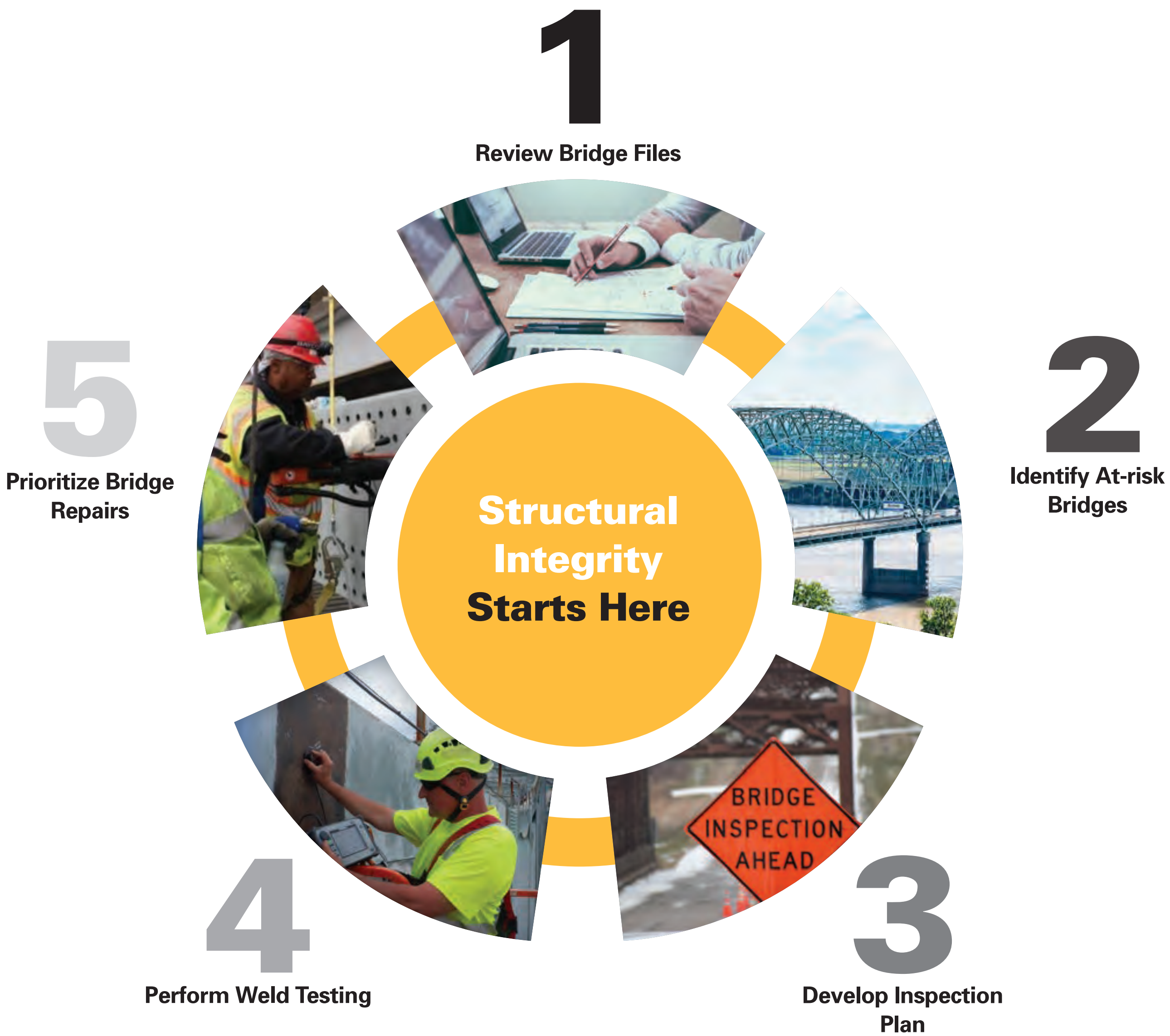
2022

Special Report:

How to Meet Federal Mandates Impacting Bridges with T-1 Steel



FICKETT Structural Solutions

Federal Mandate Addresses Need to Inspect Bridges Built with T-1 Steel

The Federal Highway Administration (FHWA) put public bridge owners on notice. Bridges built with T-1 steel from 1959-1978 may have undetected weld defects. They could eventually lead to cracking, resulting in an unexpected closure.

