected by PVC conduit to the landside of the bulkhead wall.
– CU Wiring	No. 6/7 copper wiring connects the corrosion protection system. Positive leads run to the bulk anodes and negative leads are connected to the fender system and bulkhead wall. Negative leads connect the copper conduit to the top fender wale beam and bulkhead wall in three and six locations, respectively.
– PVC Protection	Copper wiring is run through underground PVC conduit from the bulkhead wall to the five transformer-unit rectifiers.

Surface Protection Elements	
Component / Element(s)	**Description**
Surface Protection	Coatings are used in conjunction with the ICCP system for protection of the bulkhead wall and fender system.
– PU Coatings	A three-coat system is used for protection of the fender system (Epoxy Low and Intermediate Coat with an Acrylic Urethane Topcoat).
– EP Coatings	An epoxy coating system is used for protection of the bulkhead wall (details unknown).

Base Metal Components and Elements	
Component / Element(s)	**Description**
Critical	
– CS Tie Rod	Tie rods, 3-3/4 inch diameter, extending from bulkhead wale beam to dead man, spaced at approximately 15 feet on center and encased in Schedule 40 PVC Casings. • *Installed in 1990, no documented modifications or repairs.* • *Design Cross-Sectional Area = 11.0 in^2*
Typical	
– CS Bulkhead Wall	BZ-20 steel sheet piles extending from Elev. +14.65 to -58.00'. Mudline is shown at -5.00'. • *Installed in 1990, no documented modifications or repairs. BZ-20* • *Design Thickness = 0.551 in (flange), 0.394 in (web/wall)*
– CS Fender Piles	HP14x117 piles are extend from Elev. +16.0 to -69.0' and are spaced at 10'-9" on center. • *Installed in 1990, no documented modifications or repairs.* • *Design Web/Flange Thickness = 0.805 in*
Redundant	
– CS Support Framing	Structural steel framing used to support the timber facing consisting of W21x111 top wales and W14x43 bottom wales. *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Design Thickness: W14x43 (bottom)- web = 0.305 in, flange= 0.530 in* *W21x111(top)- web = 0.550 in, flange = 0.875 in* *HP14x117 (replacements) - web/flange = 0.805 in*

Inspection Plan for BCT 5

- Functionality Checks?
- Tier 1 Inspection Tasks?
- Tier 2 Inspection Tasks?
- Tier 3 Inspection Tasks?

BCT 5: Functionality Checks

Table 2.1. Guidelines for Maximum Inspection Intervals

Task Classification	Inspection Interval [Note 2]	Example Inspection Tasks [Note 1]
Functionality Checks [Note 3]	6 months	Verify functionality of ICCP system (current output, frequency, power consumption, shunts, etc.)
	1 year	Measure and record on/off structure-to-electrolyte potentials (and/or decay potentials) for cathodic protection systems
		Verify accessible negative lead-to-structure connections are intact
Tier 1 Routine Inspections	3 years	Perform above water visual assessment
		Obtain above-water thickness measurements of base metal elements
		Obtain above-water coating thickness and/or adhesion measurements
Tier 2 Routine Inspections	6 years	Level I underwater visual inspections of anodes
		Level II underwater cleaning and visual inspection of anodes and base metal elements
		Level III underwater cleaning and remaining thickness/weight measurement of base metal elements, coatings, and anodes
Tier 3 Routine Inspections	As Required [Note 4]	Visual inspection and thickness measurements of buried base metal elements or CP anodes

Note 1: Underwater inspection levels per ASCE 101

Note 2: Inspection interval for a particular asset is defined in the Inspection Plan. Interval may be reduced for assets with significant deterioration or where dictated by the type or priority of use. Interval may be increased for newly constructed assets or other assets at the discretion of the PHA.

Note 3: Typical functionality checks are as described in NACE SP0169 and SP0176. Note the frequency for Functionality checks has been modified from the referenced standards to meet the needs and desires of PHA.

Note 4: Inspection of buried elements will be as defined in the Inspection Plan. Initial inspection interval will be based on the age and visual condition of associated elements. The need and frequency of inspection for buried elements will be established based on subsequent inspections.

BCT 5: Functionality Checks

- Functionality of ICCP system (6 months)
  - Measurements at (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality
- Functionality of ICCP system (1 year)
  - On/Off Structure-to-Electrolyte Potentials
    - Bays 5, 14, 24, 33, 47 (near negative connections and mid-way between)
    - Specify elevations in the water
  - Visual observations at 9 connections (3 at FP, 6 at BW)

BCT 5: Tier 1 Inspection Tasks (3 yrs)

Table 2.1. Guidelines for Maximum Inspection Intervals

Task Classification	Inspection Interval [Note 2]	Example Inspection Tasks [Note 1]
Functionality Checks [Note 3]	6 months	Verify functionality of ICCP system (current output, frequency, power consumption, shunts, etc.)
	1 year	Measure and record on/off structure-to-electrolyte potentials (and/or decay potentials) for cathodic protection systems
		Verify accessible negative lead-to-structure connections are intact
Tier 1 Routine Inspections	3 years	Perform above water visual assessment
		Obtain above-water thickness measurements of base metal elements
		Obtain above-water coating thickness and/or adhesion measurements
Tier 2 Routine Inspections	6 years	Level I underwater visual inspections of anodes
		Level II underwater cleaning and visual inspection of anodes and base metal elements
		Level III underwater cleaning and remaining thickness/weight measurement of base metal elements, coatings, and anodes
Tier 3 Routine Inspections	As Required [Note 4]	Visual inspection and thickness measurements of buried base metal elements or CP anodes

Note 1: Underwater inspection levels per ASCE 101
Note 2: Inspection interval for a particular asset is defined in the Inspection Plan. Interval may be reduced for assets with significant deterioration or where dictated by the type or priority of use. Interval may be increased for newly constructed assets or other assets at the discretion of the PHA.
Note 3: Typical functionality checks are as described in NACE SP0169 and SP0176. Note the frequency for Functionality checks has been modified from the referenced standards to meet the needs and desires of PHA.
Note 4: Inspection of buried elements will be as defined in the Inspection Plan. Initial inspection interval will be based on the age and visual condition of associated elements. The need and frequency of inspection for buried elements will be established based on subsequent inspections.

Table 2.2. Recommended Minimum NDE Testing Intervals

Element Classification	Exposure Zone	Test Intervals [Note 1, 2]
Critical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 50 LF or 20% of elements Coating Thickness and/or Adhesion: Every 50 LF or 20%
	Submerged	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Soil	As required
Typical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required
Redundant	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required

Note 1: Individual repeated elements, such as piles, sampled on percentage basis. Large, solid-faced elements, such as bulkhead walls, measured based on plan length (linear foot = LF)
Note 2: A minimum of three test locations should be obtained for each element classification within each exposure zone, with a minimum of three individual readings at a given location (approximately 1 sq. ft.).

BCT 5: Tier 1 Inspection Tasks (3 yrs)

- Base Metal Elements
  - Bulkhead Wall (typical)
    1,000 LF total
  - Fender Piles (typical)
    48 total
  - Support Framing (redundant)
    2,000 LF total
  - Tie Rods (critical)
    76 total

Table 2.2. Recommended Minimum NDE Testing Intervals

Element Classification	Exposure Zone	Test Intervals[Note 1, 2]
Critical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 50 LF or 20% of elements Coating Thickness and/or Adhesion: Every 50 LF or 20%
	Submerged	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Soil	As required
Typical	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 100 LF or 10% of elements Coating Thickness and/or Adhesion: Every 100 LF or 10%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required
Redundant	Atmospheric / Splash / Tidal	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Submerged	Base Metal Thickness: Every 200 LF or 5% of elements Coating Thickness and/or Adhesion: Every 200 LF or 5%
	Soil	As required

Note 1: Individual repeated elements, such as piles, sampled on percentage basis. Large, solid-faced elements, such as bulkhead walls, measured based on plan length (linear foot = LF)
Note 2: A minimum of three test locations should be obtained for each element classification within each exposure zone, with a minimum of three individual readings at a given location (approximately 1 sq. ft.).

Fender Piles

48 → 10% (4.8), 5 locations for metal thickness in atmospheric/splash/tidal
→5% (2.4), 3 locations for submerged

BCT 5: Tier 1 Inspection Tasks (3 yrs)

- Visual assessment of all accessible elements
- UT Measurements: Prepare uncoated surfaces per SSPC-SP 3, SP 11, or as required per device manufacturer
- Coating Thickness Measurements: Prepare surfaces per SSPC-SP 1
- Specify elements, locations, exposure zone for measurement and frequency

BCT 5: Tier 1 Inspection Tasks (3 yrs)

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Fender Piles	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Support Framing	Atmospheric	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
	Splash	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness Measurements: 8 locations
	Tidal	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations

Test Locations
5 Locations: Bays 5, 14, 24, 33, 43
8 Locations: Bays 3, 9, 15, 22, 29, 35, 41, 47
12 Locations: Bays 1, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46

Note: *BCT5 plan originally developed using earlier version of the manual (separate quantity for atmospheric/splash/tidal)*

BCT 5: Tier 2 Inspection Tasks (6 yrs)

Table 2.1. Guidelines for Maximum Inspection Intervals

Task Classification	Inspection Interval[Note 2]	Example Inspection Tasks [Note 1]
Functionality Checks [Note 3]	6 months	Verify functionality of ICCP system (current output, frequency, power consumption, shunts, etc.)
	1 year	Measure and record on/off structure-to-electrolyte potentials (and/or decay potentials) for cathodic protection systems
		Verify accessible negative lead-to-structure connections are intact
Tier 1 Routine Inspections	3 years	Perform above water visual assessment
		Obtain above-water thickness measurements of base metal elements
		Obtain above-water coating thickness and/or adhesion measurements
Tier 2 Routine Inspections	6 years	Level I underwater visual inspections of anodes
		Level II underwater cleaning and visual inspection of anodes and base metal elements
		Level III underwater cleaning and remaining thickness/weight measurement of base metal elements, coatings, and anodes
Tier 3 Routine Inspections	As Required[Note 4]	Visual inspection and thickness measurements of buried base metal elements or CP anodes

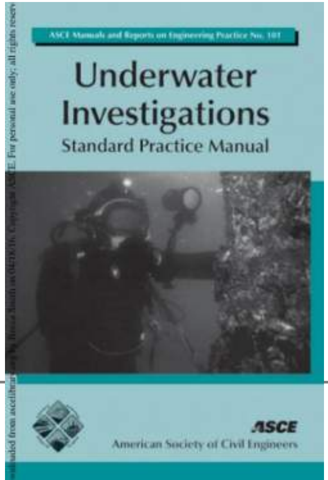
Note 1: Underwater inspection levels per ASCE 101

Note 2: Inspection interval for a particular asset is defined in the Inspection Plan. Interval may be reduced for assets with significant deterioration or where dictated by the type or priority of use. Interval may be increased for newly constructed assets or other assets at the discretion of the PHA.

Note 3: Typical functionality checks are as described in NACE SP0169 and SP0176. Note the frequency for Functionality checks has been modified from the referenced standards to meet the needs and desires of PHA.

Note 4: Inspection of buried elements will be as defined in the Inspection Plan. Initial inspection interval will be based on the age and visual condition of associated elements. The need and frequency of inspection for buried elements will be established based on subsequent inspections.

- Level I (visual, no removal)
- Level II (10%, partial removal, visual)
- Level III (5%, NDT measurements)



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BCT 5: Tier 2 Inspection Tasks (6 yrs)

- Anodes
  90 element,180 total (2 each)
- Bulkhead wall (typical)
  1,000 LF total
- Fender Piles (typical)
  48 total

Level II, 10%→47 bays total, 5 bays for cleaning and inspection
Level III, 5% →3 bays for thickness/weight

Level I underwater diving inspection of anodes as defined in ASCE 101
100 percent verification of anode placement and connection of positive lead to each anode
Level II underwater cleaning and inspection of anodes at 10% of anodes:
Bays 5, 14, 24, 33, and 43
Level III underwater thickness and weight measurements of anodes:
Bays 5, 24, and 43
Level III underwater thickness and weight measurements of base metal elements and coatings
Bays 5, 14, 24, 33, and 43

BCT 5: Tier 3 Inspection Tasks

Table 2.1. Guidelines for Maximum Inspection Intervals

Task Classification	Inspection Interval[Note 2]	Example Inspection Tasks [Note 1]
Functionality Checks [Note 3]	6 months	Verify functionality of ICCP system (current output, frequency, power consumption, shunts, etc.)
	1 year	Measure and record on/off structure-to-electrolyte potentials (and/or decay potentials) for cathodic protection systems
		Verify accessible negative lead-to-structure connections are intact
Tier 1 Routine Inspections	3 years	Perform above water visual assessment
		Obtain above-water thickness measurements of base metal elements
		Obtain above-water coating thickness and/or adhesion measurements
Tier 2 Routine Inspections	6 years	Level I underwater visual inspections of anodes
		Level II underwater cleaning and visual inspection of anodes and base metal elements
		Level III underwater cleaning and remaining thickness/weight measurement of base metal elements, coatings, and anodes
Tier 3 Routine Inspections	As Required[Note 4]	Visual inspection and thickness measurements of buried base metal elements or CP anodes

Note 1: Underwater inspection levels per ASCE 101

Note 2: Inspection interval for a particular asset is defined in the Inspection Plan. Interval may be reduced for assets with significant deterioration or where dictated by the type or priority of use. Interval may be increased for newly constructed assets or other assets at the discretion of the PHA.

Note 3: Typical functionality checks are as described in NACE SP0169 and SP0176. Note the frequency for Functionality checks has been modified from the referenced standards to meet the needs and desires of PHA.

Note 4: Inspection of buried elements will be as defined in the Inspection Plan. Initial inspection interval will be based on the age and visual condition of associated elements. The need and frequency of inspection for buried elements will be established based on subsequent inspections.

- Tie Rods
  - 1990, 30 years old, 3-3/4" dia., encased in PVC
  - No indication of failure per FICAP Maritime Structures
- No inspections of buried tie rods unless warranted during future inspections

Inspection Plan for BCT 5

Maritime Asset
Corrosion Inspection Plan

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	April 2020 (above-water) August 2020 (below-water)

Inspection Plan

Functionality Checks (Inspection Frequency = 6 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

Functionality Checks (Inspection Frequency = 1 year)

- Visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity
- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline Inspection:
    - Bays 5, 24, and 47 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Visual assessment of all accessible corrosion protection and bare metal elements
- Perform non-destructive measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline Inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 3, SP 11, or as required per device manufacturer
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web)

Maritime Asset
Corrosion Inspection Plan

Element	Exposure Zone	Required Inspections[1]
		Coating Thickness Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Fender Piles	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Support Framing	Atmospheric	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
	Splash	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness Measurements: 8 locations
	Tidal	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations

[1]Test locations shall be representative of the condition of the given element within the entire bay. Unless specific conditions were noted during the visual survey or FICAP inspection that warrant acquiring data for specific bays, bays where data is to be acquired are listed below:

- 5 Locations: Bays 5, 14, 24, 33, and 43
- 8 Locations: Bays 3, 9, 15, 22, 29, 35, 41, and 47
- 12 Locations: Bays 1, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, and 46

Tier 2 Tasks (Inspection Frequency = 6 years)

- Level I underwater diving inspection of anodes as defined in ASCE 101
  - 100 percent verification of anode placement and connection of positive lead to each anode
- Level II underwater cleaning and inspection of anodes at 10% of anodes:
  - Bays 5, 14, 24, 33, and 43
- Level III underwater thickness and weight measurements of anodes:
  - Bays 5, 24, and 43
- Level III underwater thickness and weight measurements of base metal elements and coatings (shown in Table above)
  - Bays 5, 14, 24, 33, and 43

Tier 3 Tasks

- No planned Tier 3 inspections of buried tie rods unless warranted during future inspections.

Revision History

Rev. No.	Developed by	Date	Verified by	Date	Comments
0	C. Jones	01/27/2020	S. Foster	01/27/2020	Baseline
1	C. Jones	NA	S. Foster	NA	Routine inspection developed
2	S. Foster	10/11/2022		10/11/2022	Updated for 100% Manual

Module Wrap-Up

- Engineer (Project Manager and/or Inspection Team Leader) develops asset-specific Corrosion Inspection Plan
- Inspection Planning for Baseline Inspection
  - Inventory Record
  - Drawings
  - Asset-Specific Inspection Plan
- Summarizes what the inspection team needs to do

END OF MODULE

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Module 5.2

Routine Inspection Planning

Corrosion Manual Training Course

Module Objectives

Module 5.2 Learning Outcomes

- Understand primary differences between Baseline and Routine inspections
- Modify a Corrosion Inspection Plan based on inspection findings

Routine Inspection Planning

- Inspection Types
  - Baseline
  - **Routine**
  - **Functionality Checks**

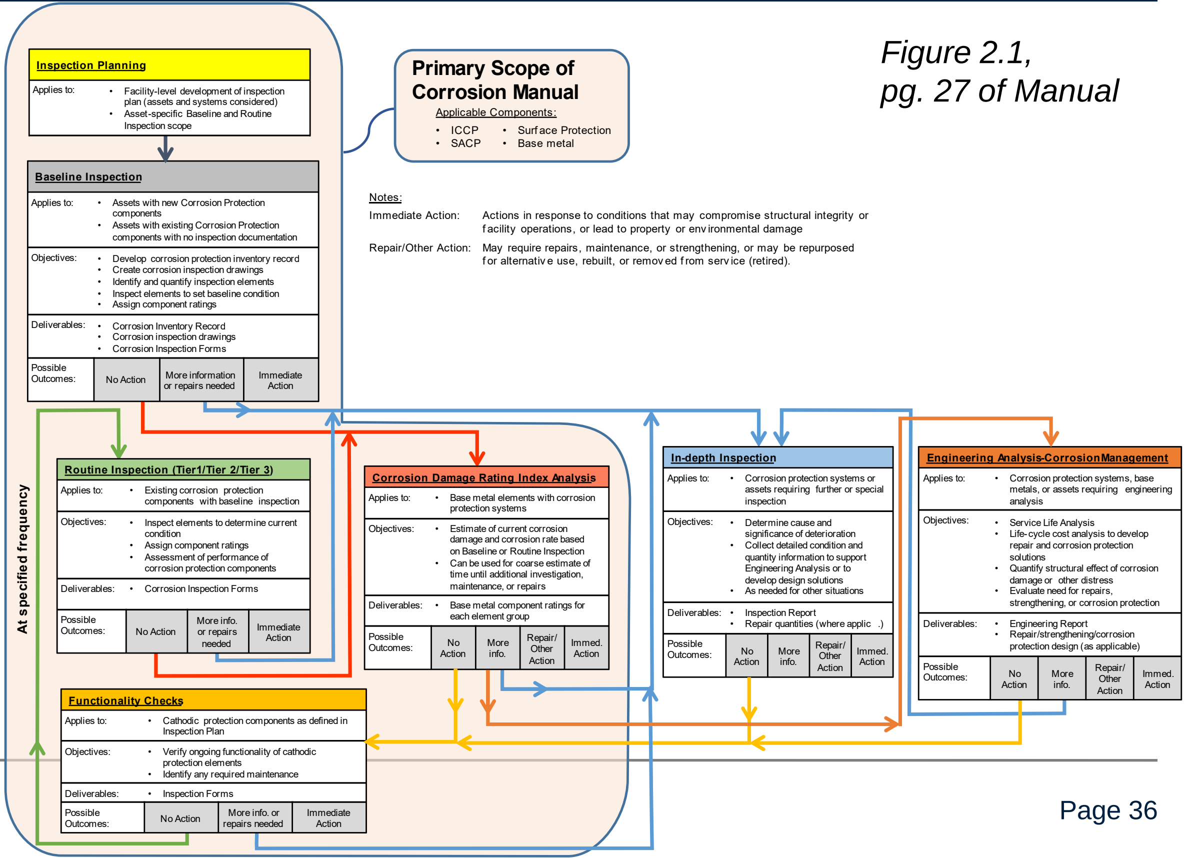

Figure 2.1, pg. 27 of Manual

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Routine Inspection Planning

- Only modify plan if needed
  - Changes to components/elements
  - Deviations from previous inspection
  - Something missing or incorrect
  - Observations from previous/current inspection

Routine Inspection Planning

- Corrosion Protection Components
  - Are all corrosion protection components the same?
  - Have any corrosion protection elements been added, changed, or removed since last inspection?
  - Identify current age(s)
  - Is everything correct?

Impressed Current Corrosion Protection Elements

Component / Element(s)	Description
Bulk Anode	Bulk anodes are installed as part of the ICCP system designed to protect both the fender piles and bulkhead wall.
– OTH Bulk Anode	Clusters of two bulk anodes are hung from the deck at approximately 35' to the landside of the fender system at 10' longitudinal spacing, totaling 200 anodes. Anodes are installed at Elev. -3.0 and -12.0'.
DC Power Supply	Three DC power supplies are installed to provide DC power for the ICCP system. Note: drawings indicate five rectifiers, but only three were installed.
– TRU DC Power Supply	Transformer-unit rectifiers are installed approximately 116-feet to the landside of the bulkhead wall adjacent to light poles 8 through 12.
Wiring and Protection	Wiring connects TRU DC Power Supplies with bulk anodes and the structure and is protected by PVC conduit to the landside of the bulkhead wall.
– CU Wiring	No. 6/7 copper wiring connects the corrosion protection system. Positive leads run to the bulk anodes and negative leads are connected to the fender system and bulkhead wall. Negative leads connect the copper conduit to the top fender wale beam and bulkhead wall in three and six locations, respectively.
– PVC Protection	Copper wiring is run through underground PVC conduit from the bulkhead wall to the five transformer-unit rectifiers.

Surface Protection Elements

Component / Element(s)	Description
Surface Protection	Coatings are used in conjunction with the ICCP system for protection of the bulkhead wall and fender system.
– PU Coatings	A three-coat system is used for protection of the fender system (Epoxy Low and Intermediate Coat with an Acrylic Urethane Topcoat).
– EP Coatings	An epoxy coating system is used for protection of the bulkhead wall (details unknown).

Routine Inspection Planning

- Base Metal Component
  - Are all base metal elements and materials the same?
  - Have any base metal elements been added, changed, or removed since last inspection?
  - Identify current age(s)
  - Is everything correct?

Base Metal Components and Elements

Component / Element(s)	Description
Critical	
– CS Tie Rod	Tie rods, 3-3/4 inch diameter, extending from bulkhead wale beam to dead man, spaced at approximately 15 feet on center and encased in Schedule 40 PVC Casings. • *Installed in 1990, no documented modifications or repairs.* • *Design Cross-Sectional Area = 11.0 in^2*
Typical	
– CS Bulkhead Wall	BZ-20 steel sheet piles extending from Elev. +14.65 to -58.00'. Mudline is shown at -5.00'. • *Installed in 1990, no documented modifications or repairs. BZ-20* • *Design Thickness = 0.551 in (flange), 0.394 in (web/wall)*
– CS Fender Piles	HP14x117 piles are extend from Elev. +16.0 to -69.0' and are spaced at 10'-9" on center. • *Installed in 1990, no documented modifications or repairs.* • *Design Web/Flange Thickness = 0.805 in*
Redundant	
– CS Support Framing	Structural steel framing used to support the timber facing consisting of W21x111 top wales and W14x43 bottom wales. *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Installed in 1990, modifications and repairs in 2002, 2004, 2008, and 2011.* • *Design Thickness: W14x43 (bottom)- web = 0.305 in, flange= 0.530 in W21x111(top)- web = 0.550 in, flange = 0.875 in HP14x117 (replacements) - web/flange = 0.805 in*

Routine Inspection Planning

- Are inspection procedures and scopes in most recent inspection plan still applicable to the asset?
- Did any follow-up actions warrant revision to the inspection plan?

