Quality Assurance is defined as meeting the expectations of internal and external customers for error free products, services and business processes through continuous improvement. Properly administered quality assurance ensures that replacements, additions, and rehabilitations of infrastructure elements are designed and constructed in accordance with the contract documents and engineering standards. Quality Assurance is an ongoing management responsibility which involves planning and implementing systematic actions to assure work processes and designed elements are functioning as intended. A properly implemented QA program will eliminate construction delays, reduce costs and change orders, and ensure that the project meets State and Federal guidelines.

About the Presenter:

Paul Rimmer received his B.S. degree in Marine Sciences from LIU at South Hampton before receiving his B.S. in Civil Engineering from SUNY Buffalo. Paul accepted a position at the NYSDOT Structures Division in August 1983. He then transferred to the Metals Engineering Unit in 1987 and was appointed supervisor in 2001. Paul has been involved in committee work with many organizations including the National Steel Bridge Alliance, American Welding Society, TRB National Institute of Steel Detailers, NCHRP.
Quality Assurance Issues in Bridge Design and Construction

Metals Engineering Perspective
Paul Rimmer P.E.
Quality Control

- Contractor’s Inspection and Testing Program Required as Necessary During Fabrication and Erection.

- To Insure that Materials, Welding and Workmanship Meets the Contract Requirements
Quality Assurance

- Ongoing Management Responsibility for Planning and Implementing Systematic Actions to Assure Work Process are Producing as Intended
Why QC/ QA?

- For Acceptance by FHWA
- Proof of Compliance with Contract Documents
- Limit Contract Liability
- Promote Economy, Safety, Value
Where QC/ QA

- QC/QA is a Necessary Part of Contract Management During:
  - Design
  - Off-site Fabrication
  - Field Erection
  - Repair
Quality Assurance is the verification that the Quality Control meets the Specification with Reasonable Certainty.
QA Inspector

- Monitors the Contractor’s QC Program and is Designated to Act on Behalf of the Owner on Inspection and Quality Matters within the Contract Scope
Acceptance by FHWA

- Required by Contract Documents
- Necessary on Federal Aid Projects
- Recommended by the Approving Authority
Elements of Contract Compliance

- Basis of Payment
- Acceptance Criterion
- Fraud and Short Cutting
- Quantity Verification
$$ Liability $$

- Limit Claims and Liens
- Limit Litigation Costs
- Avoid Disputes
- Avoid Contract Delays
QC/ QA Roles

- QC/QA Tasks May Seem Redundant, but Responsibilities and Roles are Different
Project Q/A Will Promote Economy and Value

- Less Mistakes Means Lower Cost
- Elimination of Fit up Problems
- Limit Delays to the Contract
Q/A at Project Inception

- Design Concept Review
  - Does the concept make sense?

- Evaluation of Alternatives
  - Signature Structures may not be good candidates for Pass Through LBP
  - Complex rehabilitation also may not be manageable
Q/A at Project Inception

Well Conceived Projects Ensure on Time Completion
Complex or Signature Structures

- Q/A is Significantly More Difficult as the Complexity of the Structure Increases
- The Cost of Q/A is Significantly Increased for a Signature Structure
Signature Structures

- Bridges containing Fracture Critical Members such as Trusses, Through Girders, Frames, Tied Arches
- Long Span, Curved, Highly Skewed I-Girder Bridges
- Members made from Unique Shapes such as Tubs, Tubes, or Boxes
Peer Review

- **Detail Review**
  Did we use the correct detail?

- **Scale Reviews**
  Did we use the correct size section?

- **Constructability Reviews**
  Will what we drew fit together?
Standard Details

- Standards are Continuously Evolving
  Because of Changes in Design Practice, Construction Methods, and New Materials
  - Do the drawings accurately depict the assemblies utilizing standard details?
Scale Reviews

- Will the Basic Building Blocks Deliver the Expected Performance?
  - For Example: Will the Fascia Diaphragms Carry the Forming Machine Loads?
Constructability Reviews

- The New Members Should be Able to Fit Together during Construction.
  - Will fatigue be limited by the fit up and connection and orientation of the component parts?
Shop Q/A Begins With Fabrication Drawing Review

- Very Misunderstood Portion of Q/A
- Often Blamed for Delays in Schedule
- Reviews may take as long as Drawing Development
Drawing Format

- Clear Legible Layout
- Title Block with Complete Information
- Original Drawing Size 22” x 36”
- Steel Construction Manual Section 202
Approval Of Shop Drawings

- Principal Controlling Dimensions
- Materials Specifications
- Details of Welded Joints and Bolted Connection
- Framing and Assembly Diagrams
Approval Process

