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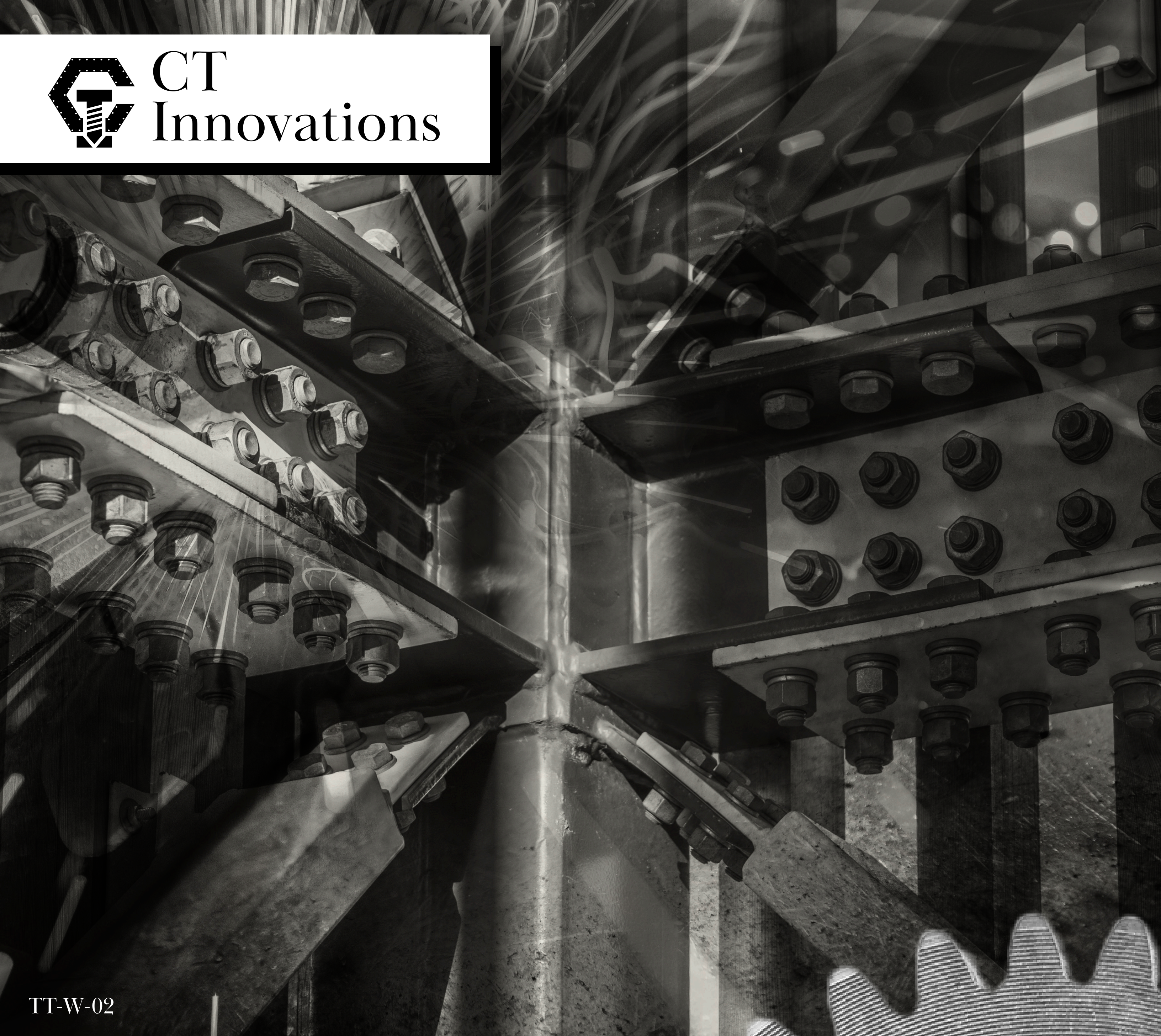


TT-W-02

Ladder Tray Construction Quality Control:

Welded & Mechnical Methods

1.0 Introduction

This technical paper considers the quality control requirements for different methods of cable ladder tray construction jointing. Identifies potential quality control risks pertaining to the safe operation of the cable ladder tray system. Highlights why quality control is relevant to cable ladder tray safety when in service. This information is provided to highlight general requirements and the importance of quality control in relation to the different methods of cable ladder tray construction jointing.