Maritime Asset Follow-up Actions

Form MSFA (V1.1)
Northside Turning Basin – CD 25
July 30, 2021
Page 5 of 5

Follow-up Actions Log

Item No.	Priority	Recommended Action	Assigned To	Assigned By	Date
1	Priority	Replace anodes and adjust rectifier current outputs to provide adequate CP of base metal elements	PHA	WJE	July 30, 2021
2	Routine	Repair electrical bond wires between fender piles and support framing	PHA	WJE	July 30, 2021
3	Routine	Clean and coat fender pile and support framing elements in the tidal and splash zone.	PHA	WJE	July 30, 2021
4	Routine	Monitor coating defects of bulkhead wall in future inspections.	PHA	WJE	July 30, 2021

Routine Inspection Planning

- Update detailed inspection procedures as necessary
- Separate tasks into tiers and assign inspection frequencies

Maritime Asset
Corrosion Inspection Plan

Form CMIP (V1.0)
Barbours Cut Terminal – BCT 5
Last update: October 11, 2022
Page 1 of 2

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	April 2020 (above-water) August 2020 (below-water)

Inspection Plan

Functionality Checks (Inspection Frequency = 6 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

Functionality Checks (Inspection Frequency = 1 year)

- Visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity
- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline Inspection:
    - Bays 5, 24, and 47 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Visual assessment of all accessible corrosion protection and bare metal elements
- Perform non-destructive measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline Inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 3, SP 11, or as required per device manufacturer
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web)

Maritime Asset
Corrosion Inspection Plan

Form CMIP (V1.0)
Barbours Cut Terminal – BCT 5
Last update: October 11, 2022
Page 2 of 2

Element	Exposure Zone	Required Inspections[1]
		Coating Thickness Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Fender Piles	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Support Framing	Atmospheric	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
	Splash	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness Measurements: 8 locations
	Tidal	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations

[1]Test locations shall be representative of the condition of the given element within the entire bay. Unless specific conditions were noted during the visual survey or FICAP inspection that warrant acquiring data for specific bays, bays where data is to be acquired are listed below:

- 5 Locations: Bays 5, 14, 24, 33, and 43
- 8 Locations: Bays 3, 9, 15, 22, 29, 35, 41, and 47
- 12 Locations: Bays 1, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, and 46

Tier 2 Tasks (Inspection Frequency = 6 years)

- Level I underwater diving inspection of anodes as defined in ASCE 101
  - 100 percent verification of anode placement and connection of positive lead to each anode
- Level II underwater cleaning and inspection of anodes at 10% of anodes:
  - Bays 5, 14, 24, 33, and 43
- Level III underwater thickness and weight measurements of anodes:
  - Bays 5, 24, and 43
- Level III underwater thickness and weight measurements of base metal elements and coatings (shown in Table above)
  - Bays 5, 14, 24, 33, and 43

Tier 3 Tasks

- No planned Tier 3 inspections of buried tie rods unless warranted during future inspections.

Revision History

Rev. No.	Developed by	Date	Verified by	Date	Comments
0	C. Jones	01/27/2020	S. Foster	01/27/2020	Baseline
1	C. Jones	NA	S. Foster	NA	Routine inspection developed
2	S. Foster	10/11/2022		10/11/2022	Updated for 100% Manual

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Routine Inspection Planning

- Update requirements of quantitative tests
  - Based on findings of baseline inspection
  - Show specific locations

Maritime Asset
Corrosion Inspection Plan

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
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- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

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	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web)

Maritime Asset
Corrosion Inspection Plan

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	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
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	Splash	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness Measurements: 8 locations
	Tidal	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations

[1] Test locations shall be representative of the condition of the given element within the entire bay. Unless specific conditions were noted during the visual survey or FICAP inspection that warrant acquiring data for specific bays, bays where data is to be acquired are listed below:

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  - 100 percent verification of anode placement and connection of positive lead to each anode
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- Level III underwater thickness and weight measurements of anodes:
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- Level III underwater thickness and weight measurements of base metal elements and coatings (shown in Table above)
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2	S. Foster	10/11/2022		10/11/2022	Updated for 100% Manual

Module Wrap-Up

- When do you modify an inspection plan?
  - Addition and/or modification of existing systems
  - Change in conditions/performance/risk
- Who is responsible for determining appropriateness of modifying inspection plan?
  - Engineer (Project Manager and/or Inspection Team Leader)
- What are two different inspection techniques that may require different time intervals between inspections?
  - Underwater inspections vs Functionality Checks

END OF MODULE

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Module 6.1

Condition Assessment and Rating Approach

Corrosion Manual Training Course

Module Objectives

Module 6.1 Learning Outcomes

- Summarize approach to corrosion condition assessments for Port Houston
- Outline methodology for numerical ratings of components and scoring for assets

Module References

- Chapter 6: Assessment and Rating Approach
- Chapter 8: Documentation and Reporting
  - 8.5 Corrosion Inspection Summary
- Appendix F: Documentation and Reporting Forms

Overview of Rating Approach

Element Condition States
(CS1, CS2, CS3, CS4)

Module 4

Condition Assessment (Module 6.1)

(engineering judgment & functional condition)

Component Ratings
(1- Critical to 6- Good)

Modules 6.2 and 6.3

Numerical Formula

Overall Corrosion Condition Rating
(score out of 100)

Module 6.4

Element Based Approach

Elements:

- Condition States based on Inspection

Components:

- Numerical rating based on judgment and functional condition

Asset

- Corrosion Condition Rating (based on component ratings)

Table 1.1: Summary of Element-Based Approach

Level	Purpose	Comment
Asset	▪ Corrosion assessment for asset guides follow-up actions and asset management decisions.	▪ Overall corrosion condition rating (CCR) is a numerical rating and is supplemented by a qualitative (descriptive) assessment.
Component	▪ Component condition assessment indicates condition of corrosion protection or base metal components. ▪ Where appropriate, inspection measurements provide basis for overall component condition. ▪ Provide basis to determine overall corrosion condition.	▪ Numerical component rating is based on an engineering interpretation of the element condition states, inspection data, and their corresponding implication(s) on the functional condition of the component. ▪ Base metal component rating is based on the estimated corrosion damage rating index of critical, typical, and redundant elements.

Element	▪ Condition states document occurrence of damage, deterioration, or defects at time of inspection in terms of:
	  ▪ Type of condition(s) (i.e. damage mechanism)
	  ▪ Severity of defect (i.e. moderate, severe)
	  ▪ Extent of defect (i.e. localized or general)
	▪ Correlates conditions to element and material type.
	▪ Tracks conditions over time as indicated by inspections conducted at regular intervals.
	▪ Selective measurements of key parameters provide basis for corrosion damage rating index of overall component.
	▪ Provides basis for component rating.
		▪ Detailed visual inspections are conducted at the element level.
		▪ Element condition states are assigned based on predefined categories and quantified to define element condition.

Element Condition States

- Observed damage/distress
  - Type, Severity, Quantity
- Provide a consistent, credible indication of each element
- Used by Engineer for Condition Assessment of Components

Type	Code	Condition Name	Condition Definition	Condition States CS1 (Good)	CS2 (Fair)	CS3 (Poor)	CS4 (Severe)
Anodes	CNSM	Consumption	Consumption of anode.	<10% consumed by weight	10-50% consumed by weight	51-75% consumed by weight	>75% consumed by weight
	CONA	Condition of Connection	Condition of thermite weld connecting anode to the wiring.	No connection distress; connection is in place and functioning as intended.	Minor distress without distortion is present, but connection is in place and functioning as intended.	Cracked weld or damaged connection; assessment has determined electrical connection has not been compromised.	Cracked weld or failed connection resulting in electrical isolation of the anode.
	MARG	Marine Growth	Organic growth on bulk and/or ribbon anodes.	No marine growth present.	Minor marine growth on anode.	Moderate marine growth on anode that may affect functionality.	Significant marine growth on anode affecting functionality.
	MISS	Missing	Element intended to be in place is missing. Does not apply to elements that have	Element is present.	Parts of an element are missing, however does not affect functionality.	Element is missing but assessment has determined element is	Element is missing.

Elements → Component Ratings

Element Condition States

- Specific to each element
  - Type of distress *at that element*
  - Severity of distress *at that element*
  - Amount of distress *for that element*

Component Ratings

- Representative of numerous and varied elements
  - Severity and extent of conditions *across numerous elements*
  - Implications of conditions *on overall performance*

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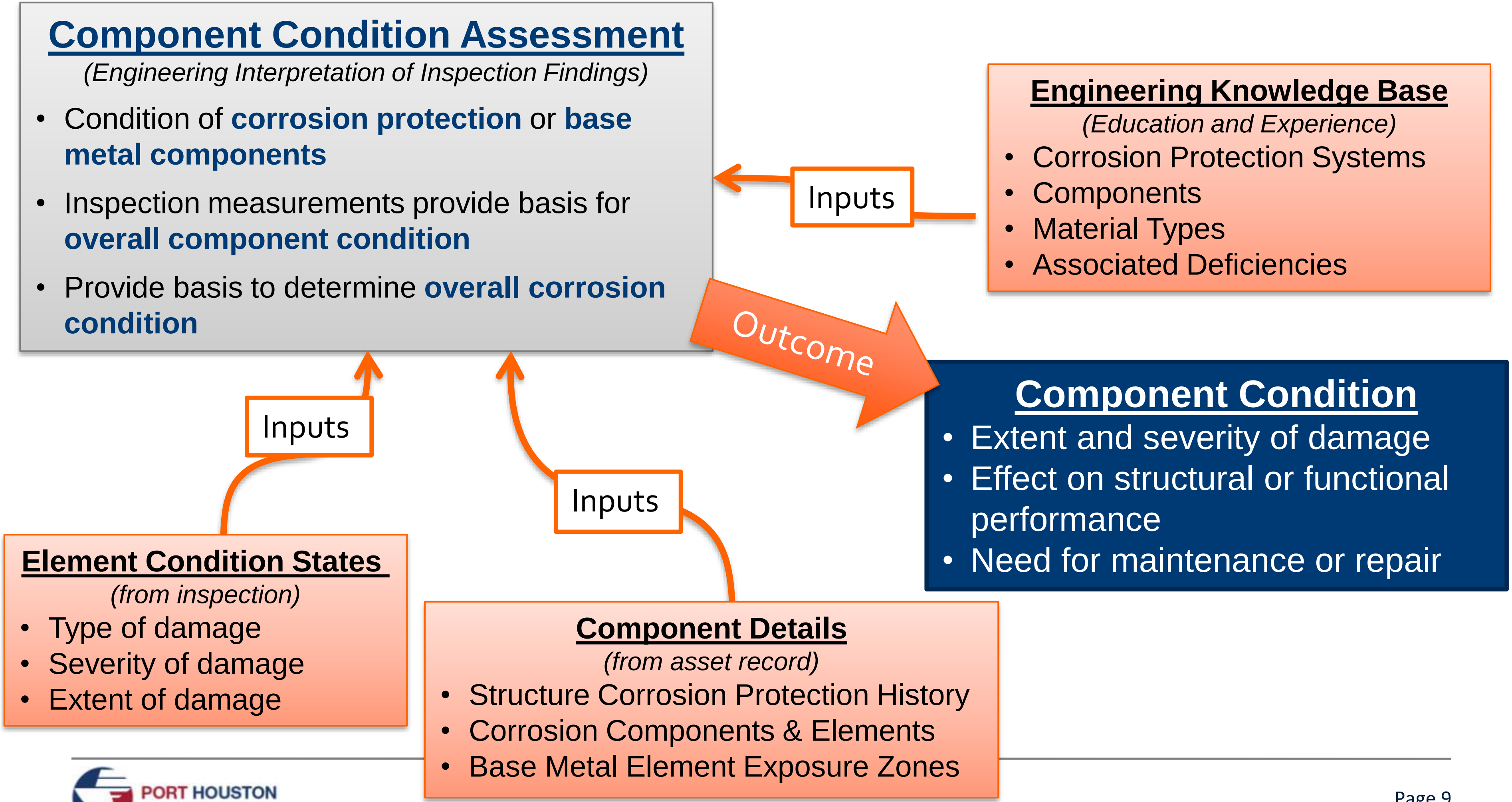
Elements → Component Ratings

- In spite of quantitative element condition information, the relationship between **element condition** and **component rating** is **not** quantitative
  - influence of element conditions on component condition depends on many complex factors

    → no formula!

Component condition must be determined through an ***engineering interpretation*** of the effect of the element condition on the component condition.


Component Condition Assessment
(Engineering Interpretation of Inspection Findings)
Condition of corrosion protection or base metal components
Inspection measurements provide basis for overall component condition
Provide basis to determine overall corrosion condition
Inputs
Engineering Knowledge Base
(Education and Experience)
Corrosion Protection Systems
Components
Material Types
Associated Deficiencies
Outcome
Component Condition
Extent and severity of damage
Effect on structural or functional performance
Need for maintenance or repair
Inputs
Inputs
Element Condition States
(from inspection)
Type of damage
Severity of damage
Extent of damage
Component Details
(from asset record)
Structure Corrosion Protection History
Corrosion Components & Elements
Base Metal Element Exposure Zones

Component Ratings

- **Corrosion Protection Component Rating**
  - **Functional Rating:** Numerical rating to indicate functional condition of ICCP/SACP systems
  - **Visual Condition Rating:** Based on engineering interpretation of element conditions

- knowledge
- experience
- judgement

→ **Assign Component Rating**

1 (critical) to 6 (good) scale

Component Ratings

- **Base Metal Component Rating (Corrosion Damage Rating)**
  - Based on thickness measurements and an estimate of the corrosion rate
  - Visual observation is important to ascertain representative locations are selected for measurement

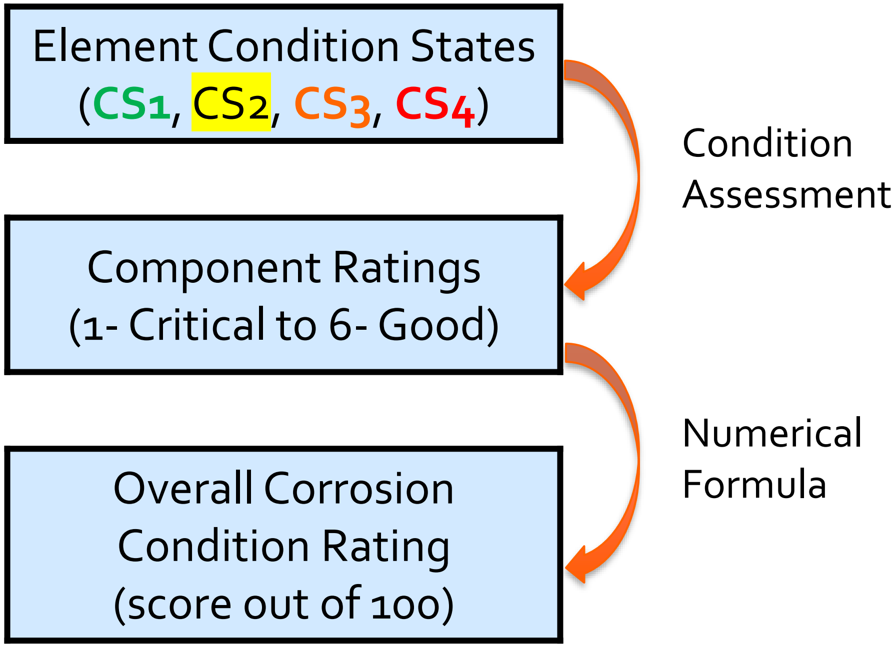
- **Section loss measurements**
- **Estimated corrosion rates**
- **Experience and judgement**

→ **Assign Component Rating**

1 (critical) to 6 (good) scale

Summary

- Element condition based on visual and quantitative data
- Engineering judgment used to determine component ratings *(1 to 6 scale)*
- Corrosion Condition Rating based on numerical formula *(Deductions for any components rated less than 6-Good)*



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END OF MODULE

Module 6.2

Corrosion Protection Component Ratings

Corrosion Manual Training Course

Module Objectives

Module 6.2 Learning Outcomes

- Summarize rating process for corrosion protection components (ICCP, SACP, and Surface Protection)
- Discuss implication of element condition states (type, severity, and extent) on component condition rating
- Employ engineering judgement to assign component ratings
- Describe use of Corrosion Inspection Summary Form to record component rating information

Corrosion Component Ratings

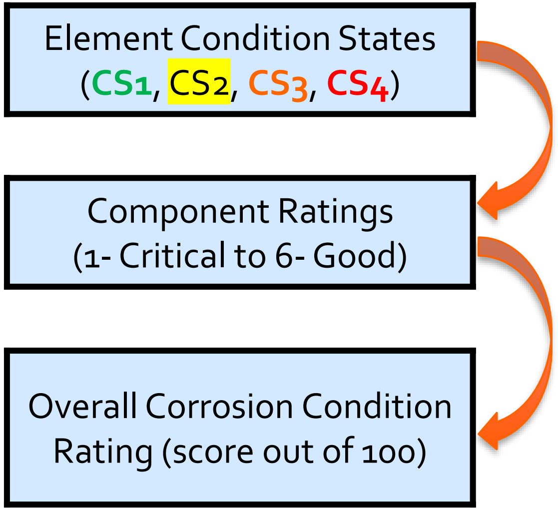
- Applicable to Baseline, Routine and Functionality Check Inspections
  - May be applied to In-Depth Inspections
- Corrosion Component Ratings are:
  - Assigned relative to assumed **as-built condition** of component
  - Intended to reflect physical conditions including the effects of deterioration or damage
  - **Indicator of:** Is component performing its **functional purpose**? Is the condition going to lead to deterioration of base elements?

Corrosion Component Ratings

- Component ratings are based on an evaluation of element inspection results considering significance of observed conditions

➔ **Condition Assessment**

- Based on engineering judgment, knowledge & experience
- Considers qualitative and quantitative inspection findings
- May be supplemented by calculations



Corrosion Component Ratings

- Once the *condition assessment* has established the *component condition*, a **Component Rating** is assigned
  - Baseline, Routine, and Functionality Check Inspections
  - Scale of 1 to 6 (Critical to Good)
  - Different rating scales for:
    - ICCP components
    - SACP components
    - Surface Protection Components
  - Consider both **visual** findings and **functional** performance

Corrosion Manual
6.2.1 – 6.2.2

CP Component Ratings

- Rating descriptions include language to address:
  - Functional ratings and visual condition ratings
  - Overall performance with respect to industry standards
  - How various elements within cathodic protection are working together to provide intended protection
- <u>Functional Rating:</u> Based on NACE standards and field measurements to ensure functionality
- <u>Visual Rating:</u> Visual observation / measurements of elements

CP Component Functional Ratings

- 6 – Good
- 5 – Satisfactory
- 4 – Fair
- 3 – Poor
- 2 – Serious
- 1 – Critical

Table 6.1. Functionality Ratings for Cathodic Protection Components

Rating	Description
6 Good	One of the following criteria is met at all test locations: ▪ A negative (cathodic) voltage of -850 mV CSE (millivolt versus copper/copper sulfate reference electrode) or more negative between metal elements and the electrolyte, without risk of hydrogen embrittlement. ▪ A minimum of 100 mV of cathodic polarization, as measured by either polarization formation or decay. ▪ Test coupons are used to otherwise demonstrate adequate corrosion protection is being applied to the structure.* ▪ For reinforced concrete elements, the depolarized potential of the steel in wet saturated concrete is more negative than -720 mV CSE with the anode disconnected for a minimum of 24 hours, or a minimum of 100 mV of cathodic polarization, as measured by either polarization formation or decay
5 Satisfactory	One of the above criteria is met at least at 80 percent of the test locations. Damage, electrical malfunctions, or deterioration have affected the functionality of the ICCP or SACP system, such that the above criteria are not met at limited locations. Potential for overprotection or coating damage may be noted at some locations, but metals have low risk of embrittlement.
4 Fair	One of the above criteria is met for at least 50 percent of the test locations. The system is partially functional but may not be providing adequate corrosion protection to some base metal elements (or reinforced concrete elements, if applicable). Metals with high risk of steel embrittlement are subject to cathodic overprotection (instant off voltage more negative than - 1,000 mV CSE). Coatings with high risk of disbondment are subject to cathodic overprotection (instant off voltage more negative than -1200 mV CSE).
3 Poor	One of the above criteria are met at less than 50 percent of the test locations. Widespread performance deficiencies are observed for the cathodic protection systems.
2 Serious	One of the above criteria is met at less than 10 percent test locations. Evidence of nonfunctional cathodic protection system is noted at most locations.
1 Critical	ICCP or SACP system is not functional or is not providing corrosion protection at any test locations as intended.
Applicable Component Types: Impressed Current Cathodic Protection Systems, Sacrificial Anode Cathodic Protection Systems, Spray Metalizing with Monitoring Boxes	

*Reference NACE SP0104, *Standard Practice: The Use of Coupons for Cathodic Protection Monitoring Applications*. If corrosion rate is used as an evaluating metric, the corrosion rate should be no greater than 2 mpy to achieve a rating of 6- Good.

CP Component Visual Ratings

- Visual rating may score **higher or lower** than the functional rating
- Functional and visual ratings are weighted and scored differently for CCR

Table 6.2. Visual Ratings for Cathodic Protection Components

Rating	Description
6 Good	Very minor or no problems observed. Also applies to newly constructed or rehabilitated protective components.
5 Satisfactory	Limited minor defects, damage, or deterioration - not extensive to multiple elements.
4 Fair	Extensive minor or limited moderate defects, damage, or deterioration. All primary elements and their attachment to the asset are sound and functional purpose/use of the component is not affected. Minor repairs or maintenance may be required.
3 Poor	Extensive moderate defects, damage or deterioration that affects functional purpose/use of the component or compromises attachment of the component to the asset.
2 Serious	Defects, damage, or deterioration significantly affect functional purpose/use of the component.
1 Critical	Advanced damage or deterioration expected to result in failure(s) of component to provide adequate protection. The component can no longer serve its functional purpose/use and/or conditions are present that may lead to imminent failure of the ICCP system.
Applicable Element Types: Anodes, Supplementary Anode Materials, DC Power Supply, Monitoring Equipment, Wiring and Protection, Cathodic Protection Jackets, CP Supports	

Surface Protection Component Ratings

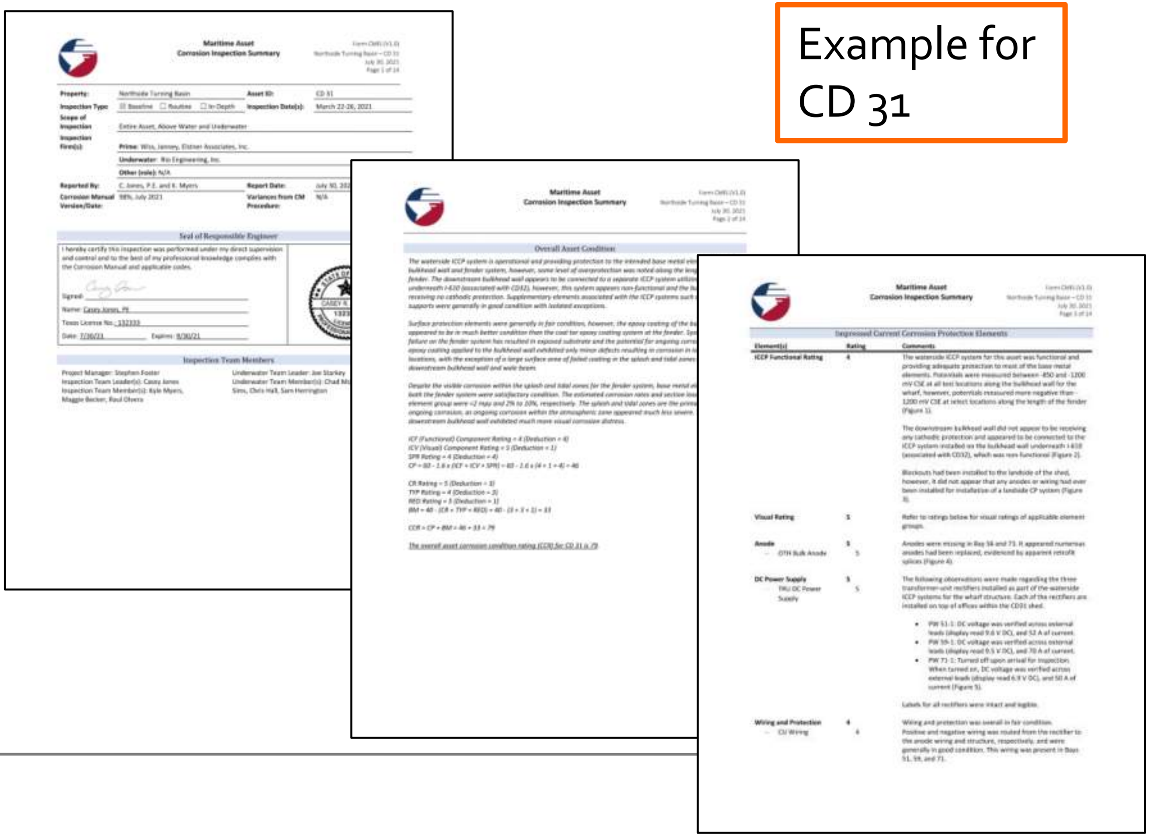
- Typical element groups
  - Coatings
  - Wraps
  - Spray Metallizing
- Based on visual observations and measurements/testing