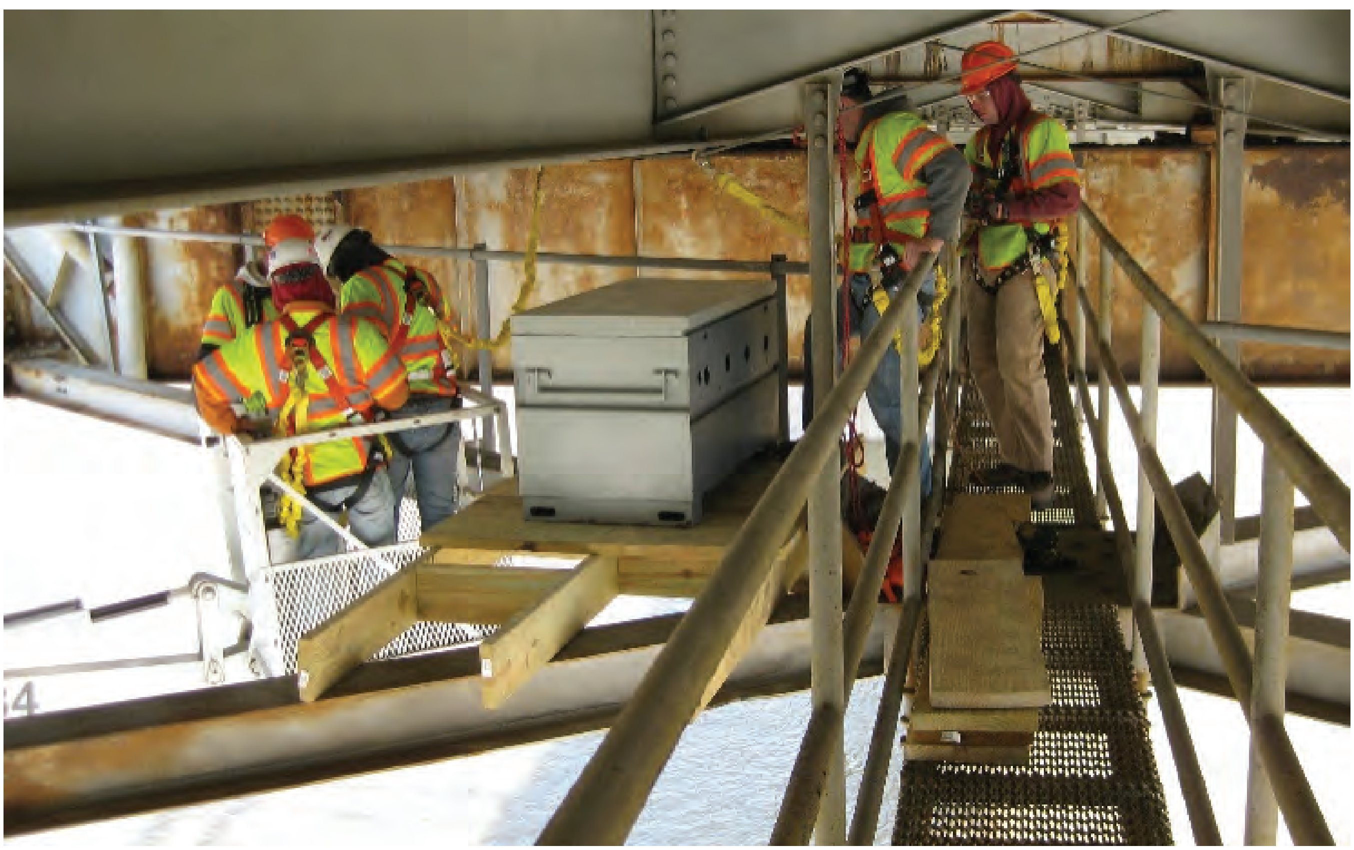
Through its Dec. 13, 2021, Memorandum, FHWA provided direction regarding the inventory, special in-service inspection, and testing of butt welds for these bridges. These inspections could help prevent sudden shutdowns and the resulting inconveniences to the vehicular traffic above and the maritime traffic below. (See Appendix on Page 7.)