- Preliminary Review
- Signature Approval
- Distribution
- Disposal of Original Drawings
Q/ A During Shop Fabrication

- Material Inspection
- Welding Inspection
- Weld Witnessing
- Non Destructive Testing
QC/ QA Monitoring During Fabrication

- QC Personnel
  - QC Manager
  - CWI/ASNT II
  - Assistant Inspectors
  - Multiple Welders
  - Layout and Fitters

- Q/A Personnel
  - Inspector
Material Inspection

- Review of Mill Certifications
- Review of Test Results
- Sampling of Fastener Lots
Bolt Sampling

- In Accordance with SCM Section 10.2, Bolts and Nuts shall be Sampled from Each Control Lot
- A Control Lot for a Primary Connection are all the Fasteners for the Same Grade and Size
Steel Welding

Welding Defined

- Fusion of Metals
  - Using Heat
  - Using Current
  - Using Force
Factors Affecting Welding

- Steel Composition
- Joint Fit-up
- Technique
- Energy Input
Critical Parameters

- Process
- Preheat
- Rod Type
- Travel Speed
- Interpass Temperature
- Post Heat
Welding Procedure Specification

Material specification: ASTM A36
Welding process: SHIELDED METAL ARC WELDING (SMAW)
Manual, semiautomatic or automatic: MANUAL
Position of welding: VERTICAL & Overhead
Filler metal specification AWS: A 5.1
Filler metal classification: E 7018
Electrode and manufacturer: ANY MADE IN U.S.A.
Plug and manufacturer: N/A
Shielding gas: N/A
Double joint: N/A
Flow rate: N/A
Single or multiple pass: SINGLE
Single, or multipass arc: SINGLE
Welding current: DIRECT
Polarity: REVERSE (DC +)
Welding progression: VERTICAL UP
Root treatment: CLEAN AS PER SECTION 603 OF S.C.M.
Preheat and interpass temperature: 250 F MIN.
Postheat treatment: NONE

WELDING PROCEDURE

<table>
<thead>
<tr>
<th>Pass no.</th>
<th>Electrode size</th>
<th>Welding parameters</th>
<th>Travel speed</th>
<th>Joint detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/32</td>
<td>130-170</td>
<td>1-3 IPM</td>
<td></td>
</tr>
<tr>
<td>Over</td>
<td>5/32</td>
<td>140-180</td>
<td>4-9 IPM</td>
<td></td>
</tr>
</tbody>
</table>

This procedure may vary due to fabrication sequence, flaws, pass details, etc., within the limitations of variables given in Section 5A.

Procedure no.: WPS -
Authorizing or Reactor:
Revision no.: 
Authorized by: 
Date:
Welder Certification

- Welding “License”
- Positions
- Work Record
Base Metal and Preparation

- **Shop Welding**
  - Material Certifications
  - Clean Steel
  - No Oil
  - Tight Mill Scale

- **Field Welding**
  - Record Plans
  - Paint Removed
  - Corrosion Removed
Weld Joint Preparation

- Remove Contamination
- Edge Preparation
- Accessibility
- Root Opening and Fit Up
- Joint Geometry
Filler Materials and their Storage

- Electrodes (Stick)
- Wire and Fluxes (SAW or Flux Core)

Control of Fracture Critical Wire is More Restrictive for Diffusible Hydrogen

Canisters are Lot Certified

Holding Ovens
Inspection Will Identify Material Defects

- Visually Detected
- Lamination
- Inclusions
- Cracks or Tears
- Dimensional Tolerances
- Other Causes for Rejection
Reason for Control

- Low Hydrogen Practice
- Encourage Hydrogen Diffusion
- Limit Embrittlement
- These Conditions Will Cause Weld Cracking
Joint Fit-up

Joint preparations with poor fit-up
Shrinkage Due to Lack of Preheat

RESULTS OF STRESS DUE TO SHRINKAGE
Welding Operation

- Quality of Welds as Defined by Steel Construction Manual in Section 724
  - The Weld has No Cracks
  - Thorough Fusion Exists in Weld Passes
  - All Craters are Filled to Full Section
  - Undercut is Below Minimum Specs
  - Porosity is Below Minimum Specs
  - Fillet Weld Meets Minimum Size
Process of Welding

- Welder Performs Operation
  - We look for:
    - Smooth application
    - Proper profile
    - No undercut
Q/A Investigates Weld for Discontinuities

- Types, Sizes and Location
- Discontinuities that Exceed the Size Allowed by the Specification are Considered Defects
- Location may be in the Weld or in the Heat Affected Zone (HAZ)
Discontinuities