Table 6.3. Ratings for Surface Protection Components

Rating	Description
6 Good	Very minor or no problems observed. Also applies to newly constructed or rehabilitated components.
5 Satisfactory	Limited minor defects, damage, or deterioration such as chalking, blushing, blistering, etc. - not extensive.
4 Fair	Extensive minor or limited moderate defects, damage, or deterioration. Coating, wrap, and/or metalizing may be peeling or missing in localized areas.
3 Poor	Extensive moderate defects, damage or deterioration. Coating, wrap, and/or metalizing may be peeling or missing in not more than 50 percent of coated surfaces.
2 Serious	Defects, damage or deterioration has significantly reduced protection of base steel elements. Coatings, wraps, and/or metalizing elements are only providing protection in localized locations.
1 Critical	Advanced defects, damage, or deterioration categorized as a systematic coating failure. Coatings, wraps, and/or metalizing elements do not protect base metal elements.
Applicable Element Types: Coatings, Wraps, and Spray Metalizing	

Documenting and Reporting

- Corrosion protection component ratings included on:
  - Inspection History Form
  - Inspection Summary Form
  - PHA Database



Example for CD 31

Inspection Summary Form

Example for CD 31

Maritime Asset
Corrosion Inspection Summary

Form CMIS (V1.0)
Northside Turning Basin – CD 31
July 30, 2021
Page 3 of 14

Impressed Current Corrosion Protection Elements

Element(s)	Rating	Comments
ICCP Functional Rating	4	The waterside ICCP system for this asset was functional and providing adequate protection to most of the base metal elements. Potentials were measured between -850 and -1200 mV CSE at all test locations along the bulkhead wall for the wharf, however, potentials measured more negative than -1200 mV CSE at select locations along the length of the fender (Figure 1). The downstream bulkhead wall did not appear to be receiving any cathodic protection and appeared to be connected to the ICCP system installed on the bulkhead wall underneath I-610 (associated with CD32), which was non-functional (Figure 2). Blockouts had been installed to the landside of the shed, however, it did not appear that any anodes or wiring had ever been installed for installation of a landside CP system (Figure 3).
Visual Rating	5	Refer to ratings below for visual ratings of applicable element groups.
Anode	5	Anodes were missing in Bay 56 and 73. It appeared numerous anodes had been replaced, evidenced by apparent retrofit splices (Figure 4).
– OTH Bulk Anode	5	

Functional Rating (overall)

Visual Rating (overall)

Element(s)	Rating	Comments
Anode	5	Anodes were missing in Bay 56 and 73. It appeared numerous anodes had been replaced, evidenced by apparent retrofit splices (Figure 4).
– OTH Bulk Anode	5	
DC Power Supply	5	The following observations were made regarding the three transformer-unit rectifiers installed as part of the waterside ICCP systems for the wharf structure. Each of the rectifiers are installed on top of offices within the CD31 shed. • PW 51-1: DC voltage was verified across external leads (display read 9.6 V DC), and 52 A of current. • PW 59-1: DC voltage was verified across external leads (display read 9.5 V DC), and 70 A of current. • PW 71-1: Turned off upon arrival for inspection. When turned on, DC voltage was verified across external leads (display read 6.9 V DC), and 50 A of current (Figure 5). Labels for all rectifiers were intact and legible.
– TRU DC Power Supply	5	
Wiring and Protection	4	Wiring and protection was overall in fair condition. Positive and negative wiring was routed from the rectifier to the anode wiring and structure, respectively, and were generally in good condition. This wiring was present in Bays 51, 59, and 71.
– CU Wiring	4	

Ratings by Element Group/Type

Provide commentary to explain reasoning behind rating

Inspection Summary Form

Example for CD 31

Surface Protection Elements

Element(s)	Rating	Comments
Surface Protection	**4**	Overall, surface protection elements were in fair condition. Coal tar epoxy was applied to the fender system and recoating was not evident. Epoxy coating was applied to the bulkhead wall and appeared to be in satisfactory condition above the bulkhead wale beam. Although isolated locations indicated coating thickness measurements less than 18 mil, the average thickness for the epoxy coating on the bulkhead wall was approximately 24 mils, indicating a CS1. Where coating was intact on the fender system, coating thickness generally exceeded 18 mils, corresponding with a CS1 rating.
– CT Coatings	4	The original coal tar epoxy exhibited extensive minor peeling and coating failure resulting in exposed bare steel in the tidal and splash zones at approximately 10 percent of the steel surface area (Figure 9). The majority of the coating appeared to still be functioning in the atmospheric exposure zone with minor defects primarily at corners and connections.
– EP Coatings	4	The epoxy coating was generally in good condition above the bulkhead wale beam for the length of the wharf with only minor distress observed at corners and seams (Figure 9). The epoxy coating applied to the downstream bulkhead wall and wale beam was in much worse condition had generally failed in the tidal and splash zones resulting in ongoing corrosion (Figure 10).

Visual Rating (overall)

Ratings by Element Group/Type

Provide commentary to explain reasoning behind rating

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Use Engineering Judgment

- Many complex factors influence the effect of element conditions on overall component condition
  - Functional and Visual Categories are framework for that influence on overall performance
  - Functional performance is more “black and white”
- It is not possible to develop a single formula to address any and all situations
  - Requires engineering judgement

Consideration Factors

- What information, factors, etc., should be considered in the process of condition assessment for components? *(choose all that apply)*
  a) Element conditions
  b) Intended use and design loads for asset
  c) Component system(s), purpose of elements
  d) Damage and deterioration related mechanisms
  e) Value of the asset or component
  f) Serviceability requirements / impact / ease of repair/ access

Example: ICCP Component Ratings

- Impressed Current Cathodic Protection (ICCP)
  - ICCP Functional Component Rating
  - ICCP Visual Component Rating

ICCP Functional Component Rating

Potential Units	ON Potential	Instant OFF Potential
mV vs. CSE	-1050	-940
mV vs. CSE	-980	-860
mV vs. CSE	-1210	-970
mV vs. CSE	-1150	-910
mV vs. CSE	-1260	-1010
mV vs. CSE	-1200	-950
mV vs. CSE	-1180	-970
mV vs. CSE	-1100	-890
mV vs. CSE	-1100	-900
mV vs. CSE	-1110	-920
mV vs. CSE	-670	-670
mV vs. CSE	-890	-890
	-890	-880
	-1190	-1130
	-1620	-1500
	-1380	-1120
	-1290	-1070
	-1070	-900
	-980	-890

Waterside System (Bulkhead & Fender Piles)

Nearly all Instant OFF potentials are more negative than -850mV NACE criteria

One area of wall with no protection

One area with OFF potential was more negative than -1200mV, potential concern for overprotection

ICCP Functional Component Rating

- Waterside System (Bulkhead Wall & Fender Piles)

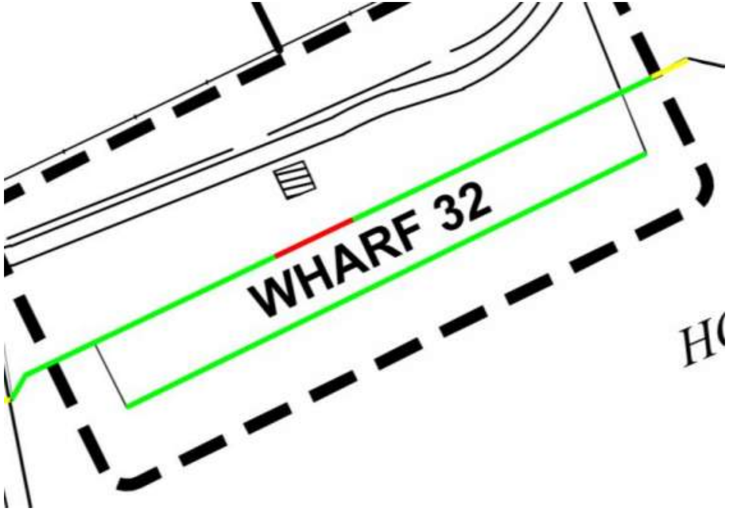

Table 6.1. Functionality Ratings for Cathodic Protection Components

Rating	Description
6 Good	One of the following criteria is met at all test locations: ▪ A negative (cathodic) voltage of -850 mV CSE (millivolt versus copper/copper sulfate reference electrode) or more negative between metal elements and the electrolyte, without risk of hydrogen embrittlement. ▪ A minimum of 100 mV of cathodic polarization, as measured by either polarization formation or decay. ▪ Test coupons are used to otherwise demonstrate adequate corrosion protection is being applied to the structure.* ▪ For reinforced concrete elements, the depolarized potential of the steel in wet saturated concrete is more negative than -720 mV CSE with the anode disconnected for a minimum of 24 hours, or a minimum of 100 mV of cathodic polarization, as measured by either polarization formation or decay
5 Satisfactory	One of the above criteria is met at least at 80 percent of the test locations. Damage, electrical malfunctions, or deterioration have affected the functionality of the ICCP or SACP system, such that the above criteria are not met at limited locations. Potential for overprotection or coating damage may be noted at some locations, but metals have low risk of embrittlement.
4 Fair	One of the above criteria is met for at least 50 percent of the test locations. The system is partially functional but may not be providing adequate corrosion protection to some base metal elements (or reinforced concrete elements, if applicable). Metals with high risk of steel embrittlement are subject to cathodic overprotection (instant off voltage more negative than - 1,000 mV CSE). Coatings with high risk of disbondment are subject to cathodic overprotection (instant off voltage more negative than -1200 mV CSE).
3 Poor	One of the above criteria are met at less than 50 percent of the test locations. Widespread performance deficiencies are observed for the cathodic protection systems.
2 Serious	One of the above criteria is met at less than 10 percent test locations. Evidence of nonfunctional cathodic protection system is noted at most locations.
1 Critical	ICCP or SACP system is not functional or is not providing corrosion protection at any test locations as intended.
Applicable Component Types: Impressed Current Cathodic Protection Systems, Sacrificial Anode Cathodic Protection Systems, Spray Metalizing with Monitoring Boxes	

*Reference NACE SP0104, *Standard Practice: The Use of Coupons for Cathodic Protection Monitoring Applications*. If corrosion rate is used as an evaluating metric, the corrosion rate should be no greater than 2 mpy to achieve a rating of 6- Good.

ICCP Functional Component Rating

- Upstream Bulkhead Wall
  - The rectifier installed as part of the upstream ICCP system not functional
  - No shift in On/Instant Off (-670mV to -890mV potential readings

ICCP Functional Component Rating

- Waterside & Upstream Systems

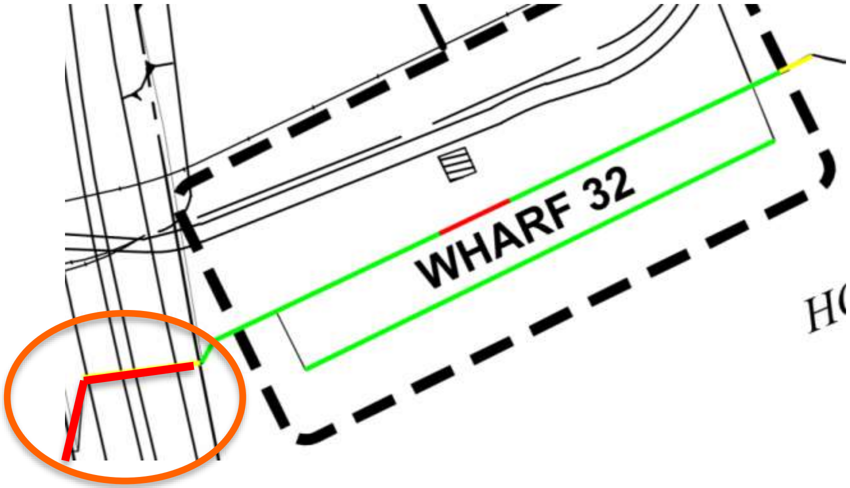

Table 6.1. Functionality Ratings for Cathodic Protection Components

Rating	Description
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5 Satisfactory	One of the above criteria is met at least at 80 percent of the test locations. Damage, electrical malfunctions, or deterioration have affected the functionality of the ICCP or SACP system, such that the above criteria are not met at limited locations. Potential for overprotection or coating damage may be noted at some locations, but metals have low risk of embrittlement.
4 Fair	One of the above criteria is met for at least 50 percent of the test locations. The system is partially functional but may not be providing adequate corrosion protection to some base metal elements (or reinforced concrete elements, if applicable). Metals with high risk of steel embrittlement are subject to cathodic overprotection (instant off voltage more negative than - 1,000 mV CSE). Coatings with high risk of disbondment are subject to cathodic overprotection (instant off voltage more negative than -1200 mV CSE).
3 Poor	One of the above criteria are met at less than 50 percent of the test locations. Widespread performance deficiencies are observed for the cathodic protection systems.
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1 Critical	ICCP or SACP system is not functional or is not providing corrosion protection at any test locations as intended.
Applicable Component Types: Impressed Current Cathodic Protection Systems, Sacrificial Anode Cathodic Protection Systems, Spray Metalizing with Monitoring Boxes	

*Reference NACE SP0104, *Standard Practice: The Use of Coupons for Cathodic Protection Monitoring Applications*. If corrosion rate is used as an evaluating metric, the corrosion rate should be no greater than 2 mpy to achieve a rating of 6- Good.

ICCP Visual Component Rating

Typical condition of CS conduit, protecting wiring

Negative structure connection exhibiting moderate corrosion

Typical Anode support in good condition

ICCP Visual Component Rating

- Measurements from rectifiers are shown below:

- PW 5-1: 5.9 V DC measured across external leads (display read 5.1 V DC), however, no current was flowing (Figure 2).
- PW 24-1: Output display showed 5.8 V DC and 25A and measured values showed <10% variation.
- PW 37-1: Output display showed 4.0 V DC and 24A, however, measured current was 5.8 V DC. Amperage output display panel was within 10% of measured values.

ICCP Visual Component Rating

Minor anode consumption

Some anodes missing

ICCP Visual Component Rating

- Extensive defects (not significant)
- Functionality has been impacted

3 – Poor

Table 6.2. Visual Ratings for Cathodic Protection Components

Rating	Description
6 Good	Very minor or no problems observed. Also applies to newly constructed or rehabilitated protective components.
5 Satisfactory	Limited minor defects, damage, or deterioration - not extensive to multiple elements.
4 Fair	Extensive minor or limited moderate defects, damage, or deterioration. All primary elements and their attachment to the asset are sound and functional purpose/use of the component is not affected. Minor repairs or maintenance may be required.
3 Poor	Extensive moderate defects, damage or deterioration that affects functional purpose/use of the component or compromises attachment of the component to the asset.
2 Serious	Defects, damage, or deterioration significantly affect functional purpose/use of the component.
1 Critical	Advanced damage or deterioration expected to result in failure(s) of component to provide adequate protection. The component can no longer serve its functional purpose/use and/or conditions are present that may lead to imminent failure of the ICCP system.
Applicable Element Types: Anodes, Supplementary Anode Materials, DC Power Supply, Monitoring Equipment, Wiring and Protection, Cathodic Protection Jackets, CP Supports	

ICCP Component Rating

- Functional Rating - 4
- Visual Rating – 3
  - Wiring – 5
  - Protection – 4
  - Supports – 5
  - Anodes – 3
  - Power Supplies – 3

Impressed Current Corrosion Protection Elements

Element(s)	Rating	Comments
Functional	4	Instant-off potentials of the bulkhead wall were measured as more negative than -850 mV vs. CSE along the length with the exception of the upstream bulkhead wall under the I-610 bridge and east end of the downstream bulkhead wall. The potential measurement at the bulkhead wall in Bay 16 was measured at -1500 mV vs. CSE, which is in excess of the -1200 mV vs. CSE maximum threshold. At the fender, instant-off potential measurements were all measured as more negative than -850 mV vs. CSE. Figure 1 provides a visual representation of the ICCP potential data. The entire upstream system appeared non-functional.
Visual (Overall)	3	Refer to ratings below for visual ratings of applicable element groups.
Wiring and Protection	5	Wiring and protection was in satisfactory condition.
– CU Wiring	5	Accessible portions of wiring appeared to be in satisfactory condition with minor corrosion at the connections. Accessible wiring included including negative structure wire extending from the rectifier to the bulkhead wall, positive anode wiring from the rectifiers to the submerged anodes, and bond wires installed to electrically connect the fender system to the bulkhead wall. The most significant corrosion was observed at the negative connection in Bay 5 (Figure 3).
– CS Protection	4	Exposed carbon steel conduit extended through the bulkhead wall at locations where subgrade wiring was routed. This conduit appeared to be in serviceable condition with minor ongoing corrosion (Figure 4).
– PVC Protection	NA	Inaccessible
– CP Supports	5	Supports were in satisfactory condition.
– GS Supports	5	All galvanized steel anode supports were still in serviceable condition (Figure 5).
Anodes	3	Minimal marine growth and minor section loss, typical. Some anodes missing.
– OTH Bulk Anode	3	
DC Power Supply	3	The following observations were made regarding the three transformer-unit rectifiers installed as part of the waterside ICCP system installed for the wharf structure. • PW 5-1: 5.9 V DC measured across external leads (display read 5.1 V DC), however, no current was flowing (Figure 2).
– TRU DC Power Supply	3	

Example: Surface Protection Rating

Epoxy Coating at Bulkhead Wall

- Good adhesion (exceeded 250 psi)
- Varying degrees of peeling/exposed substrate
  - Mostly splash and tidal zones
  - Localized

Example: Surface Protection Rating

- Recently recoated
- Good adhesion & thickness
- Limited distress

Example: Surface Protection Rating

- ~30% of area with CS4 peeling/exposed substrate (widespread)

Coal Tar Coating at Fender System

Example: Surface Protection Rating

Surface Protection Elements

Element(s)	Rating	Comments
Surface Protection	**4**	Overall, surface protection elements were in fair condition. The upstream portion of the wall under I-610 had been recently recoated and was in the best condition of the length of the wall. The coal tar epoxy coating on the fender system, which appeared to be the original coating, was in poor condition. All adhesion measurements for coatings applied on the bulkhead wall and fender elements exceeded 250 psi.
– CE Coatings	3	The coal tar epoxy coating was installed on the fender system, including the piles and support framing. This coating was in poor condition on all observed elements, with approximately 20 percent of the base metal exposed on the piles and framing, respectively. Coating defects were typically observed in the splash and tidal zones on the fender piles, while the coating distress of the framing appeared to generally originate from typical structural details that are difficult to coat (stiffener plates, holes, etc.).
– EP Coatings	4	The bulkhead wall coatings overall were in fair condition, with varying degrees of peeling and blistering observed along the length of the wall. Higher concentrations of distressed or failed coatings was typically observed in the splash and tidal zones. The original upstream bulkhead wall under the I-610 bridge had been recoated (details unknown) and was in satisfactory condition. Approximately 35 mils DFT was measured in the atmospheric exposure zone and typically, exposed steel was isolated and typically only observed at weld connections to the anode support angles and vertical seams (Figure 6).

Table 6.3. Ratings for Surface Protection Components

Rating	Description
6 Good	Very minor or no problems observed. Also applies to newly constructed or rehabilitated components.
5 Satisfactory	Limited minor defects, damage, or deterioration such as chalking, blushing, blistering, etc. - not extensive.
4 Fair	Extensive minor or limited moderate defects, damage, or deterioration. Coating, wrap, and/or metalizing may be peeling or missing in localized areas.
3 Poor	Extensive moderate defects, damage or deterioration. Coating, wrap, and/or metalizing may be peeling or missing in not more than 50 percent of coated surfaces.
2 Serious	Defects, damage or deterioration has significantly reduced protection of base steel elements. Coatings, wraps, and/or metalizing elements are only providing protection in localized locations.
1 Critical	Advanced defects, damage, or deterioration categorized as a systematic coating failure. Coatings, wraps, and/or metalizing elements do not protect base metal elements.
Applicable Element Types: Coatings, Wraps, and Spray Metalizing	

END OF MODULE

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Module 6.3

Base Metal Component Ratings

Corrosion Manual Training Course

Module Objectives

Module 6.3 Learning Outcomes

- Summarize rating process for base metal components
- Describe the relationship of element condition states and base metal components
- Employ engineering judgement and determine the Corrosion Damage Index and assign component ratings for base metal components
- Describe use of Corrosion Inspection Summary Form to record component rating information

Base Metal Component Ratings

- Baseline and Routine Inspections
- Numerical Rating: 1 to 6 scale (Corrosion Damage Rating Index)
  - Thickness Measurements (Section Loss)
  - Estimated Corrosion Rate

Table 6.4. Corrosion Damage Rating Index for Base Metal Components

		Estimated Corrosion Rate (mpy)			
		≤ 2	**2 < x ≤ 6**	**6 < x ≤ 11**	**>11**
Section Loss	**≤ 2%**	6 Good	6 Good	5 Satisfactory	5 Satisfactory
	>2% to ≤ 10%	5 Satisfactory	4 Fair	4 Fair	3 Poor
	>10% to ≤ 30%	3 Poor	3 Poor	3 Poor	2 Serious
	> 30%	2 Serious	2 Serious	1 Critical	1 Critical

6 – Good
5 – Satisfactory
4 – Fair
3 – Poor
2 – Serious
1 – Critical

Base Metal Component Ratings

- Multiple elements, multiple exposure zones
- Summary rating for the component group
  - Critical
  - Typical
  - Redundant
- Follow-up actions for specific circumstances

Base Metal Component Ratings

- Steel section thickness for base metal element:
  - Section loss based on thickness measurements
  - Location(s) and/or exposure zones with associated section loss
  - Representative conditions across element and element group, multiple element groups per component
  - Type of corrosion (uniform, pitting, crevice, MIC,…etc.)
- Corrosion rate estimate by Engineer
  - Meant to be representative of element groups, exposure zones, corrosion type

Base Metal Component Ratings

- **Section Loss:** Percent decrease in thickness relative to the thickness recorded in the design (or Baseline Inspection):

$$SL = \frac{(T_B - T_R)}{T_B} * 100$$

  - SL: Section Loss (average for each element group and exposure zone)
  - T_B: Initial as-built or design thickness
  - T_R: Thickness measured in most recent inspection