This directive follows the emergency closure of the I-40 Hernando de Soto Bridge on May 11, 2021, after an inspector discovered a fracture. Also related is the 2011 closure of the I-64 Sherman-Minton Bridge because of similar issues and fracture concerns.

The Sherman-Minton Bridge was closed for approximately five months while repairs were made to address hydrogen-induced weld cracking. The Hernando de Soto Bridge was closed for approximately 2½ months while the partially fractured tie girder and additional locations with hydrogen cracking were inspected and then repaired.

According to FHWA, "These significant disruptions to the Interstate system had profound effects on the lives and livelihoods of the traveling public, the regional and national mobility of freight, and the vitality of the local and regional economies."

This Special Report outlines the process that State Departments of Transportation and other bridge owners must follow to identify and inspect bridges.



Nondestructive Evaluation personnel inspecting the Sherman-Minton Bridge. (Fickett Photo)

Cover Photos: 1-40 Hernando de Soto Bridge overview, (Photo Courtesy Arkansas DOT); Bridge inspection sign (Fickett Photo), Ultrasonic testing on the de Soto Bridge (Michael Baker International Photo); Bridge repair photo on the Sherman Minton Bridge (Construction Equipment Guide Photo)

Why T-1 Steel Bridges Are a Potential Safety Threat

What's the core problem with these bridges built with T-1 steel? The steel isn't the problem. It's the welds. They were potentially produced without methods or materials that protect against cracking.

Todd Niemann, P.E. (Fickett Photo)

Todd Niemann, P.E., a Principal Engineer with Fickett Structural Solutions (Fickett), is in charge of the firm's inspection initiative.

Niemann brings over 30 years of experience and leadership in welding technologies, bridge fabrication, Nondestructive Evaluation (NDE), and safety inspections.

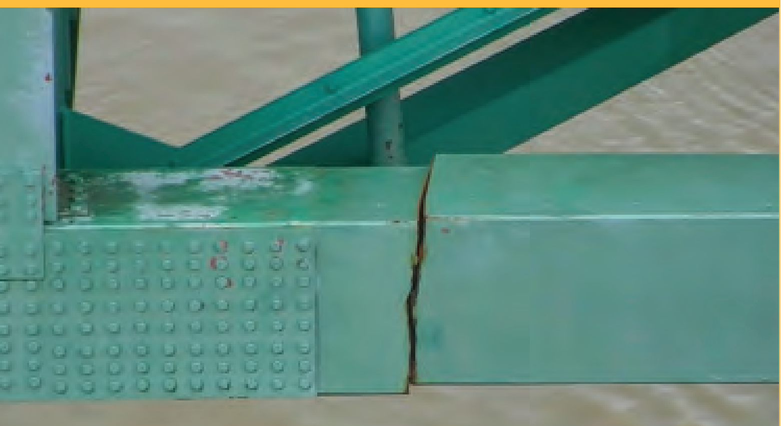
"During my career, I helped manage the aftermath of the I-35W Mississippi River Bridge collapse that resulted in 13 deaths," said Niemann. "While the cause of that collapse in Minnesota wasn't related to T-1 steel, it was a bridge tragedy that I don't want to see repeated for any reason."

Niemann emphasized, "I want to help bridge owners mitigate risks to prevent future tragedies."

"I want to help bridge owners mitigate risks to prevent future tragedies."

– Todd Niemann, P.E.

I-40 Hernando de Soto Bridge, Between Memphis, Tennessee, and West Memphis, Arkansas



Hernando de Soto Bridge tie bridge fracture ***(Photo Courtesy Arkansas DOT)***

Nondestructive Evaluation of A514 Tension Member Weldments

On May 11, 2021, an inspector from Michael Baker International discovered a fracture in one of the main span tension tie girders. The fracture occurred at a butt-welded joint.