2.0 Cable Ladder Tray

Cable ladder tray is a mechanical support system typically used to safely support and protect electrical cables installed within the tray. It must be manufactured and tested in accordance with the governing industry standards such as NEMA VE 1 and IEC 61537.

3.0 Cable Ladder Tray Construction

Cable ladder tray straight sections and fittings are manufactured by the forming of side-rail and rung sections which are then joined together to construct the ladder tray. Common methods of joining the side-rails and rungs together are by welding and mechanical fastening.

4.0 The Importance of Manufacturer Quality Control

The manufacturer must ensure adequate quality control procedures are implemented and records kept for the construction of the ladder tray. The quality control of construction methods ensures the entire ladder tray system performs its intended function safely meeting the design loads and duties specified.

5.0 Product Safety and Quality Control

Cable ladder tray systems are designed, manufactured, tested and certified to meet the requirements of industry standards such as NEMA VE-1 and IEC 61537. Tray samples tested to these standards are the basis of published cable tray design loads (safe working loads) and factors of safety. In service performance expectations are based upon performance data derived from these tests.

Should the manufacturer fail to control the ladder tray construction quality during volume manufacturing; the ladder tray construction may not perform as intended nor perform as was previously tested and certified. In that instance it may not meet the specified design performance, which should be considered a risk to the safe support and protection of the electrical wiring system cabling.

The published NEMA VE 1 design loads for cable ladder tray include a 1.5 (50%) factor of safety. When compared to the factors of safety included for civil structure 2.0 (100%) and mechanical strut support systems is 5.0 (500%). The lower the products factor of safety, the higher the importance of quality control in identifying non-compliance that may impact product performance and safety.

6.0 Why Quality Control Complexity is Relevant to Safety

The more complex the ladder tray construction methods are, the more complex the quality control procedures will be. Different methods of ladder tray construction will require different quality control procedures, some more complex than others and carrying inherently higher risk of non-compliance. The need for skilled labor, skills training, certification, re-certification, and documentation control are an ongoing constraint within the manufacturing industry. Even the best quality control procedure can fail if it is not correctly resourced, enforced, managed, and recorded. Failure that can lead to product failure in the field which in turn could result in loss of power or personnel injury.

7.0 Why In-Service Performance Risks Are Increasing

Cable ladder tray in commonly in service outdoors and exposed to the elements. In normal service the ladder tray construction joints are continuously subjected to static load due to cable weight and thermal dynamic loads due to material expansion/contraction with environmental events such as high wind subjecting the joints to additional dynamic loads.

With continuous static and thermal dynamic loads imposed upon the ladder tray construction joints continuously present and environmental dynamic loads forecast to increase into the future, it is imperative the manufacturers quality control procedures identify construction joint compliance and rectifies non-compliance before the ladder tray is commissioned into service.

8.0 Construction Methods Quality Control

Examples of typical quality control requirements for Welded and Mechanical Fixing construction methods are shown below for comparison:

Welded Quality Control Requirements
Quality Plan
Assembly Procedure
Welding Procedure Specification
Welding Procedure Qualification
Welder Certification
Welding Filler Material Certificates
Base Material Certificates
Welding Inspection Test Procedure
Welding Inspection Test Plan
Welding Non-Destructive Testing
Welding Inspection Test Record
Welding Equipment Calibration Records
Material Storage Procedure
Material Cleaning Procedure
Documentation Record Book

The above are typical examples for information and are not exhaustive

Mechanical Quality Control Requirements
Quality Plan
Assembly Procedure
Mechanical Fastener Specification
Mechanical Fastener Material Certificate
Mechanical Inspection Test Procedure
Mechanical Inspection Test Plan
Mechanical Inspection Record
Torque Tooling Calibration Records
Documentation Record Book