Base Metal Component Ratings

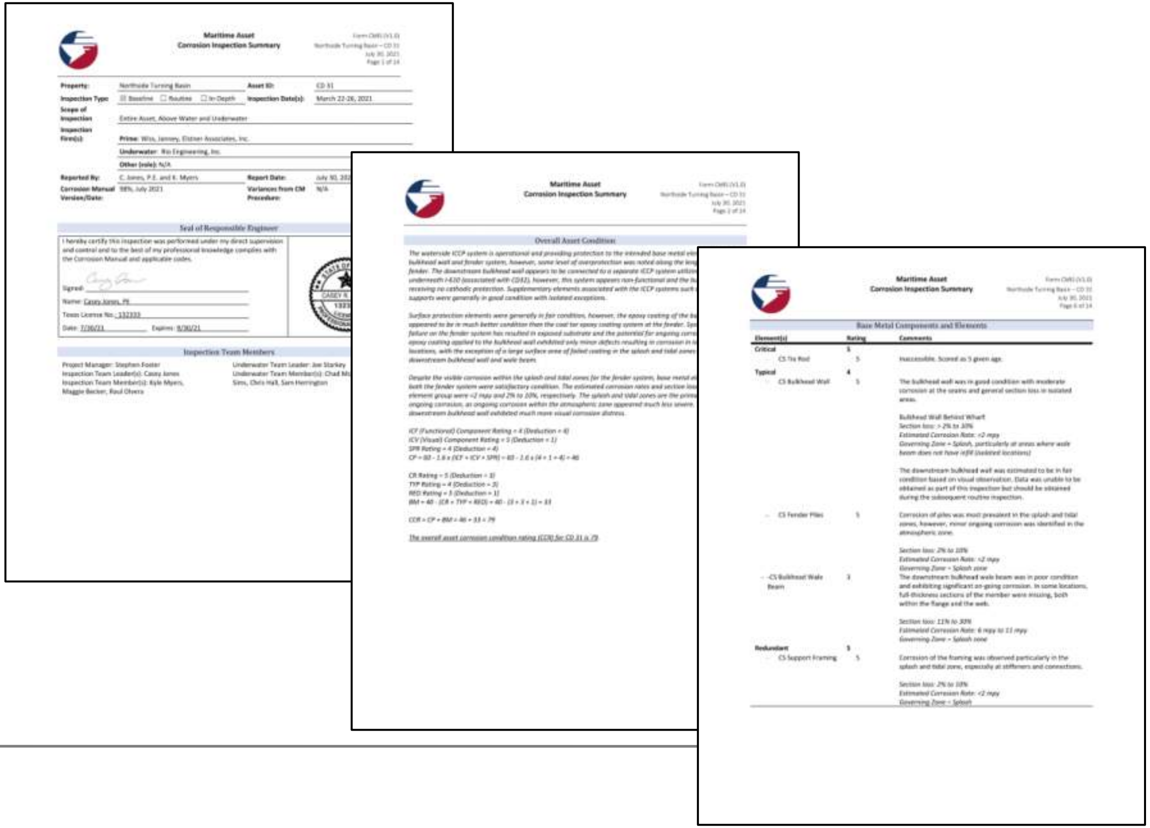
- **Corrosion Rate**: from time of the previous inspection:

$$CR = \frac{T_{R-1} - T_R}{I}$$

  - CR: Corrosion Rate in mils per year
  - T_R: Avg. thickness in current inspection (mils)
  - T_{R-1}: Avg. thickness in previous inspection (mils)
  - I: Time between previous and current inspection (years)

Documenting and Reporting

- Base metal component ratings included on:
  - Inspection History Form
  - Inspection Summary Form
  - PHA Database



Documenting and Reporting

Base Metal Components and Elements

Element(s)	Rating	Comments
Critical	**NA**	Inaccessible
– CS Tie Rod	NA	
Typical	**5**	
– CS Bulkhead Wall	5	The bulkhead wall was in good condition with minor corrosion at the seams and minimal general section loss. *Section loss: (Good < 2%)* *Estimated Corrosion Rate: (Satisfactory <6mpy)*
– CS Fender Piles	4	Impact damage and corrosion of piles was observed near the waterline. *Section loss: (Satisfactory/Fair <10%)* *Estimated Corrosion Rate: (Fair/Poor <11mpy)*
Redundant	**4**	
– CS Support Framing	4	Impact damage and corrosion of framing was observed near the waterline, particularly at connections. *Section loss: (Satisfactory/Fair <10%)* *Estimated Corrosion Rate: (Fair/Poor <11mpy)*

Overall Component Ratings for Classification Group

Provides commentary to explain reasoning behind rating

Include controlling section loss and corrosion rate estimate used to establish rating

Element Ratings

Example: CD32 Base Metal Ratings

- Critical
  - Tie Rods
    (Not Accessible)
- Typical
  - Bulkhead Walls
  - Fender Piles
- Redundant
  - Support Framing

Example: CD32 Bulkhead Walls

Example: CD32 Bulkhead Walls

Exposure Zone	Element	Location Description	Thickness (in.)					Avg. Thickness (in.)	Section Loss (%)	Condition State
Atmospheric	BW 1-1	Flange, +6.0, upstream BW under I-610 bridge	0.428	0.437	0.427	0.434	0.432	0.432	0%	CS1
		Web, +6.0, upstream BW under I-610 bridge	0.394	0.401	0.4	0.37	0.399	0.393	0%	CS1
		Flange, +8.0, diag. BW between wharf and I-610 bridge	0.4	0.406	0.399	0.4	0.4	0.401	0%	CS1
		Web, +8.0, diag. BW between wharf and I-610 bridge	0.384	0.382	0.377	0.38	0.376	0.38	0%	CS1
		Flange, +8.0, 40' west of wharf	0.415	0.416	0.412	0.411	0.416	0.414	0%	CS1
		Web, +8.0, 40' west of wharf	0.395	0.394	0.399	0.393	0.401	0.396	0%	CS1
	BW 5-1	Flange, +10.0	0.405	0.402	0.403	0.406	0.4	0.403	0%	CS1
		Web, +10.0	0.38	0.379	0.383	0.385	0.391	0.384	0%	CS1
	BW 10-1	Flange, +10.0	0.436	0.415	0.415	0.406	0.416	0.418	0%	CS1
		Web, +10.0	0.38	0.378	0.372	0.372	0.378	0.376	0%	CS1
	BW 16-1	Flange, +10.0	0.401	0.402	0.413	0.398	0.402	0.403	0%	CS1
		Web, +10.0	0.378	0.375	0.377	0.378	0.374	0.376	0%	CS1
	BW 22-1	Flange, +10.0	0.4	0.4	0.398	0.406	0.414	0.404	0%	CS1
		Web, +10.0	0.384	0.386	0.385	0.39	0.381	0.385	0%	CS1
	BW 25-1	Flange, +10.0	0.383	0.386	0.4	0.43	0.45	0.41	0%	CS1
		Web, +10.0	0.371	0.372	0.369	0.373	0.372	0.371	1%	CS1

Splash	BW 1-2	Below wale beam	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 1-3	Below wale beam	0.38	0.38	0.385	0.38	0.385	0.382	3%	CS2
	BW 4-1	Below wale beam	0.375	0.375	0.375	0.375	0.375	0.375	5%	CS2
	BW 8-1	Below wale beam	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 12-1	Below wale beam	0.375	0.375	0.37	0.37	0.37	0.372	6%	CS2
	BW 15-1	Below wale beam	0.4	0.4	0.4	0.4	0.4	0.4	0%	CS1
	BW 18-1	Below wale beam	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 22-1	Below wale beam	0.395	0.395	0.395	0.395	0.395	0.395	0%	CS1
	BW 25-1	Below wale beam	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 31-1	Below wale beam	0.405	0.405	0.405	0.405	0.405	0.405	0%	CS1
	BW 34-1	Below wale beam	0.375	0.375	0.375	0.375	0.38	0.376	5%	CS2
	BW 37-1	Below wale beam	0.37	0.37	0.37	0.37	0.37	0.37	6%	CS2
	BW 39-1	Below wale beam	0.35	0.35	0.35	0.35	0.355	0.351	11%	CS3
Tidal	BW 1-1	Waterline	0.425	0.425	0.425	0.42	0.42	0.423	0%	CS1
	BW 1-2	Waterline	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 1-3	Waterline	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 4-1	Waterline	0.375	0.375	0.375	0.375	0.375	0.375	5%	CS2
	BW 8-1	Waterline	0.375	0.375	0.375	0.375	0.375	0.375	5%	CS2
	BW 12-1	Waterline	0.375	0.375	0.375	0.37	0.37	0.373	6%	CS2
	BW 15-1	Waterline	0.4	0.4	0.4	0.4	0.4	0.4	0%	CS1
	BW 18-1	Waterline	0.375	0.375	0.375	0.37	0.37	0.373	6%	CS2
	BW 22-1	Waterline	0.395	0.395	0.395	0.395	0.395	0.395	0%	CS1
	BW 25-1	Waterline	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2
	BW 31-1	Waterline	0.405	0.405	0.405	0.405	0.41	0.406	0%	CS1
	BW 34-1	Waterline	0.37	0.37	0.37	0.37	0.37	0.37	6%	CS2
	BW 37-1	Waterline	0.375	0.375	0.375	0.375	0.375	0.375	5%	CS2
	BW 39-1	Waterline	0.385	0.385	0.385	0.385	0.385	0.385	3%	CS2
Submerged	BW 1-1	Mudline	0.43	0.43	0.43	0.425	0.425	0.428	0%	CS1
	BW 1-2	Mudline	0.38	0.385	0.38	0.38	0.385	0.382	3%	CS2
	BW 1-3	Mudline	0.385	0.38	0.385	0.385	0.38	0.383	3%	CS2
	BW 7-1	Mudline	0.365	0.365	0.365	0.365	0.365	0.365	8%	CS2
	BW 14-1	Mudline	0.375	0.375	0.38	0.38	0.38	0.378	4%	CS2
	BW 20-1	Mudline	0.375	0.375	0.375	0.38	0.38	0.377	5%	CS2
	BW 26-1	Mudline	0.405	0.405	0.405	0.405	0.405	0.405	0%	CS1
	BW 32-1	Mudline	0.375	0.375	0.375	0.375	0.38	0.376	5%	CS2
	BW 39-1	Mudline	0.38	0.38	0.38	0.38	0.38	0.38	4%	CS2

Example: CD32 Bulkhead Walls

- Avg. 4% section loss in Splash Zone (controlling zone)
- Installed in 1982 – Baseline Inspection 2020
  - 15.8 mils of metal loss in 38 years → ~0.5 mpy
- ICCP (Functional – 4 Fair, Visual – 3 Poor)
- Coating: 4 – Fair

5 - Satisfactory

Table 6.4. Corrosion Damage Rating Index for Base Metal Components

		Estimated Corrosion Rate (mpy)			
		≤ 2	2 < x ≤ 6	6 < x ≤ 11	>11
Section Loss	≤ 2%	6 Good	6 Good	5 Satisfactory	5 Satisfactory
	>2% to ≤ 10%	5 Satisfactory	4 Fair	4 Fair	3 Poor
	>10% to ≤ 30%	3 Poor	3 Poor	3 Poor	2 Serious
	> 30%	2 Serious	2 Serious	1 Critical	1 Critical

Example: CD32 Fender Piles

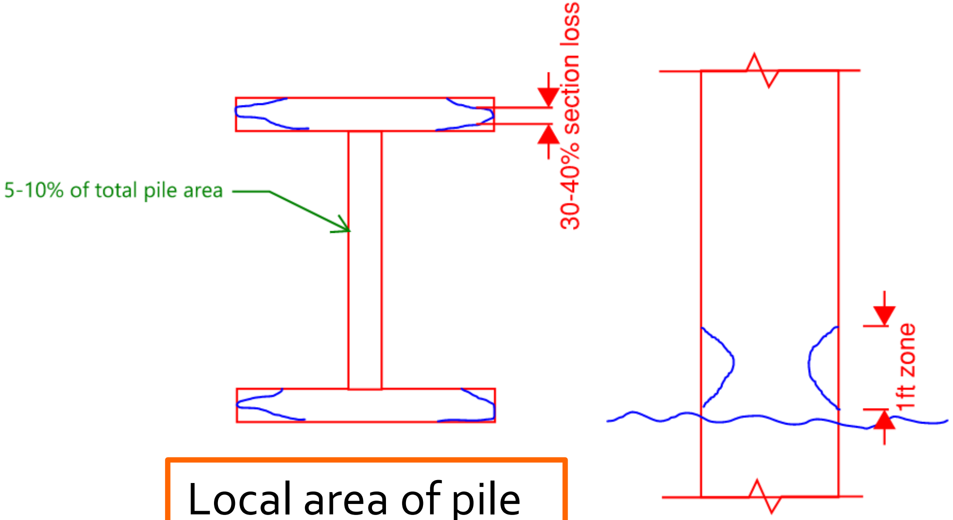
Example: CD32 Fender Piles

Exposure Zone	Element	Location Description	Thickness (in.)					Avg. Thickness (in.)	Section Loss (%)	Condition State
Atmospheric	FP 5-1	6 ft	0.6	0.601	0.593	0.598	0.595	0.597	3%	CS2
	FP 16-1	6 ft	0.649	0.645	0.652	0.654	0.648	0.65	0%	CS1
	FP 25-1	6 ft	0.597	0.597	0.596	0.597	0.587	0.595	3%	CS2
	FP 33-1	6 ft	0.609	0.609	0.606	0.612	0.606	0.608	1%	CS1
Splash	FP 5-1	1.5 ft	0.521	0.392	0.375	0.473	0.42	0.436	29%	CS3
	FP 16-1	1.5 ft	0.471	0.325	0.366	0.381	0.491	0.407	34%	CS4
	FP 25-1	1.5 ft	0.265	0.41	0.248	0.385	-	0.327	47%	CS4
	FP 33-1	1.5 ft	0.343	0.228	0.366	0.308	0.294	0.308	50%	CS4
Tidal	FP 5-1	W/L	0.615	0.61	0.61	0.615	0.615	0.613	0%	CS1
	FP 16-1	W/L	0.64	0.64	0.64	0.635	0.635	0.638	0%	CS1
	FP 25-1	W/L	0.48	0.48	0.48	0.48	0.485	0.481	22%	CS3
	FP 33-1	W/L	0.6	0.6	0.6	0.6	0.6	0.6	2%	CS2
Submerged	FP 1-1	5’ below water	0.565	0.565	0.565	0.57	0.57	0.567	8%	CS2
	FP 7-1	5’ below water	0.6	0.6	0.6	0.595	0.6	0.599	3%	CS2
	FP 14-1	5’ below water	0.605	0.605	0.605	0.605	0.61	0.606	1%	CS1
	FP 20-1	5’ below water	0.615	0.615	0.615	0.615	0.62	0.616	0%	CS1
	FP 26-1	5’ below water	0.565	0.565	0.565	0.565	0.565	0.565	8%	CS2
	FP 32-1	5’ below water	0.57	0.57	0.57	0.57	0.565	0.569	7%	CS2
	FP 39-1	5’ below water	0.58	0.58	0.58	0.585	0.585	0.582	5%	CS2

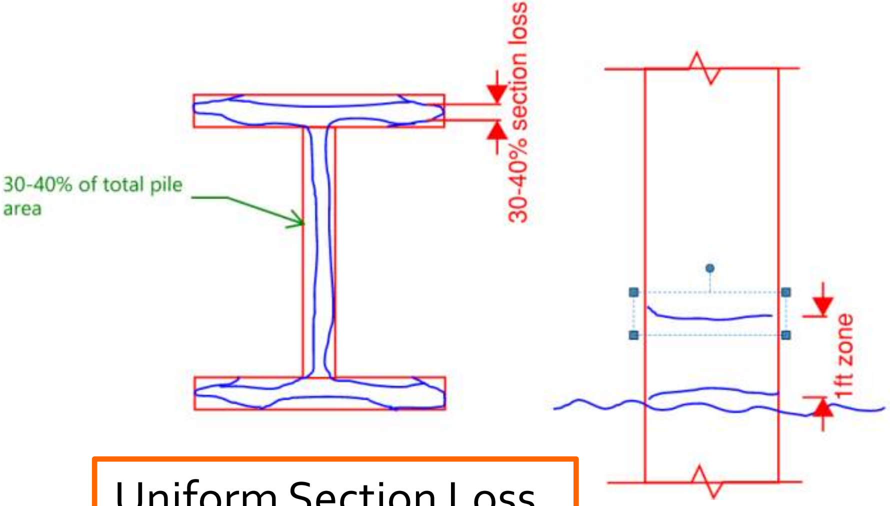
40% section loss average in splash zone

Example: CD32 Fender Piles

- Localized to flange
- Not uniform corrosion at full element



Local area of pile



Uniform Section Loss

Example: CD32 Fender Piles

- Avg. ~10% total element section loss in Splash Zone (controls)
- Installed in 1982 – Baseline Inspection 2020
  - 246 mils of metal loss in 38 years → ~6.5 mpy (equivalent)
- ICCP (Functional – 4 Fair, Visual – 3 Poor)
- Coating: 3 – Poor

4 - Fair

Table 6.4. Corrosion Damage Rating Index for Base Metal Components

		Estimated Corrosion Rate (mpy)			
		≤ 2	2 < x ≤ 6	6 < x ≤ 11	>11
Section Loss	≤ 2%	6 Good	6 Good	5 Satisfactory	5 Satisfactory
	>2% to ≤ 10%	5 Satisfactory	4 Fair	4 Fair	3 Poor
	>10% to ≤ 30%	3 Poor	3 Poor	3 Poor	2 Serious
	> 30%	2 Serious	2 Serious	1 Critical	1 Critical

Example: CD32 Base Metal Ratings

- Ratings and descriptions on Inspection Form
- Measurement data on Inspection Data Form

Base Metal Components and Elements

Element(s)	Rating	Comments
Critical	**5**	Inaccessible. Scored as 5 due to age.
– CS Bulkhead Tie Rod	NA	
Typical	**4**	
– CS Bulkhead Wall	5	The bulkhead wall was in satisfactory condition with minor corrosion at the seams and minimal general section loss, approximately 5% in the splash zone. *Section loss: (Satisfactory, >2% to <10%)* *Estimated Corrosion Rate: (Satisfactory, <2 mpy)* *Governing Zone = Splash*
– CS Fender Piles	4	Impact damage and corrosion of piles was observed near the waterline. Corrosion at the flanges was worst in the splash zone with an average loss of approximately 25%. Webs were in generally good condition with minimal section loss. *Section loss: (Fair, >2% to <10%)* *Estimated Corrosion Rate: (Fair, 6 to 11 mpy)* *Governing Zone = Splash*
Redundant	**3**	
– CS Support Framing	3	Impact damage and corrosion of framing was observed near the waterline, particularly at connections. Framing in splash zone with approximately 12% section loss in the flanges and corrosion at web. *Section loss: (Poor, >10% to 30%)* *Estimated Corrosion Rate: (Poor, 6 to 11 mpy)* *Governing Zone = Splash*

Summary

- Numerical Rating: 1 to 6 scale (Corrosion Damage Rating Index)
  - Thickness Measurements (Section Loss)
  - Estimated Corrosion Rate
- Still have to employ Engineering judgement

Table 6.4. Corrosion Damage Rating Index for Base Metal Components

		Estimated Corrosion Rate (mpy)			
		≤ 2	2 < x ≤ 6	6 < x ≤ 11	>11
Section Loss	≤ 2%	6 Good	6 Good	5 Satisfactory	5 Satisfactory
	>2% to ≤ 10%	5 Satisfactory	4 Fair	4 Fair	3 Poor
	>10% to ≤ 30%	3 Poor	3 Poor	3 Poor	2 Serious
	> 30%	2 Serious	2 Serious	1 Critical	1 Critical

6 – Good
5 – Satisfactory
4 – Fair
3 – Poor
2 – Serious
1 – Critical

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END OF MODULE

Module 6.4

Asset Corrosion Condition Rating

Corrosion Manual Training Course

Module Objectives

Module 6.4 Learning Outcomes

- Understand the overall rating system of the CM program
- Discuss the relationships between component ratings, component combined rating, and asset corrosion condition rating
- Use component ratings to calculate asset corrosion condition ratings

Overview of Process

<u>CM Outcome</u>

Condition Assessment (Module 6.1)

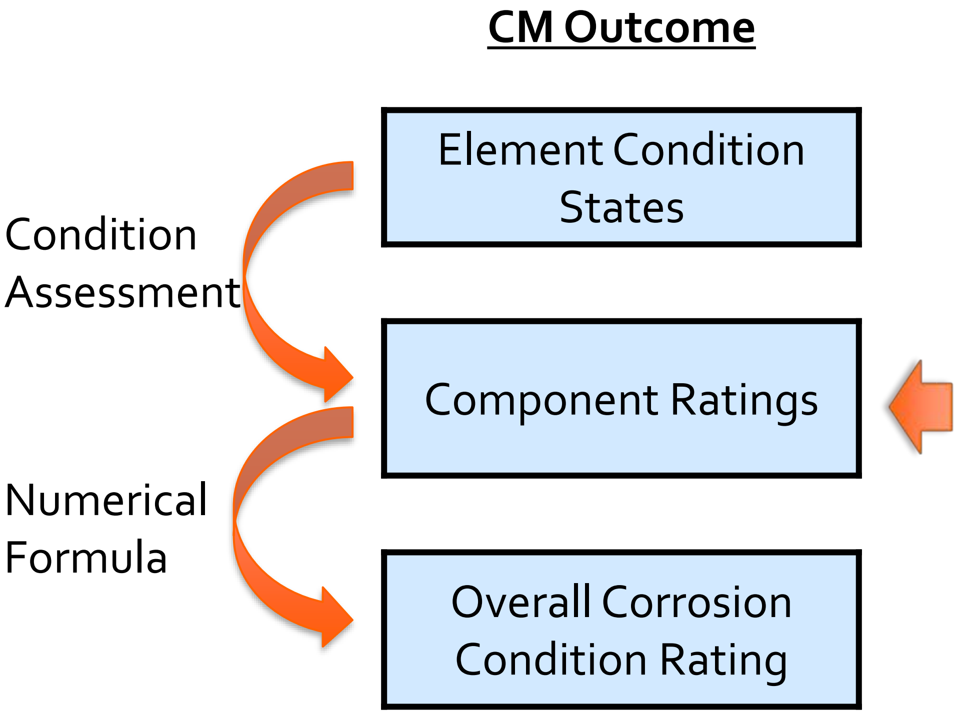
Numerical Formula

Element Condition States — Module 4

Component Ratings — Modules 6.2 and 6.3

Overall Corrosion Condition Rating — Module 6.4

Overview of Process



- Five possible corrosion protection component ratings
  - ICF – ICCP Functionality
  - ICV – ICCP Visual
  - SAF – SACP Functionality
  - SAV – SACP Visual
  - SPR – Surface Protection Rating
- All five corrosion component ratings may not be applicable to each asset

Overview of Process

CM Outcome

Condition Assessment

Element Condition States

Component Ratings

Numerical Formula

Overall Corrosion Condition Rating

- Three possible base metal component ratings
  - CR – Critical
  - TYP – Typical
  - RED - Redundant
- All three base metal components may not be applicable to each asset

Corrosion Condition Rating (CCR)

- A numeric value between 0 and 100 that reflects the overall condition of the asset with respect to corrosion control
  - CCR = CP + BM ($0 \le CCR \le 100$)
    - CP: Corrosion Protection Component Combined Rating ($0 \le CP \le 60$)
    - BM: Base Metal Component Combined Rating ($0 \le BM \le 40$)
    - Calculated based on deductions
  - "Weighted" 60% corrosion protection, 40% base metals

Corrosion Protection Combined Rating

- $0 \leq CP \leq 60$
- Determine deductions based on Table 6.5
- Calculate CP based on numerical equations

Table 6.5: CP Deduction Table

	Component Rating	CP Deductions by Component				
		ICCP Functionality (ICF)	ICCP Visual (ICV)	Sacrificial Anode Functionality (SAF)	Sacrificial Anode Visual (SAV)	Surface Protection (SPR)
Critical	= 1	30	10	30	10	30
Serious	= 2	15	5	15	5	15
Poor	= 3	8	3	8	3	8
Fair	= 4	4	2	4	2	4
Satisfactory	= 5	2	1	2	1	2
Good	= 6	0	0	0	0	0

$CP = 60 - (ICF + ICV + SAF + SAV + SPR) \geq 0$ for assets with each corrosion protection system

$CP = 60 - 1.6 \times (ICF + ICV + SPR) \geq 0$ for assets with no sacrificial anode components

$CP = 60 - 1.6 \times (SAF + SAV + SPR) \geq 0$ for assets with no impressed current components

$CP = 60 - 3.6 \times (SPR) \geq 0$ for assets with only SPR components

Base Metal Combined Rating

- $0 \leq BM \leq 40$
- Determine deductions based on Table 6.7
- Calculate BM based on numerical equation

Table 6.6: BM Deduction Table

	Component Rating	BM Deductions by Component		
		Critical Components	Typical Components	Redundant Components
		CR	TYP	RED
Critical	= 1	40	25	10
Serious	= 2	25	13	5
Poor	= 3	13	6	3
Fair	= 4	6	3	2
Satisfactory	= 5	3	2	1
Good	= 6	0	0	0

$$BM = 40 - (CR + TYP + RED) \geq 0$$

Corrosion Condition Rating Summary

Given: Assessment Complete & Component Ratings

- Corrosion Protection
  - ICCP
  - SACP
  - Surface Protection
- Base Metal
  - Critical
  - Typical
  - Redundant