The structure, which carries four lanes of interstate traffic over the Mississippi River, was immediately closed because of safety concerns, halting vehicular and maritime traffic. After the investigation, it was determined that hydrogen cracking was the probable cause of the weld fracture.

This structure is a fracture critical tied arch-truss bridge that consists of two 900-foot main spans. The box-shaped tension tie girders of the main spans were fabricated with T-1 steel.

Responded to Emergency Call

After the unexpected closure of the bridge, Fickett received a call asking for immediate Nondestructive Evaluation (NDE) inspection assistance. With some shuffling of resources, we provided an experienced bridge NDE inspector to assist with the unplanned work on the bridge.

Fickett's work consisted of NDE of the A514 (T-1) Tension Member Weldments on the bridge. Our services included the following:

- Performed NDE on the South Truss in Span A. We inspected eight locations on the upper chord and ten locations on diagonals.
- Accessed all areas using a boom lift.
- Provided one inspector certified as an ASNT Level II in ultrasonic testing (UT).

Also, as part of our services for Michael Baker International, Fickett provided consultation for the proposed UT and analyzed the testing results. We also outlined proposed recommendations.

Fickett recommends following a five-step process to address at-risk bridges made with T-1 steel.

"This bridge identification and inspection process isn't straightforward," said Fickett President Andy Fickett. "Owners will face different challenges with each bridge."

STEP 1: Review Bridge Inventory

Identifying at-risk bridges with T-1 steel isn't an easy process. You can't perform a reliable database or inventory search for specific materials used in bridges. A good starting point is to research your records to find as-builts, fabrication shop drawings, and other documentation. Then determine if T-1 steel was used during the designated timeframe.

The FHWA mandate limits the search to bridges classified as fracture critical. Bridge owners should determine if they also should investigate non-fracture critical bridges.

Niemann said, "Look for bridges welded with 100 ksi steel. That's the key."

"Owners will face different challenges with each bridge."
– President Andy Fickett

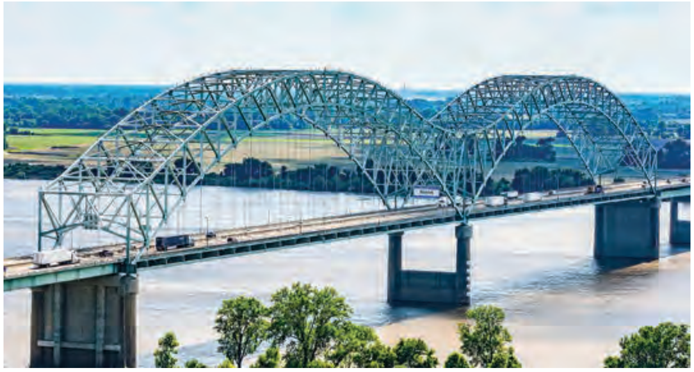
Bridges containing T-1 steel may have been produced with various steel grades and strengths. Potential alternate call outs or names for T-1 steel include:

- ASTM A514
- T1
- Grade 100 Steel
- Quenched & Tempered (Q & T) steel
- High-Strength Steel
- Combinations of the above

Research records to discover if T-1 steel was used in bridges built from 1959-1978.

STEP 2: Identify At-Risk Bridges

After you've identified potential bridges, look for those with at-risk welds, with an emphasis on butt welds. Welds subject to tensile forces under cyclic or dynamic loads can be susceptible to fatigue cracking that grows from internal weld flaws. Fickett can help identify bridges that may have problems.