The above are typical examples for information and are not exhaustive

9.0 Quality Control Observations

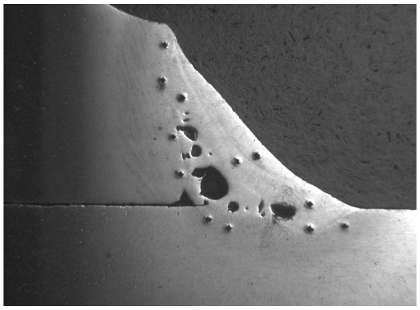
With reference to the examples given in Paragraph-6.0 the following observations are given with corr esponding comment for consideration.

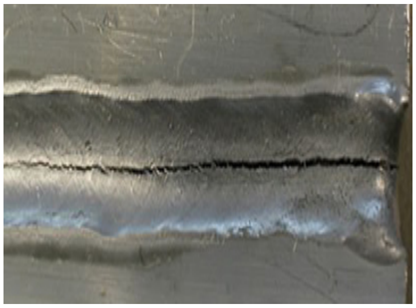
Welded Joint Method Observations
There are 15 separate requirements to manage
Skilled labor will be required to manage these
Complexity of requirements increases control risks
High level of documentation/record management
High level of inspection to guarantee compliance
Non-Destructive inspection testing may be required

Mechanical Joint Method Observations
There are 9 separate requirements to manage
Skilled labor is not required
Low complexity requirements lower control risks
Lower level documentation/record management
Lower level of inspection to guarantee compliance
Non-Destructive inspection testing is not required

10.0 Typical Quality Non-Compliance

Shown below are some of the typical non-compliant quality failures associated with welded joints.


POROSITY: Aluminum Fillet Weld


CRACKED: Aluminum Fillet Weld


UNDERFILL: Aluminum Fillet Weld

There are numerous and common non-compliance quality failures associated with welded joints.

11.0 Quality Control Challenges

8.1 Listed below are some of the quality control challenges that can arise with welded joints.

a. *Are skilled certified welders used?*
b. *Is welder certification valid?*
c. *Is welding ITP adequate to identify weld joint imperfections?*
d. *Are inspection test reports issued?*
e. *Are material certificates checked for compliance?*
f. *Is all documentation and records checked for compliance?*
g. *Do all welded tray joints provide the same consistent quality?*

8.2 Listed below are some of the quality control challenges that can arise with mechanical joints.

a. *Calibration records must be available for mechanical fastening tooling.*
b. *Material certificates for mechanical fasteners must be recorded and available.*
c. *No other challenges have been identified.*

12.0 Summary

Based upon the information contained within this paper, the quality control of welded joints poses the greatest quality management challenge when considering the complexity of quality control required. Control that must ensure not only quality compliance but also quality consistency. When considering a ladder tray straight section of 20-feet length with 9-inch rung spacing typically consists of 156 individual welds; the total quantity of welds to be inspected on small manufacturing volumes can be in the 10's of thousand.

It is recommended special consideration be given to weld joint porosity, especially internal porosity which is *not visible to the naked eye*. The method of inspection for porosity becomes critical to prevent quality non-compliance, the potential in-service weld joint failure and the safety risks it may present.

As visual inspection may not be adequate to identify weld quality non-compliance, it is CT Innovations recommendation that a thorough evaluation of weld joint inspection methods be undertaken to ensure the non-complaint welds are identified and rectified before a cable ladder tray enters service.

With mechanically fastened joints CT Innovations recommends the quality control measures focus predominantly on fastener material certification, torque tooling calibration with batch inspection testing of the joint fastener torque before a cable ladder tray enters service.

The information contained within this document is provided by CT Innovations for the consideration of the reader. Customers should ensure a cable ladder tray manufacturer has quality control procedures that are adequate to control consistent quality and to identify the quality compliance of the jointing method used.

Failure to ensure consistent quality control of tray construction methods may result in failure when in service.

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