6 – Good
5 – Satisfactory
4 – Fair
3 – Poor
2 – Serious
1 – Critical

Corrosion Condition Rating Summary

- Step 1: Determine deductions for applicable components

Table 6.5: CP Deduction Table

Component Rating	CP Deductions by Component				
	ICCP Functionality (ICF)	ICCP Visual (ICV)	Sacrificial Anode Functionality (SAF)	Sacrificial Anode Visual (SAV)	Surface Protection (SPR)
= 1	30	10	30	10	30
= 2	15	5	15	5	15
= 3	8	3	8	3	8
= 4	4	2	4	2	4
= 5	2	1	2	1	2
= 6	0	0	0	0	0

Table 6.6: BM Deduction Table

Component Rating	BM Deductions by Component		
	Critical Components	Typical Components	Redundant Components
	CR	TYP	RED
= 1	40	25	10
= 2	25	13	5
= 3	13	6	3
= 4	6	3	2
= 5	3	2	1
= 6	0	0	0

Corrosion Condition Rating Summary

- Step 2: Calculate CP & BM

$CP = 60 - (ICF + ICV + SAF + SAV + SPR) \geq 0$ for assets with each corrosion protection system

$CP = 60 - 1.6 \times (ICF + ICV + SPR) \geq 0$ for assets with no sacrificial anode components

$CP = 60 - 1.6 \times (SAF + SAV + SPR) \geq 0$ for assets with no impressed current components

$CP = 60 - 3.6 \times (SPR) \geq 0$ for assets with only SPR components

$BM = 40 - (CR + TYP + RED) \geq 0$

No deductions if
no CR, TYP, RED component

Corrosion Condition Rating Summary

- Step 3: Calculate CCR
  - CCR = CP + BM ($0 \le CCR \le 100$)
    - CP: Corrosion Protection Component Combined Rating ($0 \le CP \le 60$)
    - BM: Base Metal Component Combined Rating ($0 \le BM \le 40$)

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Corrosion Component	Rating	Deduction
ICF	4	
ICV	5	
SAF	N/A	
SAV	N/A	
SPR	3	

Base Metal Component	Rating	Deduction
CR	5	
TYP	4	
RED	4	

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Corrosion Component	Rating	Deduction
ICF	4	4
ICV	5	
SAF	N/A	
SAV	N/A	
SPR	3	

Table 6.5: CP Deduction Table

Component Rating	CP Deductions by Component				
	ICCP Functionality (ICF)	ICCP Visual (ICV)	Sacrificial Anode Functionality (SAF)	Sacrificial Anode Visual (SAV)	Surface Protection (SPR)
= 1	30	10	30	10	30
= 2	15	5	15	5	15
= 3	8	3	8	3	8
= 4	4	2	4	2	4
= 5	2	1	2	1	2
= 6	0	0	0	0	0

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Corrosion Component	Rating	Deduction
ICF	4	4
ICV	5	1
SAF	N/A	
SAV	N/A	
SPR	3	

Table 6.5: CP Deduction Table

Component Rating	CP Deductions by Component				
	ICCP Functionality (ICF)	ICCP Visual (ICV)	Sacrificial Anode Functionality (SAF)	Sacrificial Anode Visual (SAV)	Surface Protection (SPR)
= 1	30	10	30	10	30
= 2	15	5	15	5	15
= 3	8	3	8	3	8
= 4	4	2	4	2	4
= 5	2	1	2	1	2
= 6	0	0	0	0	0

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Corrosion Component	Rating	Deduction
ICF	4	4
ICV	5	1
SAF	N/A	N/A
SAV	N/A	N/A
SPR	3	

Table 6.5: CP Deduction Table

Component Rating	CP Deductions by Component				
	ICCP Functionality (ICF)	ICCP Visual (ICV)	Sacrificial Anode Functionality (SAF)	Sacrificial Anode Visual (SAV)	Surface Protection (SPR)
= 1	30	10	30	10	30
= 2	15	5	15	5	15
= 3	8	3	8	3	8
= 4	4	2	4	2	4
= 5	2	1	2	1	2
= 6	0	0	0	0	0

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Corrosion Component	Rating	Deduction
ICF	4	4
ICV	5	1
SAF	N/A	N/A
SAV	N/A	N/A
SPR	3	8

Table 6.5: CP Deduction Table

Component Rating	CP Deductions by Component				
	ICCP Functionality (ICF)	ICCP Visual (ICV)	Sacrificial Anode Functionality (SAF)	Sacrificial Anode Visual (SAV)	Surface Protection (SPR)
= 1	30	10	30	10	30
= 2	15	5	15	5	15
= 3	8	3	8	3	8
= 4	4	2	4	2	4
= 5	2	1	2	1	2
= 6	0	0	0	0	0

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Table 6.6: BM Deduction Table

Component Rating	BM Deductions by Component		
	Critical Components	Typical Components	Redundant Components
	CR	TYP	RED
= 1	40	25	10
= 2	25	13	5
= 3	13	6	3
= 4	6	3	2
= 5	3	2	1
= 6	0	0	0

Base Metal Component	Rating	Deduction
CR	5	3
TYP	4	
RED	4	

Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Table 6.6: BM Deduction Table

Component Rating	BM Deductions by Component		
	Critical Components	Typical Components	Redundant Components
	CR	TYP	RED
= 1	40	25	10
= 2	25	13	5
= 3	13	6	3
= 4	6	3	2
= 5	3	2	1
= 6	0	0	0

Base Metal Component	Rating	Deduction
CR	5	3
TYP	4	3
RED	4	

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Example CCR Calculation

- Step 1: Determine deductions for applicable components on the asset

Table 6.6: BM Deduction Table

Component Rating	BM Deductions by Component		
	Critical Components	Typical Components	Redundant Components
	CR	TYP	RED
= 1	40	25	10
= 2	25	13	5
= 3	13	6	3
= 4	6	3	2
= 5	3	2	1
= 6	0	0	0

Base Metal Component	Rating	Deduction
CR	5	3
TYP	4	3
RED	4	2

Example CCR Calculation

- Step 2: Calculate CP

Corrosion Component	Rating	Deduction
ICF	4	**4**
ICV	5	**1**
SAF	N/A	N/A
SAV	N/A	N/A
SPR	3	**8**

CP = 60 - (ICF + ICV + SAF + SAV+SPR) ≥ 0	for assets with each corrosion protection system
CP = 60 - 1.6 x (ICF + ICV + SPR) ≥ 0	for assets with no sacrificial anode components
CP = 60 - 1.6 x (SAF + SAV + SPR) ≥ 0	for assets with no impressed current components
CP = 60 - 3.6 x (SPR) ≥ 0	for assets with only SPR components

$$CP = 60 - 1.6 \times (ICF + ICV + SPR) \geq 0$$
$$= 60 - 1.6 \times (4 + 1 + 8)$$
$$= 39$$

Example CCR Calculation

- Step 3: Calculate BM

Base Metal Component	Rating	Deduction
CR	5	**3**
TYP	4	**3**
RED	4	**2**

$$BM = 40 - (CR + TYP + RED) \geq 0$$
$$= 40 - (3 + 3 + 2)$$
$$= 32$$

Example CCR Calculation

- Step 4: Calculate CCR

$CP = 60 – 1.6 \times (ICF + ICV + SPR) \geq 0$
$= 60 – 1.6 \times (4 + 1 + 8)$
$= 39$

$BM = 40 – (CR + TYP + RED) \geq 0$
$= 40 – (3 + 3 + 2)$
$= 32$

$CCR = CP + BM \geq 0$
$= 39 + 32$
$\mathbf{= 71}$

Example CCR Calculation

- What if we had a slight change in component rating(s)?

Corrosion Component	Rating	Deduction
ICF	4	4
ICV	~~5~~ **4**	~~1~~ **2**
SAF	N/A	N/A
SAV	N/A	N/A
SPR	3	8

Base Metal Component	Rating	Deduction
CR	5	3
TYP	~~4~~ **3**	~~3~~ 6
RED	4	2

$CCR = CP + BM \geq 0$

= ~~*39*~~ *38* + ~~*32*~~ *29*

= ~~71~~ 67

Documentation and Reporting

- Documented on the following forms:
  - Inspection History
  - Inspection Summary
  - PHA Database

Maritime Asset Inspection History

Form CMIH (V1.0)
Barbours Cut Terminal – BCT 5
Last updated: January 27, 2020
Page 1 of 1

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Classification:	Wharf	**Year of Original Construction:**	1990
Inspection Frequency:	Ref. Inspection Plan	**Year(s) of Significant Modifications or Repairs:**	2002, 2004, 2008, 2011

Dates of Inspections, Asset, and Component Ratings

Date:	1/24/2020				
Inspection Type:	Baseline				
Inspection Status	Completed				
Inspection Firm: Above Water	WJE				
Inspection Firm: Underwater	Rio				
Corrosion Condition Rating (CCR)	**70**				
Corrosion Protection (CP)	**38**				
ICCP Functionality	4				
ICCP Visual	4				
SA Functionality	NA				
SA Visual	NA				
Surface Protection	3				
Base Metal (BM)	**32**				
Critical	5				
Typical	4				
Redundant	4				

Inspection History

Documentation and Reporting

Maritime Asset
Corrosion Inspection Summary

Form CMS (V1.0)
Northside Turning Basin – CD 32
May 15, 2020
Page 1 of 11

Property:	Northside Turning Basin	**Asset ID:**	CD 32
Inspection Type	☒ Baseline ☐ Routine ☐ In-Depth	**Inspection Date(s):**	May 20, 2020 (abovewater) August 7, 2020 (underwater)
Scope of Inspection	Entire Asset, Above Water and Under Water		
Inspection Firm(s):	**Prime:** Wiss, Janney, Elstner Associates, Inc.		
	Underwater: Rio Engineering, Inc.		
	Other (role): N/A		
Reported By:	S. Foster, P.E.	**Report Date:**	May 11, 2021
Corrosion Manual Version/Date:	95%, June 2020	**Variances from CM Procedure:**	N/A

Seal of Responsible Engineer

I hereby certify this inspection was performed under my direct supervision and control and to the best of my professional knowledge complies with the Corrosion Manual and applicable codes.

Signed: ______________

Name: Stephen Foster, PE

Texas License No.: 116280

Date: 5/11/21 Expires: 9/30/21

STATE OF TEXAS
STEPHEN W. FOSTER
116280
LICENSED
PROFESSIONAL ENGINEER

Seal

Inspection Team Members

Project Manager: Stephen Foster
Inspection Team Leader(s): Stephen Foster
Inspection Team Member(s): Casey Jones, Kyle Myers, Lane Thompson

Underwater Team Leader: Joe Starkey
Underwater Team Member(s):

Overall, the bulkhead wall was in good condition with minimal measured section loss when compared to design thicknesses. On the other hand, the measured section loss and estimated corrosion rates for the fender elements led to lower ratings. For fender pile elements, moderate section loss was measured in the splash zone along with an approximate corrosion rate of between 6 and 11 mpy, resulting in a poor rating. Corrosion was observed in the support framing with a similar rating.

The corrosion protection system of the wharf appeared to be mostly functional. The rectifier in Bay 5 was not outputting current, likely due to discontinuity in the external leads. Despite this, potentials showed adequate protection for the entire fender and approximately 80 percent of the length of the bulkhead wall. 300mV of overprotection was measured at Bay 16, possible correlating to the coating distress located in this area. Submerged anodes were evaluated as part of the underwater assessment, and overall were in fair condition with minor pitting with some of the anodes having moderate section loss at the ends. This wharf contained two different kinds of anodes, one type of anode is encased within a PVC casing that weighs less and are shorter in length than the original anodes. These more recently installed encased anodes can be visually noted by the splicing of wiring. The original anodes are longer and heavier and are not encased. Note that the weight of the anode includes both the anode and the casing for those which included a PVC casing. The wiring of all anodes and supports appeared intact and functioning.

The second ICCP system installed on the upstream bulkhead wall under I-610 was non-functional. At a minimum, the rectifier was non-functional and therefore, measurements could not be obtained with the system turned on.

ICF (Functional) Component Rating = 4 (Deduction = 4)
ICV (Visual) Component Rating = 3 (Deduction = 3)
SPR Rating = 4 (Deduction = 4)
CP = 60 - 1.6 x (ICF + ICV + COA) = 60 - 1.6 x (4 + 3 + 4) = 42

CR Rating = 5 (Deduction = 3)
TYP Rating = 4 (Deduction = 3)
RED Rating = 3 (Deduction = 3)
BM = 40 - (CR + TYP + RED) = 40 - (3 +3 + 3) = 31

CCR = CP + BM = 42 + 31 = 73

The overall asset corrosion condition rating (CCR) for CD 32 is 73.

Inspection Summary

Documentation and Reporting

- In addition to the CCR, Inspection Summary forms are to include:
  - Brief discussion of the ratings for all corrosion and base metal components of the asset
  - Discussion of the implications of the reported component ratings on the overall corrosion condition rating and recommended actions
  - Discussion of recommended follow-up actions.

Module Wrap-Up

- Summarize Corrosion Manual approach to condition assessment of components and assets
- Assign component ratings for ICCP, SACP, Surface Protection and Base Metal components
- Use component ratings to determine the overall asset corrosion condition rating (CCR)
- Use of Corrosion Manual Inspection Summary Form and Inspection History Form to record condition assessment information

END OF MODULE

Module 7.1

Recommended Follow-up Actions

Corrosion Manual Training Course

Module Objectives

Module 7.1 Learning Outcomes

- Describe the categories of recommended follow-up actions
- Formulate follow-up action recommendations
- Distinguish between immediate, priority, and routine follow-up actions
- Document follow-up actions using appropriate forms

Module References

- Chapter 7: Recommended Follow-Up Action Guidelines
- Appendix F: Documentation and Reporting Forms
    - Follow-Up Action Form

Recommended Follow-Up Actions

- Follow-Up Actions helps guide *what should happen next* for each asset
  - Assists PHA with planning and management decisions
- Possible options
  - No Action Required
  - Routine Follow-Up Action
  - Priority Follow-Up Action
  - In-Depth Inspection
  - Refined Analysis
  - Immediate Actions (emergency)
  - Inspection Plan Modifications

Follow-Up Actions

- Conditions requiring maintenance
- Conditions requiring minor repairs
- Conditions requiring replacement of one or more non-structural element
- Elements where a condition state of CS4 (Severe) was assigned during the inspection
- CP systems for which functionality has been affected

Priority vs. Routine Actions

- **<u>Priority</u>** – The action to address the observed condition should ***take precedence over other actions*** (e.g. routine actions), but the condition needing repair does not appear to immediately compromise the structural integrity
  - May affect functionality
  - May be necessary to prevent further damage, deterioration, or defects from reaching the point at which future repairs become significantly more costly

Priority vs. Routine Actions

- **Routine** – The action can be addressed as part of a routine ***maintenance*** program
  - Scheduled in the future without compromising the structural integrity or functionality of the asset
  - Waiting does not significantly increase the future costs of the maintenance or repair

Immediate Actions

- **Immediate** – Required when an inspection identifies severe conditions that have occurred, or appear likely to occur, that have the potential for ***property or environmental damage***, or that may affect ***structural integrity*** or facility operations
  - Notify Port Houston immediately by phone and in writing with documentation within 24 hours
  - Provide justification for the immediate action

In-Depth Inspection

- **<u>In-Depth Inspection</u>** – May be recommended as a follow-up action to a in order to obtain the information required:
  - For the preparation of repair design and construction documents
  - Where atypical conditions have been identified that require more information to access
  - When functionality of corrosion protection systems have been compromised for reasons unable to be identified during the Routine Inspection

Recommended Follow-Up Actions

- Every Baseline and Routine Inspection requires completion of the “Follow-Up Actions Form”
  - If no conditions require action, recommendation is ***“No action required”***
  - If needed, engineer should recommend timing for next Inspection:
    - Based on standard interval (Table 2.1)
    - Increased or reduced interval* (*Final selection by Port Houston)

Examples

Follow-Up Action Examples

- **Component:** Surface Protection
- **Elements:** Coatings (CT-CE)
- **Follow-up Action:** Recoating warranted
- **Priority?** Routine

Follow-Up Action Examples

- **Corrosion Component:** ICCP
- **Element:** TRU DC Power Supply (PW-TRU)
- **Follow-up Action:** Perform follow-up investigation to determine cause(s) and repair or replace system
- **Priority?** Priority


Rectifier is non-functional

Follow-Up Action Examples

- **Corrosion Component:** ICCP
- **Element:** TRU DC Power Supply (PW-TRU)
- **Follow-up Action:** Restore and/or replace support to electrical breaker panel support leg to a secure position
- **Priority?** Priority

Follow-Up Action Examples

- **Corrosion Component:** ICCP
- **Element:** Wiring (WI-CU)
- **Follow-up Action:** Restore and/or replace bond wire connections between each fender pile and support framing.
- **Priority?** Routine

Follow-Up Action Examples

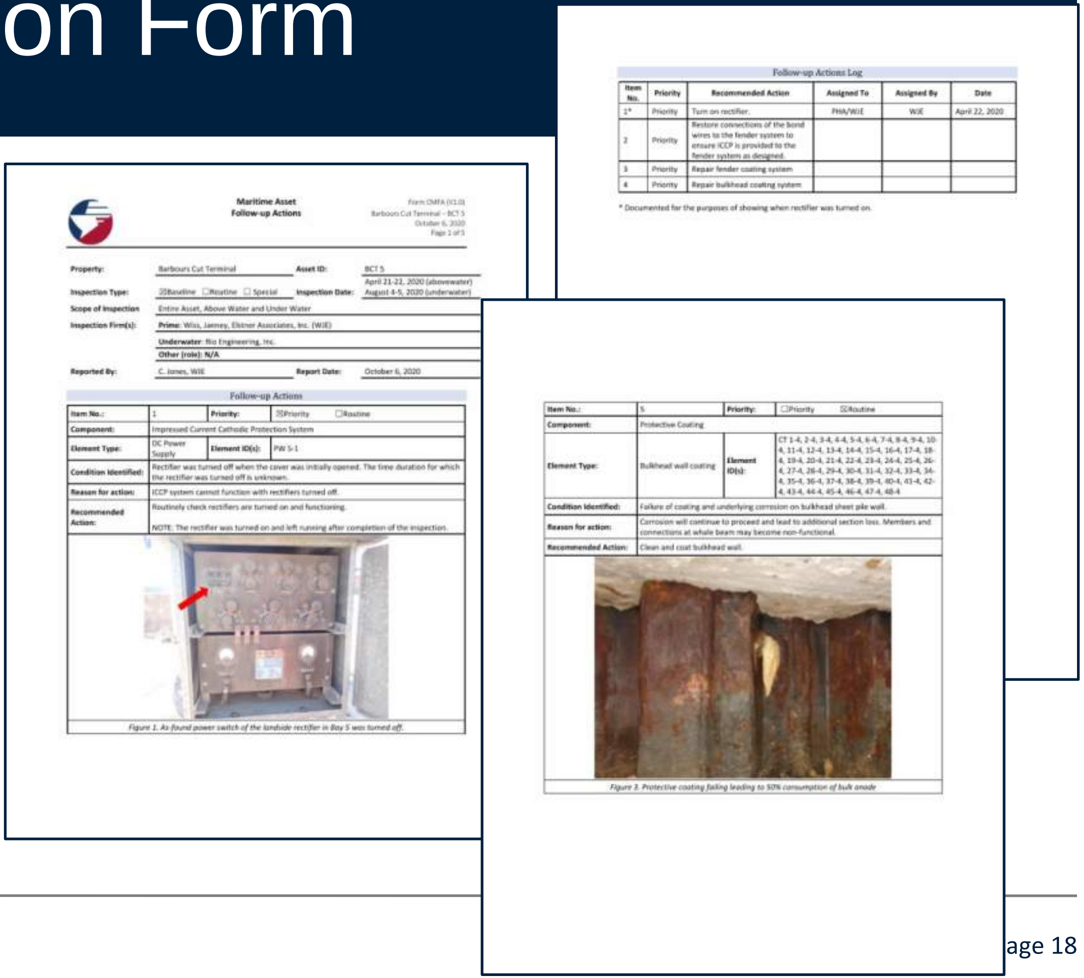
- **Component:** Surface Protection
- **Elements:** Coatings (CT-EP)
- **Follow-up Action:** Recoating of the bulkhead wall should be considered
- **Priority?** Routine

Follow-Up Action Examples

- **Corrosion Component:** ICCP
- **Element:** Wiring (WI-CU) & Supports (SI-GS)
- **Follow-up Action:** Replace anode supports in Bays 56 and 59 and anodes in Bay 56. Ensure anodes are submerged at design elevations.
- **Priority?** Routine

Follow-Up Action Form

- Summary of Recommended Follow-Up Actions
- Asset Identification
- Inspection Information
- Follow-Up Action(s) & Log



Maritime Asset Follow-up Actions

Form OMFA (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 1 of 5

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Inspection Type:	☒Baseline ☐Routine ☐ Special	**Inspection Date:**	April 21-22, 2020 (abovewater) August 4-5, 2020 (underwater)
Scope of Inspection	Entire Asset, Above Water and Under Water		
Inspection Firm(s):	**Prime**: Wiss, Janney, Elstner Associates, Inc. (WJE)		
	Underwater: Rio Engineering, Inc.		
	Other (role): N/A		
Reported By:	C. Jones, WJE	**Report Date:**	October 6, 2020

Follow-up Actions

Item No.:	1	**Priority:**	☒Priority ☐Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	Rectifier was turned off when the cover was initially opened. The time duration for which the rectifier was turned off is unknown.		
Reason for action:	ICCP system cannot function with rectifiers turned off.		
Recommended Action:	Routinely check rectifiers are turned on and functioning. NOTE: The rectifier was turned on and left running after completion of the inspection.		

Figure 1. As-found power switch of the landside rectifier in Bay 5 was turned off.

Follow-up Actions Log

Item No.	Priority	Recommended Action	Assigned To	Assigned By	Date
1*	Priority	Turn on rectifier.	PHA/WJE	WJE	April 22, 2020
2	Priority	Restore connections of the bond wires to the fender system to ensure ICCP is provided to the fender system as designed.			
3	Priority	Repair fender coating system			
4	Priority	Repair bulkhead coating system			

* Documented for the purposes of showing when rectifier was turned on.

Item No.:	5	**Priority:**	☐Priority ☒Routine
Component:	Protective Coating		
Element Type:	Bulkhead wall coating	**Element ID(s):**	CT 1-4, 2-4, 3-4, 4-4, 5-4, 6-4, 7-4, 8-4, 9-4, 10-4, 11-4, 12-4, 13-4, 14-4, 15-4, 16-4, 17-4, 18-4, 19-4, 20-4, 21-4, 22-4, 23-4, 24-4, 25-4, 26-4, 27-4, 28-4, 29-4, 30-4, 31-4, 32-4, 33-4, 34-4, 35-4, 36-4, 37-4, 38-4, 39-4, 40-4, 41-4, 42-4, 43-4, 44-4, 45-4, 46-4, 47-4, 48-4
Condition Identified:	Failure of coating and underlying corrosion on bulkhead sheet pile wall.		
Reason for action:	Corrosion will continue to proceed and lead to additional section loss. Members and connections at whale beam may become non-functional.		
Recommended Action:	Clean and coat bulkhead wall.		