- Caused Mainly by Slag Entrapment and Porosity
- May Indicate a Void in the Flux or Other Deficiency in the Flux (Moisture)
Inspection Processes

- Destructive Methods
- Non Destructive Methods
- Acceptance Methods
- Cost Impacts
Inspection Processes

- Inspection Processes are used to Evaluate Discontinuities
- Visual and Dye Penetrant Methods are used for Cracks Near the Surface
- Magnetic Particle, Ultrasonics, and Radiography are used for Deeper Cracks
Visual Inspection

- Magnifying Glass
- Welding Gauge
- 100% Hands on Inspection
Visual Discontinuities

- Porosity
- Crater Cracks
- Sagging
- Undercut
Hidden Defects

- Found By NDT
  - Slag
  - Lack of fusion
  - Porosity
  - Delaminations
Destructive Methods

- Tension Tests
- Charpy Tests
- Chemical Analysis
Non Destructive Testing

- Dye Penetrant
- Magnetic Particle
- Ultrasonic
- Radiography
Dye Penetrant

- Inexpensive
- Reasonably Rapid
- Easy to Learn
- Few False Indications
- Interpretation is Easy
Testing Sequence

DYE PENETRANT TESTING (DPT)

1. Subvisible Crack
2. Cleaned Surface
3. Penetrant Applied
4. Excess Removed
   - Visible Indication
5. Developer Applied
Magnetic Particle Testing

- Used for Locating Surface or Near Surface Discontinuities
- A Magnetic Field is Applied to the Weldment and Iron Dust is Spread in Weld
- The Pattern of Flaws are Revealed by Particles Conforming to Distortions in the Magnetic Field
Mag Particle Machine
Prod Method

Test Prod

Weld

Magnetic Lines of Force
Ultrasonic Testing

- Applicable to Almost All Materials
- Transmission of Mechanical Energy in Wave Form at High Frequency
- Reflections of Deflected Waves on Discontinuities are Detected as Electrical Signals
Ultrasonic Method

- Pulse Generator
- Process Circuit
- Pulse Search Unit
- Initial Sound Pulse
- Ultrasound Search Pattern
- Ultrasound Sound Wave
- Flaw
- Oscilloscope Screen
- Flaw Sound Echo
- Calibrations on Screen
Radiographic Testing

- Radiographic Inspection is Suitable for all Materials, however, Applicability Depends on Joint Configuration and Material Thickness
- Flat Plates OK - Corner Joints No
Radiographic Testing

X-RAY UNIT

WELD

X-RAY FILM

X-RAY SOURCE
Non Destructive Testing

- ASNT Certification Levels
  - Level One - Dye and Mag Particle
  - Level Two - UT and RT
  - Level Three - Supervision and Test Method Development
Types of Defects

- Porosity
- Inclusions
- Incomplete Fusion
- Cracks
- Lamellar Tears
- Undercut
- Inadequate Joint Penetration
Surface Porosity
Radiograph of Porosity
Visual Appearance of Undercut
Arc Strikes

- Unintentional Melting or Heating Outside Intended Weld Area
- Produced by Careless Handling of the Rod or Improperly Secured Ground Connection
- Source of Localized Cracking or Hardening
Types of Cracks

- Generally Caused by Improper Weld Termination
  - Crater cracks
  - Throat cracks
  - Toe cracks
  - Root cracks
Cracks

- Crater Crack
- Throat Crack
- Root Crack
- Toe Crack
Insufficient Throat

Underfill
Inadequate Penetration
Acceptance by Shop Q/ A

- After Resolution of Defects by Repair(s) 
  Inspection will Recommend Acceptance of the Assembly to Approving Authority
Erection Procedure

- Review Similar to Fabrication Drawings
- Girder Stability Computations
- Crane Capacity and Radius
- Bolting and Pin Requirements
- Falsework and Blocking Details
Bolt Torque Inspection

- Turn of the Nut Method
- Tension to be Verified by Use of Inspection Torque Wrench Operated by Contractor
- Inspection Torque is Determined Once Each Day by Examining Three Bolts of Each Length and Diameter at Random
Typical Field Repair

- Response to Red Flag
- Fabrication Error
- Impact Damage
- Field Rehabilitation
Q/A is Necessary Component of the Contract Process

- Properly Done, Q/A is Potentially the Best Opportunity to Ensure the Members are Correctly Fabricated and Fulfill the Designer’s Intent.

- May Require a Significant Portion of the Finances Allocated for the Design and Construction of the Structure
Thank You

- Questions???????