Figure 3. Protective coating failing leading to 50% consumption of bulk anode

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Recommended Follow-Up Actions

- Important Points:
  - More than one recommended action may arise from the condition assessment of a given asset
  - All actions should be prioritized in a consistent manner
  - A brief justification (written explanation) should be provided for any recommended actions
  - Documented on **Follow-Up Actions Form**

Required Documentation

- Follow-Up Actions Form
  - List all follow-up actions for given asset
  - Complete follow-up actions log for PHA use

PORT HOUSTON

Maritime Asset
Follow-up Actions

Form MSFA (V1.1)
Property – Asset ID
MMMM DD, YYYY
Page 1 of 8

Property:	Property	**Asset ID:**	Asset ID
Inspection Type:	☐Baseline ☐Routine ☐ Special	**Inspection Date:**	MMMM DD, YYYY
Scope of Inspection	[Entire Asset] / [Limited; Bays ## to ##]		
Inspection Firm(s):	**Prime:** [Firm Name]		
	Underwater: [Firm Name]		
	Other (role): [Firm Name]		
Reported By:	[L. Inspector]	**Report Date:**	MMMM DD, YYYY

Follow-up Actions

Item No.:	1	**Priority:**	☐Priority ☐Routine
Component:			
Element Type:		**Element ID(s):**	
Condition Identified:			
Reason for action:			
Recommended Action:			

Representative Photos

Figure 1. Overall view of location | *Figure 2. Close-up view of condition*

PORT HOUSTON

Maritime Asset
Follow-up Actions

Form MSFA (V1.1)
Property – Asset ID
MMMM DD, YYYY
Page 2 of 8

Follow-up Actions Log

Item No.	Priority	Action	Assigned To	Assigned By	Date
1	Priority	Schedule follow-up investigation	P. Manager	D. Engineer	MM-DD-YYYY

Appendix F

Example:
No Action Required

Using Follow-Up Action Form
(See Section 8.9)

Item No.:	1	Priority:	☐Priority ☐Routine
Component:	n/a		
Element Type:	n/a	Element ID(s):	n/a
Condition Identified:	No action required		
Reason for action:	Asset condition does not warrant further action at this time.		
Recommended Action:	Schedule next Routine Inspection at standard interval (3 yrs above water, 6 yrs below water)		

N/A	N/A
Figure 1. Overall view of location	*Figure 2. Close-up view of condition*

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Required Documentation

- Required information

Item No.:	1	**Priority:**	☐Priority ☒Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	(DISP) Error in Output Display Panels : CS4 (Severe) Panel ammeter displays 0 amps of current, voltage drop was measured across shunt and 20 amps of current was recorded, verifies broken panel meter and overall CP system is unaffected		
Reason for action:	To easily observe amount of current provided by rectifier		
Recommended Action:	Follow-up investigation to include: Replace meter or mark meter and record ammeter panel as broken. Ensures workers ignore panel reading and record current measurement across shunt to verify system is performing properly.		

Figure 1. Broken ammeter displaying 0 amps of current

Required Documentation

- Required information
  - Priority

Item No.:	1	**Priority:**	☐Priority ☒Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	(DISP) Error in Output Display Panels : CS4 (Severe) Panel ammeter displays 0 amps of current, voltage drop was measured across shunt and 20 amps of current was recorded, verifies broken panel meter and overall CP system is unaffected		
Reason for action:	To easily observe amount of current provided by rectifier		
Recommended Action:	Follow-up investigation to include: Replace meter or mark meter and record ammeter panel as broken. Ensures workers ignore panel reading and record current measurement across shunt to verify system is performing properly.		

Figure 1. Broken ammeter displaying 0 amps of current

Required Documentation

- Required information
  - Priority
  - Component
  - Element Type and ID(s)

Item No.:	1	**Priority:**	☐Priority ☒Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	(DISP) Error in Output Display Panels : CS4 (Severe) Panel ammeter displays 0 amps of current, voltage drop was measured across shunt and 20 amps of current was recorded, verifies broken panel meter and overall CP system is unaffected		
Reason for action:	To easily observe amount of current provided by rectifier		
Recommended Action:	Follow-up investigation to include: Replace meter or mark meter and record ammeter panel as broken. Ensures workers ignore panel reading and record current measurement across shunt to verify system is performing properly.		

Figure 1. Broken ammeter displaying 0 amps of current

Required Documentation

- Required information
  - Priority
  - Component
  - Element Type and ID(s)
  - Condition Identified
  - Reason for Action
  - Recommended Action(s)

Item No.:	1	**Priority:**	☐Priority ☒Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	(DISP) Error in Output Display Panels : CS4 (Severe) Panel ammeter displays 0 amps of current, voltage drop was measured across shunt and 20 amps of current was recorded, verifies broken panel meter and overall CP system is unaffected		
Reason for action:	To easily observe amount of current provided by rectifier		
Recommended Action:	Follow-up investigation to include: Replace meter or mark meter and record ammeter panel as broken. Ensures workers ignore panel reading and record current measurement across shunt to verify system is performing properly.		

Figure 1. Broken ammeter displaying 0 amps of current

Required Documentation

- Required information
  - Priority
  - Component
  - Element Type and ID(s)
  - Condition Identified
  - Reason for Action
  - Recommended Action(s)
  - Photograph(s)

Item No.:	1	**Priority:**	☐Priority ☒Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	(DISP) Error in Output Display Panels : CS4 (Severe) Panel ammeter displays 0 amps of current, voltage drop was measured across shunt and 20 amps of current was recorded, verifies broken panel meter and overall CP system is unaffected		
Reason for action:	To easily observe amount of current provided by rectifier		
Recommended Action:	Follow-up investigation to include: Replace meter or mark meter and record ammeter panel as broken. Ensures workers ignore panel reading and record current measurement across shunt to verify system is performing properly.		

Figure 1. Broken ammeter displaying 0 amps of current

Example Follow-Up Actions

Item No.:	2	**Priority:**	☒Priority ☐Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW24-1
Condition Identified:	Shunt value is indicated as a .1ohm resistor, however after obtaining voltage drops and current values the resistance value was recorded to be .01 ohm. Can be due to loose connection or resistor being overheated due to excessive voltage exceeding the power rating.		
Reason for action:	Damaged shunt inaccurately records current measurements and can lead to improper setting of rectifier.		
Recommended Action:	Replace shunt.		

Figure 3. Shunt improperly working, Resistance value does not equal .1ohm as indicated on label

Item No.:	5	**Priority:**	☒Priority ☐Routine
Component:	Protective Coating		
Element Type:	Bulkhead wall coating	**Element ID(s):**	CT 1-4, 2-4, 3-4, 4-4, 5-4, 6-4, 7-4, 8-4, 9-4, 10-4, 11-4, 12-4, 13-4, 14-4, 15-4, 16-4, 17-4, 18-4, 19-4, 20-4, 21-4, 22-4, 23-4, 24-4, 25-4, 26-4, 27-4, 28-4, 29-4, 30-4, 31-4, 32-4, 33-4, 34-4, 35-4, 36-4, 37-4, 38-4, 39-4, 40-4, 41-4, 42-4, 43-4, 44-4, 45-4, 46-4, 47-4, 48-4
Condition Identified:	Failure of coating and underlying corrosion on bulkhead sheet pile wall.		
Reason for action:	Corrosion will continue to proceed and lead to additional section loss. Members and connections at whale beam may become non-functional.		
Recommended Action:	Clean and coat bulkhead wall.		

Figure 5. Protective coating failure leading to 50% section loss of wall

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END OF MODULE

Module 8.1

Overall Documentation and Reporting Requirements

Corrosion Manual Training Course

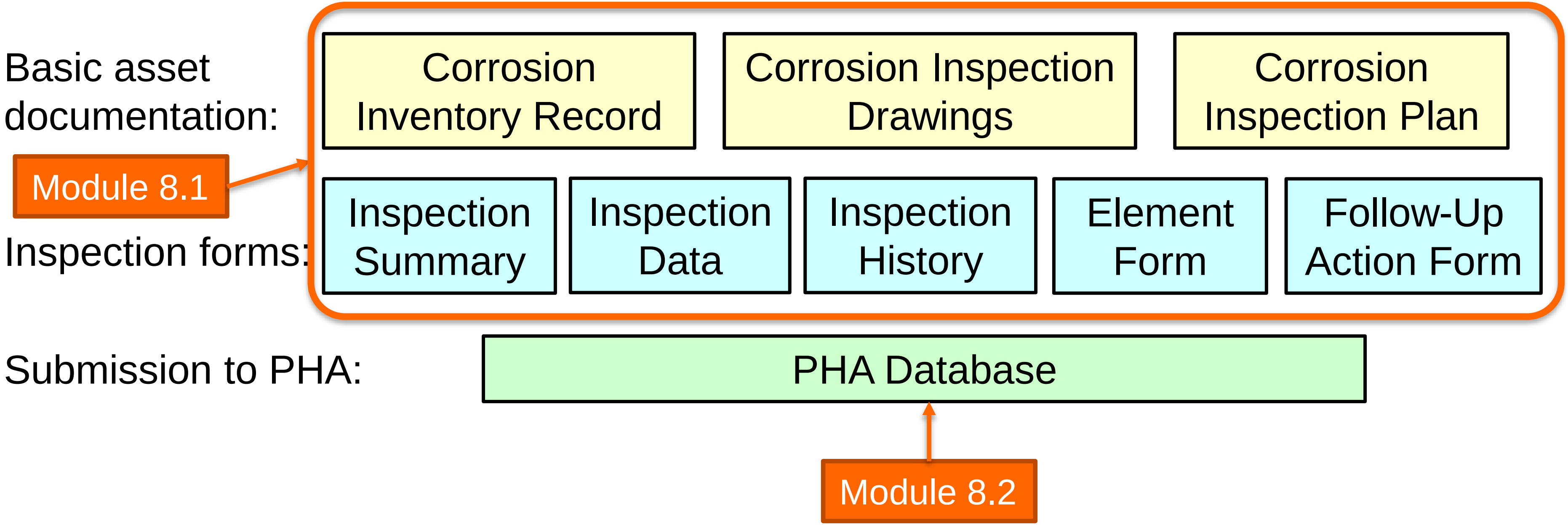
Module Objectives

- Describe overall documentation and reporting requirements for each type of inspection
- Describe the purpose of each type of documentation required by the Corrosion Manual

Module Resources

- Chapter 8: Documentation and Reporting
- Appendix F: Documentation and Reporting Forms
- Module 3.2 of Training Course

Documentation Overview



Corrosion Inventory Record

Record of as-built condition of asset.

<u>Includes:</u> *Asset Identification*
Asset Type
Original Date of Construction
Date(s) of Rehabilitation or Modification
Geometric Data
Corrosion Protection History
Asset History
Reference Drawing List
Components and Elements
Figures
Revision History

Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 1 of 8

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Last Inventory Record Update:**	January 24, 2020

Asset Geometric Data

Area:	36 acres	**Deck Elevation above MLT:**	18 ft. 0 in.
Structure Length:	1000 ft.	**Channel Depth at Fender:**	44 ft. 6 in.
Structure Width:	Deck: 108 ft. 9 in.	**Channel Depth at Bulkhead:**	7 ft. 6 in.

Recommended Access: Pedestrian access to structure top side and landside bulkhead via catwalks; boat access required to channel-side of bulkhead wall (8-foot design clear span between drilled shafts).

Structure Corrosion Protection History

BCT 5 is located near the west end of the Barbour's Cut Terminal along the south side of the channel. The original structural drawings are dated 1989, and wharf construction was completed in 1992. Several noteworthy repairs and modifications performed at various times during the service life of the wharf include the following:

- 2002: Repair and localized recoating of fender system.
- 2004: Repair and localized recoating of fender system.
- 2004: Repair of the crane rail expansion joint.
- 2008: Repair and localized recoating of fender system.
- 2011: Repair and localized recoating of fender system.

Barbour's Cut - Phase II

Generated as part of Baseline Inspection. Revised as part of Routine Inspection only if changes are identified.

PORT HOUSTON
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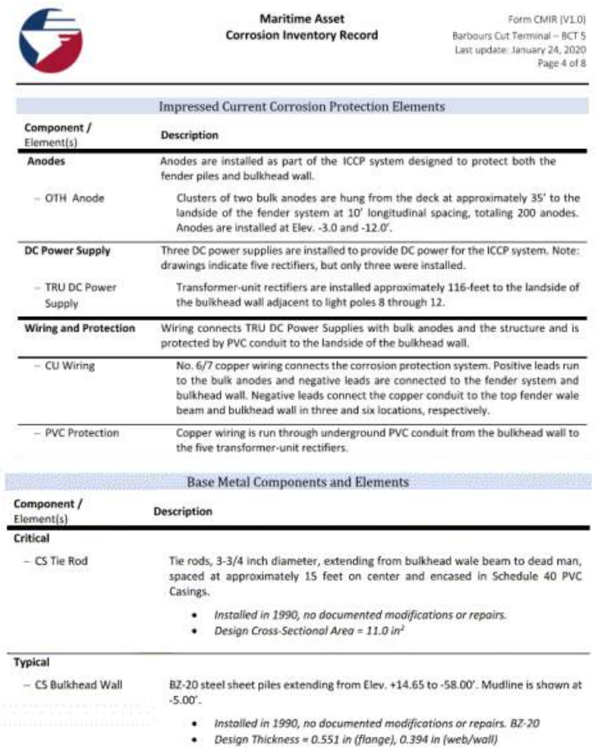
Corrosion Inventory Record



Maritime Asset
Corrosion Inventory Record

Form CMIR (V1.0)
Barbours Cut Terminal – BCT 5
Last update: January 24, 2020
Page 4 of 8

Impressed Current Corrosion Protection Elements

Component / Element(s)	Description
Anodes	Anodes are installed as part of the ICCP system designed to protect both the fender piles and bulkhead wall.
– OTH Anode	Clusters of two bulk anodes are hung from the deck at approximately 35' to the landside of the fender system at 10' longitudinal spacing, totaling 200 anodes. Anodes are installed at Elev. -3.0 and -12.0'.
DC Power Supply	Three DC power supplies are installed to provide DC power for the ICCP system. Note: drawings indicate five rectifiers, but only three were installed.
– TRU DC Power Supply	Transformer-unit rectifiers are installed approximately 116-feet to the landside of the bulkhead wall adjacent to light poles 8 through 12.
Wiring and Protection	Wiring connects TRU DC Power Supplies with bulk anodes and the structure and is protected by PVC conduit to the landside of the bulkhead wall.
– CU Wiring	No. 6/7 copper wiring connects the corrosion protection system. Positive leads run to the bulk anodes and negative leads are connected to the fender system and bulkhead wall. Negative leads connect the copper conduit to the top fender wale beam and bulkhead wall in three and six locations, respectively.
– PVC Protection	Copper wiring is run through underground PVC conduit from the bulkhead wall to the five transformer-unit rectifiers.

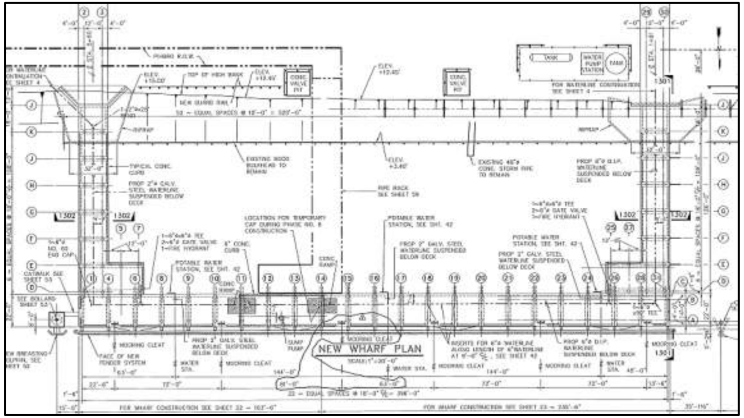
Base Metal Components and Elements

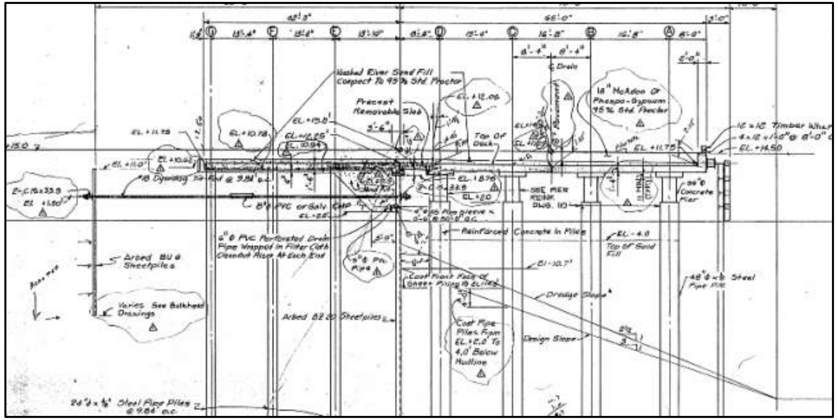
Component / Element(s)	Description
Critical	
– CS Tie Rod	Tie rods, 3-3/4 inch diameter, extending from bulkhead wale beam to dead man, spaced at approximately 15 feet on center and encased in Schedule 40 PVC Casings. • *Installed in 1990, no documented modifications or repairs.* • *Design Cross-Sectional Area = 11.0 in²*
Typical	
– CS Bulkhead Wall	BZ-20 steel sheet piles extending from Elev. +14.65 to -58.00'. Mudline is shown at -5.00'. • *Installed in 1990, no documented modifications or repairs. BZ-20* • *Design Thickness = 0.551 in (flange), 0.394 in (web/wall)*

- List of components and elements
  - Corrosion Protection
    - ICCP
    - SACP
    - Surface Protection
  - Base Metals
    - Critical, Typical, Redundant
    - Includes design thickness

Corrosion Inspection Drawings

- Original construction drawings may be too complicated or cluttered to use as inspection drawings





Corrosion Inspection Drawings

Record of as-built condition of asset.

Includes: *Layout of the structure*
Naming of bays
Types and locations of elements within the scope of the corrosion manual

Generated as part of Baseline Inspection. Revised as part of Routine Inspection only if changes are identified.

Table 8.1. List of Standard Inspection Drawings

Sheet Number	Sheet Description	Information Included
G-001	Title	Asset name PHA drawing number Date of drawing set Vicinity map Asset location map
G-002	Project Information	Sheet Index Key Plan, referencing asset plan sheets (i.e. G-1XX). The Key Plan should have notes/labels consistent with structure history on Corrosion Inventory Record form (i.e., indicate significant modifications, repairs, expansions, partial demolitions). List of Referenced Historical Drawings Definitions of Symbols Definitions of Abbreviations
G-10(x)	Bay Plan(s)	Plan view of topside of structure. Asset may be broken into multiple pages. Bays outlined and denoted per Corrosion Manual scheme (see Section 8.4.1). Grid lines, based on historic drawings if possible. Overall dimensions of bays. North Arrow Channel Designation
G-11(x)	Corrosion Protection Element Plan(s)	Corrosion Protection elements individually outlined and labeled.* Drawn as plan views. Applicable views may include the superstructure and deck elements cut at the structure topside and/or the substructure and fender elements cut below the deck level. Sheets to be ordered from Upper Plan to Lower Plan.
G-12(x)	Base Metal Element Plan(s)	Base Metal elements individually labeled.* Drawn as plan views. Applicable views may include the superstructure and deck elements cut at the structure topside and/or the substructure and fender elements cut below the deck level. Sheets to be ordered from Upper Plan to Lower Plan.
G-20(x)	Typical Sections	Cross-sections through representative portions of wharf. Include a separate cross-section for significant changes in structure configuration (e.g., change in pile type, arrangement of beams, width of structure, etc.). Provide elevations for Top of Deck; Mean Low Tide. Label typical elements with name and element code (e.g., Polyurethane Coating (CT-PU)).
G-30(x)	Typical Elevations	Elevation view of typical bay(s), as viewed from the channel. Include major corrosion protection and base metal Elements. Label typical elements with name and element code (e.g., Polyurethane Coating (CT-PU)).

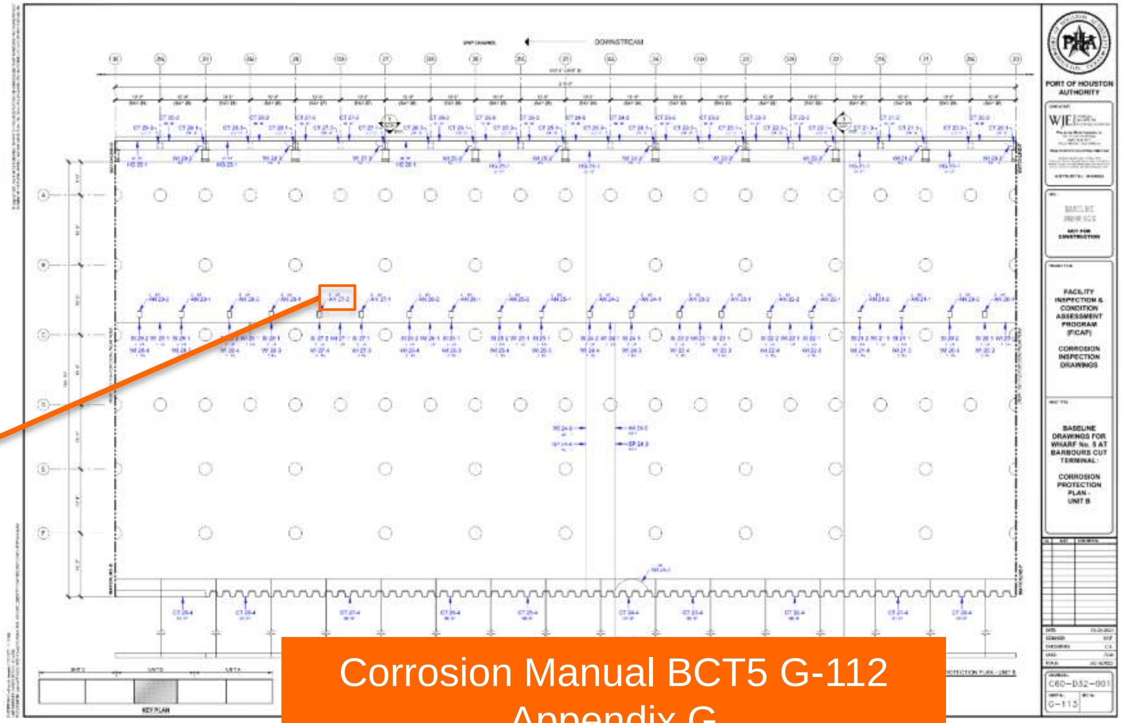
* See Section 8.4.2 for Element labeling and identification scheme

Corrosion Inspection Drawings

- Corrosion Protection Plan
- Schematic layout of corrosion elements
- Element IDs labelled

AN 27-2

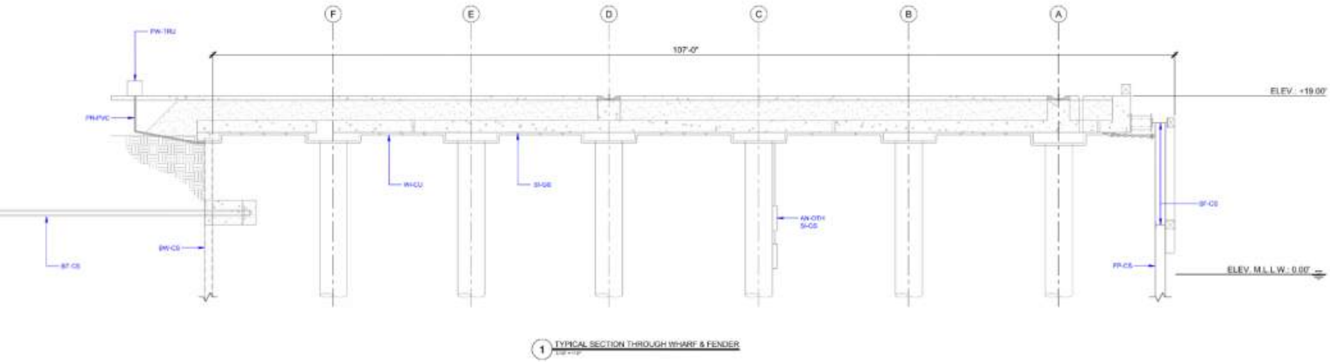
Element Code	Bay Number	Element Number
DT, PI, WL, etc.	*1, 2A, 2B, etc.*	*1, 2, 3, etc.*



Corrosion Manual BCT5 G-112 Appendix G

Corrosion Inspection Drawings

- Typical Sections
- Cross-sectional layout of corrosion and base metal elements



Corrosion Manual BCT5 G-201
Appendix G

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Corrosion Inspection Plan

- Define inspection procedures
  - Applicable standards
  - Specific test locations
  - Based on element and exposure zone

Maritime Asset
Corrosion Inspection Plan

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Type:	Wharf	**Year of Original Construction:**	1990
Wharf Type:	Open	**Year(s) of Significant Modifications or Repairs[1]:**	2002, 2004, 2008, 2011
Wharf Usage:	Containerized Cargo	**Date of Most Recent Inspection:**	April 2020 (above-water) August 2020 (below-water)

Inspection Plan

Functionality Checks (Inspection Frequency = 6 months)

- Measure and record electrical measurements from (3) Transformer-Unit Rectifiers, which includes current output, voltage output, and functionality

Functionality Checks (Inspection Frequency = 1 year)

- Visual inspection of the nine weld connections between the negative leads and structure (3 to the fender wale beams and 6 to the bulkhead wall)
  - Terminal ring leads for structure and negative leads have good crimp connections
  - Inspect for loose or broken wires of structure and negative connections
  - Remove corrosion product from electrical connections if necessary to provide electrical continuity
- Measure and record on/off structure-to-electrolyte potentials to determine polarization decay of base metal elements in general accordance with Test Method 3 of NACE TM0497 to determine if CP is adequate to criterion in NACE SP0169.
  - At a minimum, testing should be performed at the same five locations during the Baseline Inspection:
    - Bays 5, 24, and 47 (near locations of negative structure connections)
    - Bays 14 and 33 (approximately midway between negative structure connections)

Tier 1 Tasks (Inspection Frequency = 3 years)

- Visual assessment of all accessible corrosion protection and bare metal elements
- Perform non-destructive measurements for elements as specified below. Measurement locations are recorded on Corrosion Element Inspection Forms. Readings should be obtained from same locations as those during the Baseline Inspection for comparable results.
  - UT Measurements: Prepare Uncoated Surfaces per SSPC- SP 3, SP 11, or as required per device manufacturer
  - Coating Thickness Measurements: Prepare Surfaces per SSPC-SP 1

Element	Exposure Zone	Required Inspections[1]
CS Tie Rod	Soil	Visually observe encasement concrete. Cracking may be indicative of corrosion distress of tie rod.
CS Bulkhead Wall	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web)

Maritime Asset
Corrosion Inspection Plan

Element	Exposure Zone	Required Inspections[1]
		Coating Thickness Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Fender Piles	Atmospheric	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations
	Splash	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Tidal	Ultrasonic Thickness Measurements: 12 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 12 locations
	Submerged (Tier 2)	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
CS Support Framing	Atmospheric	Ultrasonic Thickness Measurements: 5 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 5 locations
	Splash	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness Measurements: 8 locations
	Tidal	Ultrasonic Thickness Measurements: 8 locations (each at flange and web) Coating Thickness and/or Adhesion Measurements: 8 locations

[1]Test locations shall be representative of the condition of the given element within the entire bay. Unless specific conditions were noted during the visual survey or FICAP inspection that warrant acquiring data for specific bays, bays where data is to be acquired are listed below:

- 5 Locations: Bays 5, 14, 24, 33, and 43
- 8 Locations: Bays 3, 9, 15, 22, 29, 35, 41, and 47
- 12 Locations: Bays 1, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, and 46

Tier 2 Tasks (Inspection Frequency = 6 years)

- Level I underwater diving inspection of anodes as defined in ASCE 101
  - 100 percent verification of anode placement and connection of positive lead to each anode
- Level II underwater cleaning and inspection of anodes at 10% of anodes:
  - Bays 5, 14, 24, 33, and 43
- Level III underwater thickness and weight measurements of anodes:
  - Bays 5, 24, and 43
- Level III underwater thickness and weight measurements of base metal elements and coatings (shown in Table above)
  - Bays 5, 14, 24, 33, and 43

Tier 3 Tasks

- No planned Tier 3 inspections of buried tie rods unless warranted during future inspections.

Revision History

Rev. No.	Developed by	Date	Verified by	Date	Comments
0	C. Jones	01/27/2020	S. Foster	01/27/2020	Baseline
1	C. Jones	NA	S. Foster	NA	Routine inspection developed
2	S. Foster	10/11/2022		10/11/2022	Updated for 100% Manual

Appendix F

Corrosion Inspection Summary

- Asset Condition
  - Corrosion Condition Rating (CCR)
  - Corrosion Protection Rating
  - Base Metal Rating
- Component Ratings by element group w/ comments
- Photographs

Required for all inspection types.

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Maritime Asset
Corrosion Inspection Summary

Form CMIS (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 2 of 20

Overall Asset Condition

Overall, the base metal elements were in fair condition with minor to moderate measured section loss. The estimated corrosion rates for the bulkhead wall, fender piles, and fender support framing were all ranked with a damage index of fair to good. There are, however, several localized areas of distress that should be prepared and recoated to maintain the current condition of the assets.

The corrosion protection systems appeared to be functioning as intended for the bulkhead wall, but not the fender piles. Current output and structure-to-electrolyte potential measurements indicate that the system is operating as intended and providing sufficient cathodic protection to the bulkhead wall. The bond wires to the fender piles were all severed and non functional.

ICF (Functional) Component Rating = 4 (Deduction = 4)
ICV (Visual) Component Rating = 4 (Deduction = 2)
SPR Rating = 3 (Deduction = 8)
CP = 60 - 1.6 x (ICF + ICV + COA) = 60 - 1.6 x (4 + 2 + 8) = 38

CR Rating = 5 (Deduction = 3)
TYP Rating = 4 (Deduction = 3)
RED Rating = 4 (Deduction = 2)
BM = 40 - (CR + TYP + RED) = 40 - (3 +3 + 2) = 32

CCR = CP + BM = 38 + 32 = 70

The overall corrosion condition rating (CCR) for BCT 5 is 70

Impressed Current Corrosion Protection Elements

Element(s)	Rating	Comments
Anodes	**4**	Limited moderate marine growth or section loss. Most elements and their attachment are sound and functional purpose/use of the component is not affected.
– OTH Bulk Anode	4	
DC Power Supply	**4 (Functional)** **4 (Visual)**	All three rectifiers are functional, proper gage readings and DC outputs were verified. PWS-1 was turned off upon arrival of the inspector, however, it was deemed functional when turned on.
– TRU DC Power Supply	4 (Funct) 4 (Visual)	All six "on" potentials of the bulkhead wall were measured as more negative than -850 mV vs. CSE. All of the "Instant off" potentials were measured as more negative than -850mV vs. CSE and more positive than -1250 mV. Measured potentials at the fender did not meet any established criteria due to disconnection of the bond wires.
Wiring and Protection	**3**	Wiring and protection was in satisfactory condition. Negative lead wiring from the bulkhead wall appeared to be in satisfactory condition with minor corrosion at the connections. Positive lead wiring to the anodes exhibited
– CU Wiring	3	

Base Metal Components and Elements

Element(s)	Rating	Comments
Critical	**NA**	Inaccessible. Rated as 5 for scoring purposes due to age.
– CS Tie Rod	NA	
Typical	**4**	
– CS Bulkhead Wall	5	The bulkhead wall was in satisfactory condition with minor corrosion at the seams and minimal general section loss, mostly in the splash and tidal zone. In 30 years of service, the average section loss was approximately 5 to 6%. *Section loss: (>2% to ≤ 10% satisfactory)* *Estimated Corrosion Rate: (Satisfactory <2mpy)*
– CS Fender Piles	4	Impact damage and corrosion of piles was observed near the waterline, with an average section loss of approximately 27% near the ends of the flanges. Webs typically have minimal section loss apart from stiffeners Overall, fair amount of section loss with estimated corrosion rate between 6 and 11 mpy. *Section loss: (Fair <10%)* *Estimated Corrosion Rate: (Fair, 6 < x ≤ 11 mpy)*
Redundant	**4**	
– CS Support Framing	4	Impact damage and corrosion of framing was observed near the waterline, particularly at connections. *Section loss: (>2% to ≤ 10%, Fair)* *Estimated Corrosion Rate: (2 < x ≤ 6 mpy, Fair)*

corrosion or distress.

Figure 8. Negative wire connection from rectifier to bulkhead wall, showing visible signs of corrosion at connection point.

Corrosion Inspection Data

- Measurements collected in field during inspection
  - Locations (exposure zone, elevation)
  - Elements
  - Units for measure

Maritime Asset
Corrosion Inspection Data Form

Form CMD (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 1 of 7

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Inspection Type	☒ Baseline ☐ Routine ☐ In-Depth	**Inspection Date(s):**	May 20, 2020 (abovewater) Aug 24, 2020 (underwater)
Scope of Inspection	Entire Asset, Above Water and Under Water		
Inspection Firm(s):	**Prime:** Wiss, Janney, Elstner Associates Inc. **Underwater:** Rio Engineering, Inc. **Other (role):** N/A		
Reported By:	S. Foster, P.E.	**Report Date:**	October 6, 2020
Corrosion Manual Version/Date:	Rev. 0, October 2022	**Variances from CM Procedure:**	N/A

Inspection Data

Transformer-Unit Rectifier Output Data

Rectifier ID	Voltage (V)	Current (amps)	Notes
PW 5-1	6.9	58	Was turned off
PW 24-1	7.1	72	
PW 43-1	5	31	

CP Potential Measurements (CS Bulkhead Wall)

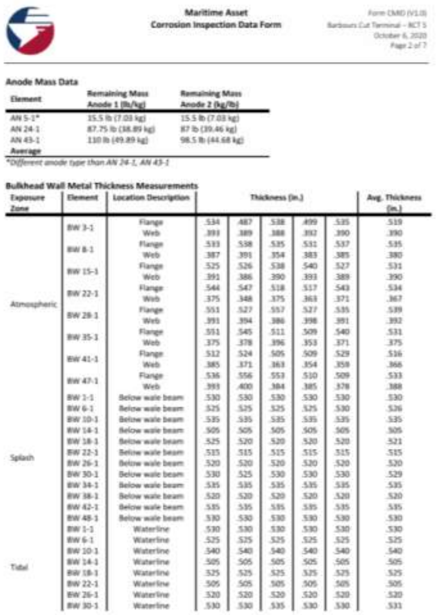
Element Location	Near Waterline On Potential	Near Waterline Off Potential
BW 5-1	-1200	-1080
BW 14-1	-1190	-1080
BW 24-1	-1470	-1132
BW 33-1	-1120	-1030
BW 37-1	-1200	-1090
BW 47-1	-1040	-920

[1] *Water only 2-4 feet deep at BW, all measurements taken near surface of water*
Units = mV vs. CSE

CP Potential Measurements (CS Fender Piles)

Element Location	Near Waterline On Potential	Near Waterline Off Potential	Near Waterline Voltage Drop
FP 5-1	-725	NA	NA
FP 24-1	-720	-695	-25
FP 47-2	-795	-785	-10

Units = mV vs. CSE



Maritime Asset
Corrosion Inspection Data Form

Form CMD (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 2 of 7

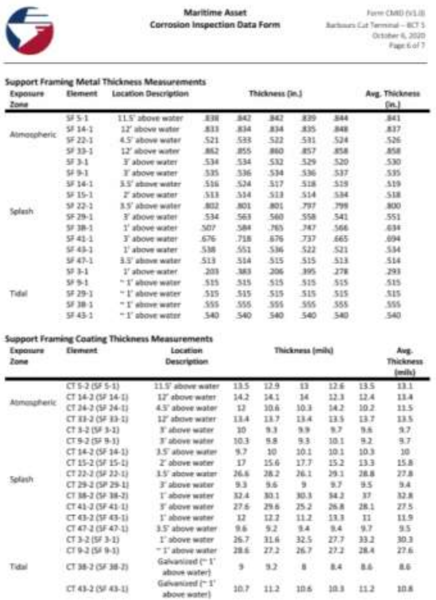
Anode Mass Data

Element	Remaining Mass Anode 1 (lb/kg)	Remaining Mass Anode 2 (kg/lb)
AN 5-1*	15.5 lb (7.03 kg)	15.5 lb (7.03 kg)
AN 24-1	87.75 lb (38.89 kg)	87 lb (39.46 kg)
AN 43-1	110 lb (49.89 kg)	98.5 lb (44.68 kg)
Average		

**Different anode type than AN 24-1, AN 43-1*

Bulkhead Wall Metal Thickness Measurements

Exposure Zone	Element	Location Description	Thickness (in.)					Avg. Thickness (in.)
Atmospheric	BW 3-1	Flange	.534	.487	.538	.499	.535	.519
		Web	.393	.389	.388	.392	.390	.390
	BW 8-1	Flange	.533	.538	.535	.531	.537	.535
		Web	.387	.391	.354	.383	.385	.380
	BW 15-1	Flange	.525	.526	.538	.540	.527	.531
		Web	.391	.386	.390	.393	.389	.390
	BW 22-1	Flange	.544	.547	.518	.517	.543	.534
		Web	.375	.348	.375	.363	.371	.367
	BW 28-1	Flange	.551	.527	.557	.527	.535	.539
		Web	.391	.394	.386	.398	.391	.392
	BW 35-1	Flange	.551	.545	.511	.509	.540	.531
		Web	.375	.378	.396	.353	.371	.375
	BW 41-1	Flange	.512	.524	.505	.509	.529	.516
		Web	.385	.371	.363	.354	.359	.366
	BW 47-1	Flange	.536	.556	.553	.510	.509	.533
		Web	.393	.400	.384	.385	.378	.388
Splash	BW 1-1	Below wale beam	.530	.530	.530	.530	.530	.530
	BW 6-1	Below wale beam	.525	.525	.525	.525	.530	.526
	BW 10-1	Below wale beam	.535	.535	.535	.535	.535	.535
	BW 14-1	Below wale beam	.505	.505	.505	.505	.505	.505
	BW 18-1	Below wale beam	.525	.520	.520	.520	.520	.521
	BW 22-1	Below wale beam	.515	.515	.515	.515	.515	.515
	BW 26-1	Below wale beam	.520	.520	.520	.520	.520	.520
	BW 30-1	Below wale beam	.530	.525	.530	.530	.530	.529
	BW 34-1	Below wale beam	.535	.535	.535	.535	.535	.535
	BW 38-1	Below wale beam	.520	.520	.520	.520	.520	.520
	BW 42-1	Below wale beam	.535	.535	.535	.535	.535	.535
	BW 48-1	Below wale beam	.530	.530	.530	.530	.530	.530
Tidal	BW 1-1	Waterline	.530	.530	.530	.530	.530	.530
	BW 6-1	Waterline	.525	.525	.525	.525	.525	.525
	BW 10-1	Waterline	.540	.540	.540	.540	.540	.540
	BW 14-1	Waterline	.505	.505	.505	.505	.505	.505
	BW 18-1	Waterline	.525	.525	.525	.525	.525	.525
	BW 22-1	Waterline	.505	.505	.505	.505	.505	.505
	BW 26-1	Waterline	.520	.520	.520	.520	.520	.520
	BW 30-1	Waterline	.530	.530	.535	.530	.530	.531



Maritime Asset
Corrosion Inspection Data Form

Form CMD (V1.0)
Barbours Cut Terminal – BCT 5
October 6, 2020
Page 6 of 7

Support Framing Metal Thickness Measurements

Exposure Zone	Element	Location Description	Thickness (in.)					Avg. Thickness (in.)
Atmospheric	SF 5-1	11.5' above water	.838	.842	.842	.839	.844	.841
	SF 14-1	12' above water	.833	.834	.834	.835	.848	.837
	SF 22-1	4.5' above water	.521	.533	.522	.531	.524	.526
	SF 33-1	12' above water	.862	.855	.860	.857	.858	.858
Splash	SF 3-1	3' above water	.534	.534	.532	.529	.520	.530
	SF 9-1	3' above water	.535	.536	.534	.536	.537	.535
	SF 14-1	3.5' above water	.516	.524	.517	.518	.519	.519
	SF 15-1	2' above water	.513	.514	.513	.514	.534	.518
	SF 22-1	3.5' above water	.802	.801	.801	.797	.799	.800
	SF 29-1	3' above water	.534	.563	.560	.558	.541	.551
	SF 38-1	1' above water	.507	.584	.765	.747	.566	.634
	SF 41-1	3' above water	.676	.718	.676	.737	.665	.694
	SF 43-1	1' above water	.538	.551	.536	.522	.521	.534
	SF 47-1	3.5' above water	.513	.514	.515	.515	.513	.514
Tidal	SF 3-1	1' above water	.203	.383	.206	.395	.278	.293
	SF 9-1	~1' above water	.515	.515	.515	.515	.515	.515
	SF 29-1	~1' above water	.515	.515	.515	.515	.515	.515
	SF 38-1	~1' above water	.555	.555	.555	.555	.555	.555
	SF 43-1	~1' above water	.540	.540	.540	.540	.540	.540

Support Framing Coating Thickness Measurements

Exposure Zone	Element	Location Description	Thickness (mils)					Avg. Thickness (mils)
Atmospheric	CT 5-2 (SF 5-1)	11.5' above water	13.5	12.9	13	12.6	13.5	13.1
	CT 14-2 (SF 14-1)	12' above water	14.2	14.1	14	12.3	12.4	13.4
	CT 24-2 (SF 24-1)	4.5' above water	12	10.6	10.3	14.2	10.2	11.5
	CT 33-2 (SF 33-1)	12' above water	13.4	13.7	13.4	13.5	13.7	13.5
Splash	CT 3-2 (SF 3-1)	3' above water	10	9.3	9.9	9.7	9.6	9.7
	CT 9-2 (SF 9-1)	3' above water	10.3	9.8	9.3	10.1	9.2	9.7
	CT 14-2 (SF 14-1)	3.5' above water	9.7	10	10.1	10.1	10.3	10
	CT 15-2 (SF 15-1)	2' above water	17	15.6	17.7	15.2	13.3	15.8
	CT 22-2 (SF 22-1)	3.5' above water	26.6	28.2	26.1	29.1	28.8	27.8
	CT 29-2 (SF 29-1)	3' above water	9.3	9.6	9	9.7	9.5	9.4
	CT 38-2 (SF 38-2)	1' above water	32.4	30.1	30.3	34.2	37	32.8
	CT 41-2 (SF 41-1)	3' above water	27.6	29.6	25.2	26.8	28.1	27.5
	CT 43-2 (SF 43-1)	1' above water	12	12.2	11.2	13.3	11	11.9
	CT 47-2 (SF 47-1)	3.5' above water	9.6	9.2	9.4	9.4	9.7	9.5
	CT 3-2 (SF 3-1)	1' above water	26.7	31.6	32.5	27.7	33.2	30.3
	CT 9-2 (SF 9-1)	~1' above water	28.6	27.2	26.7	27.2	28.4	27.6
Tidal	CT 38-2 (SF 38-2)	Galvanized (~1' above water)	9	9.2	8	8.4	8.6	8.6
	CT 43-2 (SF 43-1)	Galvanized (~1' above water)	10.7	11.2	10.6	10.3	11.2	10.8

Inspection History

Record of all inspections performed for the asset.

Includes: *Asset Identification*
Date of Inspections
Inspection Types
Inspection Firms
Component Ratings
CP, BM, and Overall CCR

Generate during baseline inspection.
Update after each subsequent inspection.

Maritime Asset
Inspection History

Form MSIH (V1.0)
Barbours Cut Terminal – BCT 5
Last updated: January 27, 2020
Page 1 of 1

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Asset Classification:	Wharf	**Year of Original Construction:**	1990
Inspection Frequency:	Ref. Inspection Plan	**Year(s) of Significant Modifications or Repairs:**	2002, 2004, 2008, 2011

Dates of Inspections, Asset, and Component Ratings

Date:	1/24/2020				
Inspection Type:	Baseline				
Inspection Status	Completed				
Inspection Firm: Above Water	WJE				
Inspection Firm: Underwater	Rio				
Corrosion Condition Rating (CCR)	**80**				
Corrosion Protection (CP)	**47**				
ICCP Functionality	5				
ICCP Visual	5				
SA Functionality	NA				
SA Visual	NA				
Surface Protection	4				
Base Metal (BM)	**33**				
Critical	5				
Typical	5				
Redundant	4				

Element Inspection Form

Record of element-level observations for an asset.

Can be generated from Port Houston Database Access File

<u>Includes:</u> *Component & Asset Identification*
Element Condition States
Photographs

Required for routine and baseline inspections.

Surface Protection

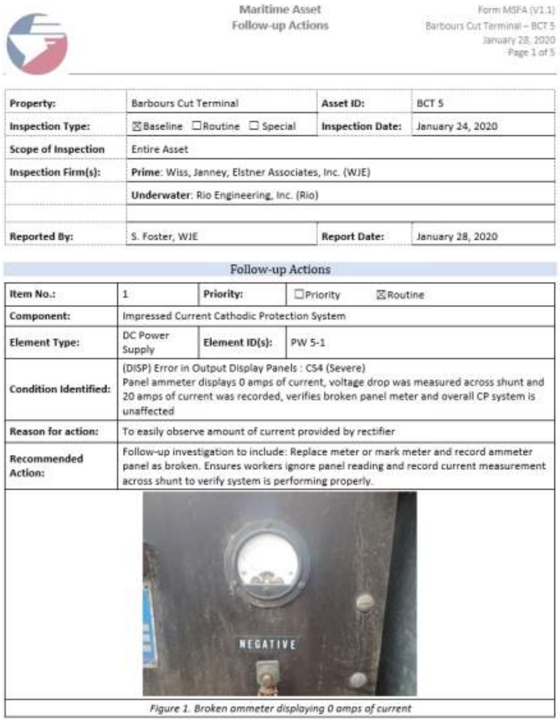
	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-1	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-1	Baseline	100	0	100	0	0	0	0	0	0
CT 1-1	ADHS		0	0	30	0	0	0	0	0
CT 1-1	PEEL		0	0	0	0	0	0	15	0
CT 1-2	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-2	Baseline	400	0	400	0	0	0	0	0	0
CT 1-2	PEEL		0	0	0	0	0	0	115	0
CT 1-2	ADHS		0	0	240	0	0	0	0	0
CT 1-3	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 1-3	Baseline	134	0	134	0	0	0	0	0	0
CT 1-3	PEEL		0	0	0	0	10	0	15	0
CT 2-1	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 2-1	Baseline	100	0	100	0	0	0	0	0	0
CT 2-1	PEEL		0	0	0	0	0	0	12	0
CT 2-2	CSCode	Total Qty.	ot Accessib	CS1	CS2	CS2NC	CS3	CS3NC	CS4	CS4NC
CT 2-2	Baseline	400	0	400	0	0	0	0	0	0
CT 2-2	PEEL		0	0	0	0	0	0	105	0

Follow-Up Action Form

Summary of recommended follow-up actions.

<u>Includes:</u> *Asset Identification*
Inspection Information
Conditions Identified &
Recommended Actions
Photographs

Required for routine and baseline inspections.



Maritime Asset
Follow-up Actions

Form MSFA (V1.1)
Barbours Cut Terminal – BCT 5
January 28, 2020
Page 1 of 5

Property:	Barbours Cut Terminal	**Asset ID:**	BCT 5
Inspection Type:	☒Baseline ☐Routine ☐ Special	**Inspection Date:**	January 24, 2020
Scope of Inspection	Entire Asset		
Inspection Firm(s):	**Prime**: Wiss, Janney, Elstner Associates, Inc. (WJE)		
	Underwater: Rio Engineering, Inc. (Rio)		
Reported By:	S. Foster, WJE	**Report Date:**	January 28, 2020

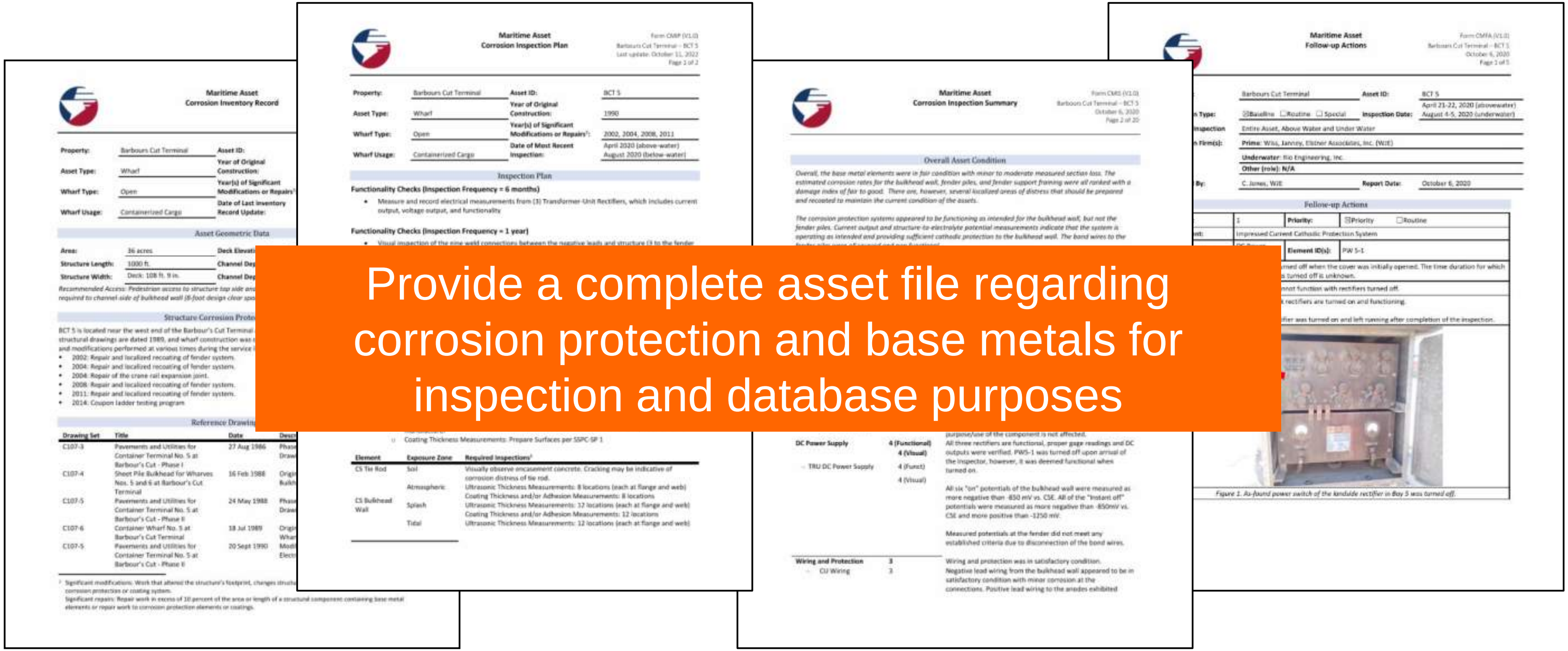
Follow-up Actions

Item No.:	1	**Priority:**	☐Priority ☒Routine
Component:	Impressed Current Cathodic Protection System		
Element Type:	DC Power Supply	**Element ID(s):**	PW 5-1
Condition Identified:	(DISP) Error in Output Display Panels : CS4 (Severe) Panel ammeter displays 0 amps of current, voltage drop was measured across shunt and 20 amps of current was recorded, verifies broken panel meter and overall CP system is unaffected		
Reason for action:	To easily observe amount of current provided by rectifier		
Recommended Action:	Follow-up investigation to include: Replace meter or mark meter and record ammeter panel as broken. Ensures workers ignore panel reading and record current measurement across shunt to verify system is performing properly.		

NEGATIVE

Figure 1. Broken ammeter displaying 0 amps of current

Inspection Deliverables



Provide a complete asset file regarding corrosion protection and base metals for inspection and database purposes

Baseline Inspection Deliverables

Basic asset documentation:

- Corrosion Inventory Record
- Corrosion Inspection Drawings
- Corrosion Inspection Plan

Inspection forms:

- Inspection Summary
- Inspection Data
- Inspection History
- Element Form
- Follow-Up Action Form

Submission to PHA:

- PHA Database

Routine Inspection Deliverables

Basic asset documentation:

- Corrosion Inventory Record
- Corrosion Inspection Drawings
- Corrosion Inspection Plan

Revise only if change(s) identified

Inspection forms:

- Inspection Summary
- Inspection Data
- Inspection History
- Element Form
- Follow-Up Action Form

Submission to PHA:

- PHA Database

Module 8.1 Wrap-Up

- Describe overall documentation and reporting requirements for each type of inspection
- Describe the purpose of each type of documentation required by the Corrosion Manual

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END OF MODULE

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Module 8.2

Database Entry and GIS

Corrosion Manual Training Course

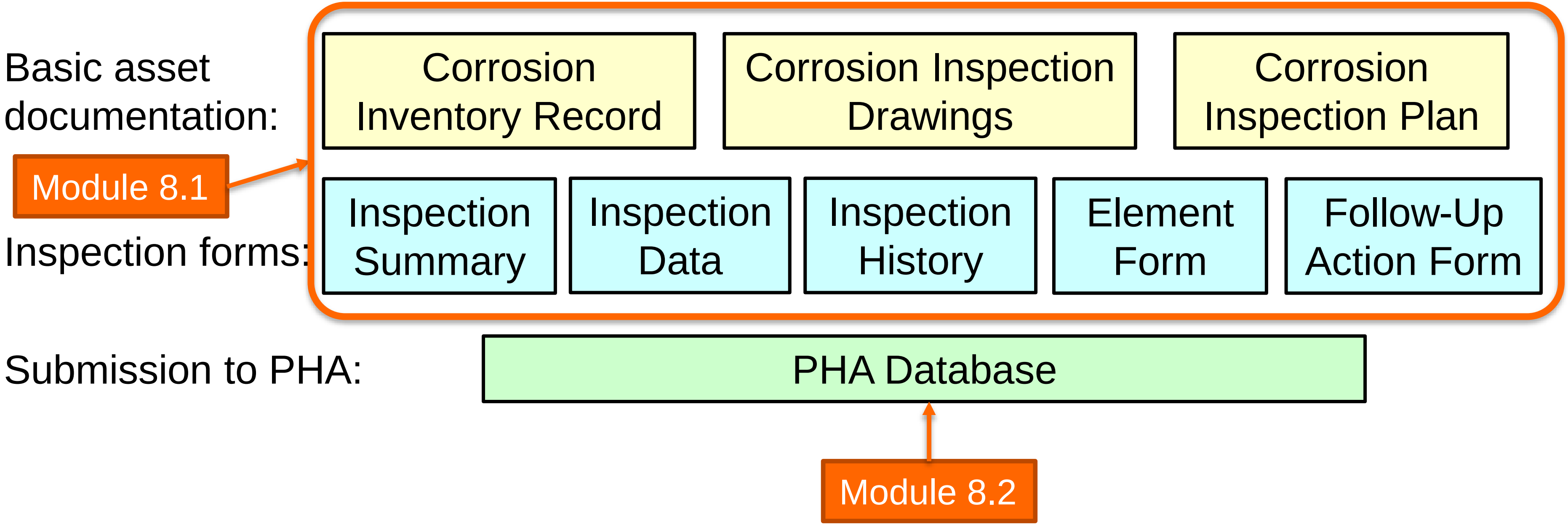
Module Objectives

- Describe overall database upload and reporting requirements for each type of inspection
- Understand key GIS requirements for Corrosion Manual and Port Requirements

Module Resources

- Chapter 8: Documentation and Reporting
  - 8.12 Inspection Database Requirements
- **FICAP Corrosion Manual Inspectors Digital Data Entry System Guide**
- MS Access Database Template

Documentation Overview



Digital Inspection Database Hierarchy

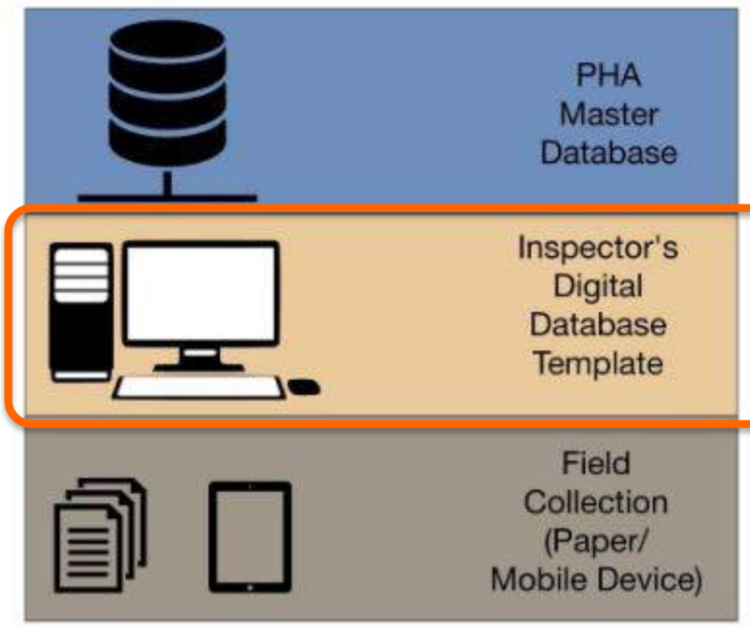


Figure 8.3. Digital inspection database hierarchy.

←Maintained by PHA (master SQL database)

←database template in Microsoft Access with basic forms to allow for data entry

←Field collection of data is up to the inspection firm

Database Entry System Guide

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Inspectors Digital Data Entry System-Corrosion v0.1

Main

Step 1: Inspection Info Setup up inspection.	Inspection Info
Step 2: Inspector Info Provide information on the firm and staff performing the inspection work.	Inspector Info
Step 3: Baseline Data Create components and elements for the asset and define their properties.	Baseline Data
Step 4: Elemental CS Ratings Enter element condition state data and attach photograhs after the field inspection.	Elemental CS Ratings
Step 4A: Base Metal Thicknesses	Base Metal Thick
Step 4B: Coating Adhesion	Coating Adhesion
Step 4C: Coating Thickness	Coating Thickness
Step 4D: Anode Mass	Anode Mass
Step 4E: Cathodic Protections Measurements Enter cathodic protection measurement information	Cathodic
Step 5: Component Ratings Enter component ratings	Component Ratings
Step 6: Print Reports Print elemental and component data for report.	Print Reports

e. **Year Constructed:** Enter the 4-digit year the structure was constructed.
f. **Significant Corrosion Maintenance Years**: Enter the string list of 4-digit years separated by commas significant maintenance was performed on the structure.
g. **Below Water Line Corrosion Inspection Interval:** Enter numerical interval in years.
h. **Date of Last Corrosion Inspection**: Enter date of last corrosion inspection formatted MM/DD/YYYY.
i. **Above Waterline Corrosion Inspection Interval**: Enter numerical interval in years.
j. **Railroad**: Enter description of railroad service.
k. **Structure History:** Enter the paragraph description of the structure history.
l. **Wharf Usage**: Enter the description of the wharf usage.
m. **Channel Depth at Fender**: Enter the numerical depth in feet.
n. **Channel Depth at Bulkhead**: Enter the numerical depth in feet.
o. **Structure Length**: Enter the numerical length in feet.
p. **Deck Area**: Enter the numerical area in square feet.
q. **Structure Deck Width**: Enter the numerical length in feet.
r. **Apron Area**: Enter the numerical area in square feet.
s. **Structure Apron Width**: Enter the numerical length in feet.
t. **Deck Elevation above MLT**: Enter the numerical length in feet.

3.3.2. Add Drawings

Baseline inspections should be accompanied with drawings used for the inspection that identify the Element ID's. The Add Drawings form provides the user the ability to identify drawing documents on the computer and have these automatically copied to drawing folder path in the IDDES database application directory.

Figure 5. Add Drawings form screen.

Add Drawings Overview

2. Enter drawing details:
   a. **Drawing Title:** Title of the drawing. *Required.*
   b. **Drawing Set:** Title of the drawing set.
   c. **Drawing Description:** Description of the drawings.
   d. **Drawing URL:** Reference location where reference drawings are loaded from. Selected by pressing File Dialog button. The Create Inspection form (i.e. prior form page) should be filled out prior to adding drawings, as information is required for the

Figure 7. Baseline Data form screen.

Baseline Data Overview

1. **Component ID:** Select the Component with Elements that exist to be inspected.
2. **Component Description:** Outputted description of the Component for the particular Asset. This is reported in the *Structure Inventory* report.
3. **Edit Component Description:** Opens a modal form to edit the component description. (See 3.5.1)
4. **Manage Element Groups:** Opens a modal form to edit the element groups. (See 3.5.2) Element groups (i.e. BR-02 CS Moveable Bearings) are required to define the Element ID. *Required.*
5. **Add Component**: All the Component ID's are initially displayed in an empty template database. Non-existing components for an asset should be removed. If a user accidently removes a component it can be added back. This button opens a modal form to add back Components that may have deleted. (See 3.5.3)
6. **Remove Component:** Deletes a Component, which should be done for components that do not exist for an asset. **WARNING:** Deleting a Component containing elements, deletes those elements and all of its associated data including ratings!
7. **Element Dataview:** Add/edit elements contained within the component. User must first add element groups to the component prior to adding elements. The following information is added in this view:
   a. **Element ID:** This is the unique ID of the element. See the Corrosion Manual for the guidance on the creation of element ID's.
   b. **Element Descriptor:** Output only, based on the selected *Element Group Code*.
   c. **Element Group Code:** The Corrosion Manual code for the element. This is limited to selection setup in the *Manage Element Groups*.
   d. **Quantity:** A positive numerical quantity value entered using the defined units of the *Element Group Code*.
   e. **Units**: Output only, a helpful indicator of the required units for the element.
8. **Switch Subform View:** Enables switching the sub-form to datasheet view. In this spreadsheet view, editing features such as copy and pasting (e.g. from Excel) are enabled in

Example Database Entry

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GIS System Requirements and AutoCAD to GIS Conversion

Port GIS Geodatabase

- Convert AutoCAD CAD .dwg corrosion inspection drawings to properly geolocated ArcGIS File Geodatabase Feature Classes.
  - After baseline inspection to verify in-situ locations, elements
- Assign proper Asset ID Attribute values to ArcGIS File Geodatabase Feature Classes according to FICAP Corrosion Manual
- Deliver Esri ArcGIS File Geodatabase & ArcGIS Pro Map Package

AutoCAD to GIS Conversion

- The following datasets are required for the AutoCAD to Geodatabase conversion:

1. CAD .dwg of the Corrosion Assets (Elements)
2. Finalized In-Situ PDF of the AutoCAD drawings
3. PHA Esri File Geodatabase template for corrosion assets

NOTE: *The process can be performed using either ESRI's ArcMap or ArcGIS Pro (preference).*

AutoCAD to GIS Workflow

Georeference the CAD
- CAD Georeference Tool

Convert CAD to Geodatabase
- CAD to Geodatabase Conversion tool

Definition Query
- Query to the specific element and annotations to a feature in the template

Join Annotation Feature to Element Feature
- Spatial join to add Text field from annotation to the correct element feature in the appropriate Geodatabase Feature Class attribute

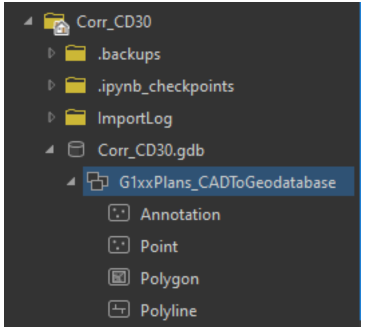
Append joined feature to Template feature
- Use append too, and map the Text field from the joined feature to the Asset ID field

Symbolize

GIS Feature Classes and Geometry

Corrosion Component	Abbreviation	Corrosion Element	Prefix	GIS Geometry (Shape)	GIS Feature Class Name
Impressed Current CP	ICCP	Protection	PR	Line (Each)	icProtection
Impressed Current CP	ICCP	Supports	SP	Line (Each)	icSupports
Impressed Current CP	ICCP	Wiring	WI	Line (Each)	icWiring
Sacrificial Anode CP	SACP	Supports	SS	Line (Each)	saSupports
Sacrificial Anode CP	SACP	Wiring	WR	Line (Each)	saWiring
Sacrificial Anode CP	SACP	Protection	PT	Line (Linear Feet)	saProtection
Impressed Current CP	ICCP	Anode	AN	Point	icAnode
Impressed Current CP	ICCP	Supplementary Anode Materials	SM	Point	icSupplementaryAnode
Sacrificial Anode CP	SACP	Anode	AS	Point	saAnode
Sacrificial Anode CP	SACP	Supplementary Anode Materials	SE	Point	saSupplementaryAnode
Sacrificial Anode CP	SACP	Cathodic Protection Jackets	JA	Point (Circle Drawn Around)	saJackets
Impressed Current CP	ICCP	DC Power Supply	PW	Point (Each)	icDCPower
Impressed Current CP	ICCP	Monitoring Equipment	ME	Point (Each)	icMonitoringEquipment
Sacrificial Anode CP	SACP	Monitoring Equipment	MS	Point (Each)	saMonitoringEquipment
Surface Protection	SPR	Metalizing	ML	Polygon	cmMetalizing
Surface Protection	SPR	Wraps	WP	Polygon	cmWraps
Surface Protection	SPR	Coatings	CT	Polygon (Square Feet)	cmCoatings
Surface Protection	SPR	Hot-Dip Galvanizing	HG	Polygon (Square Feet)	cmHotGalvanizing

AutoCAD to GIS Workflow



Example of the dataset created by the CAD to Geodatabase tool

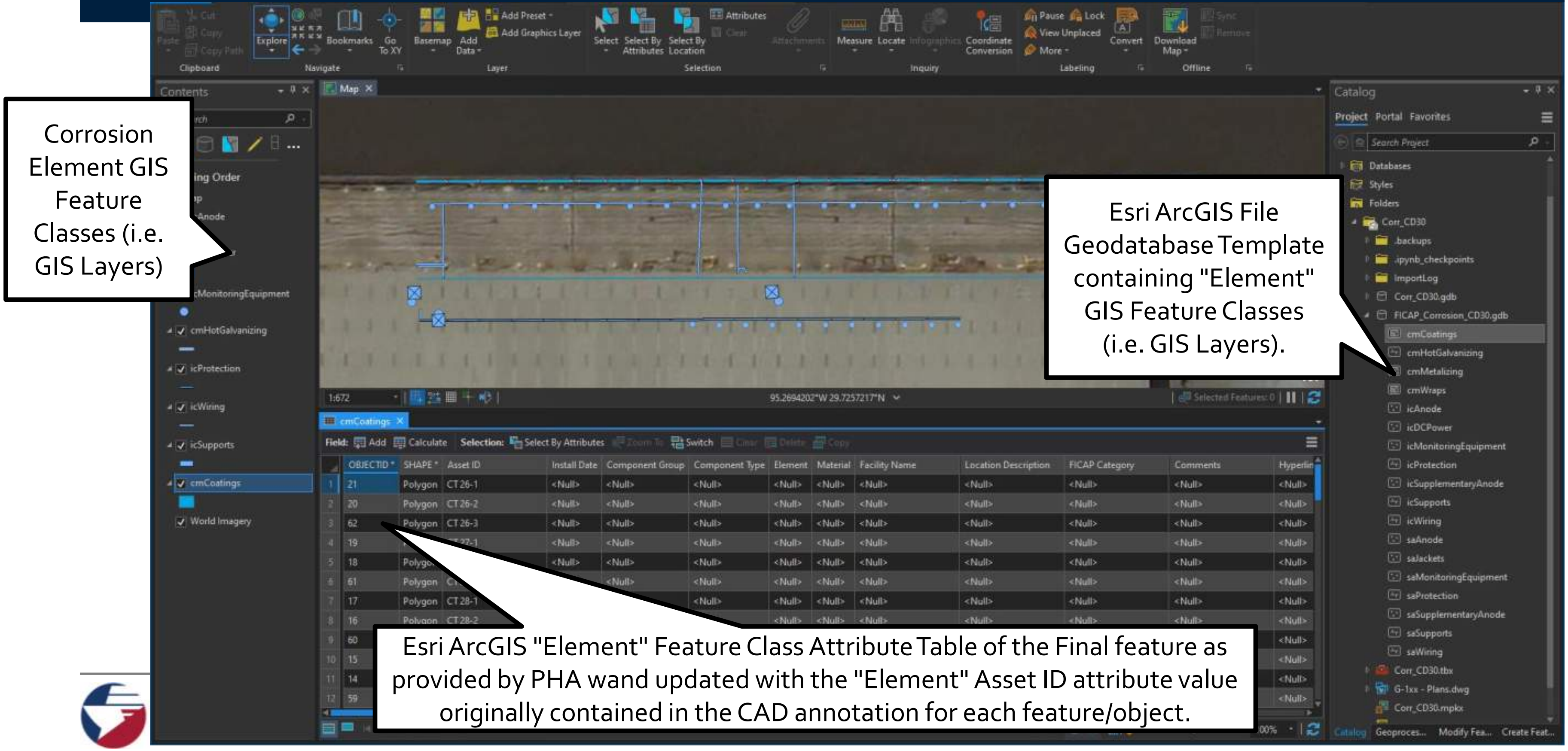
Annotation

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Delete Copy

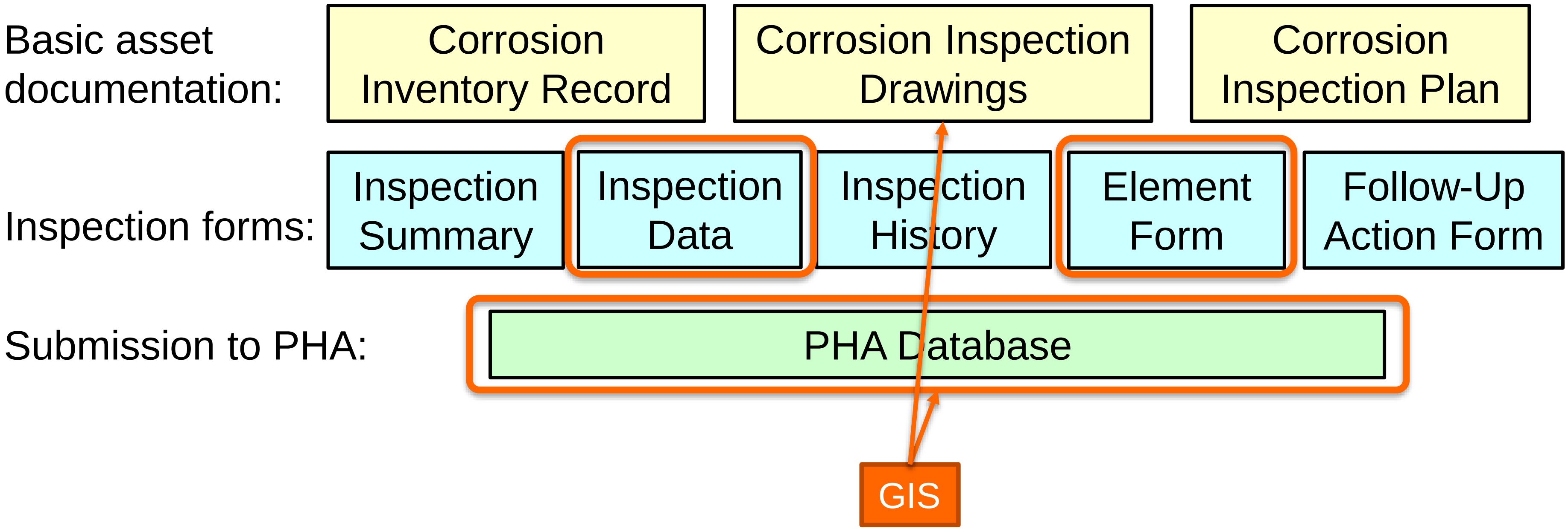
		DocVer	DocUpdate	DocId	ScaleX	ScaleY	ScaleZ	Style	FontID	Text	Height	TxtAngle	TxtWidth	TxtOblique	TxtGenType	TxtJus
5219		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-12	12.7125	0	1.13	0		Right
5220		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-12	12.7125	0	1.13	0		Right
5221		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-13	12.7125	0	1.13	0		Right
5222		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-13	12.7125	0	1.13	0		Right
5223		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-2	12.7125	0	1.13	0		Cente
5224		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-2	12.7125	0	1.13	0		Cente
5225		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-3	12.7125	0	1.13	0		Cente
5226		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-3	12.7125	0	1.13	0		Cente
5227		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-4	12.7125	0	1.13	0		Cente
5228		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-4	12.7125	0	1.13	0		Cente
5229		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-5	12.7125	0	1.13	0		Cente
5230		AC1032	8/20/2021 7:18:43 AM	1.987247e+18	1	1	1	ARIAL	27	DB 35-5	12.7125	0	1.13	0		Cente

Annotation feature table with the field “Text” containing the Asset ID for the elements

Example of GIS Deliverable



Documentation Overview



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END OF MODULE