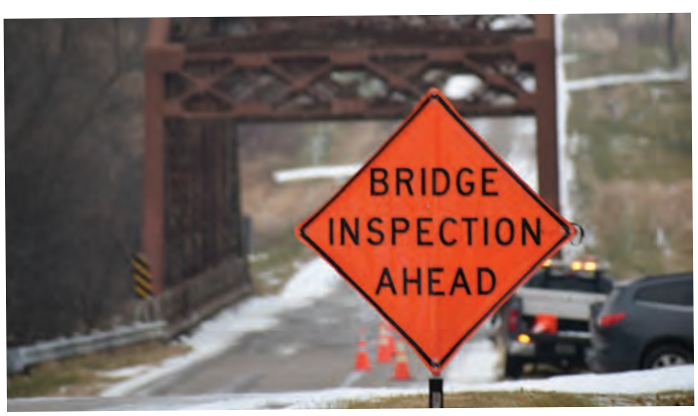


1-40 Hernando de Soto Bridge overview, (Photo Courtesy Arkansas DOT)

STEP 3: Develop Inspection Plan

Bridge inspection projects require a thorough and strategic plan to accomplish goals. Items to address include access, closures, traffic control, NDT quantities, paint removal, and paint replacement. Fickett can manage all aspects of bridge inspections.

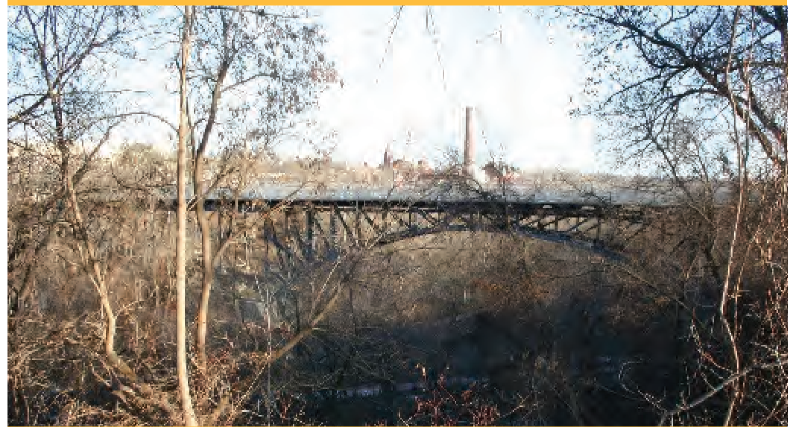
Access methods can vary depending on weld locations on the bridge and the type of service on and under the bridge. Services can include NDT inspection as well as paint removal and replacement. Generally, a work platform or Under Bridge Inspection Vehicle (UBIT) is ideal for many situations.



Signage improves safety. (Fickett Photo)

Traffic control has to be considered depending on what access is available and whether shoulders or lanes need to be closed. Coordination with other entities may be necessary if inspection operations impact railroads or navigable waterways.

Veterans Home Bridge, St. Paul, Minnesota



Veterans Home Bridge (Photo Courtesy MN DOT)

Expert Consultation and Construction Support of Early 1900s Historic Steel Arch Truss and Fracture Critical Approach Spans

The Veterans Home Bridge is a historic structure erected in 1908. A bridge strengthening project brought this early 1900s landmark steel arch-truss bridge up to current load rating standards.

The project included adding steel plates to specific members of the main arch span in addition to the fracture critical, steel approach span girders. After welding was performed, inspectors discovered numerous cracks in the new welds. The cracking problems were specific to the welds made on the girder webs of the approach span girders.

Performed Weld Analysis

Kraemer North America retained Fickett Structural Solutions to help analyze the weld cracking.

A metallurgical analysis of the bridge's original steel was needed. This analysis determined that the original steel in the webs of the approach span girders contained large amounts of phosphorus and sulfur. Steel materials from this era often contained these elements, which are problematic for welding and can lead to cracking. Because of the structural conditions, it was decided that all of the approach girders must be replaced.

Fickett witnessed the removal of the specimens in the girder approach spans and followed a pre-approved procedure. Other field welds in the arch span elements needed to be repaired to comply with welding standards. We used grinding and welding to conduct the repairs.

Our team also developed welding procedures to account for the material chemistries and field conditions. Fickett provided weld repair inspections and quality control during repairs of the retrofit reinforcing to steel elements.

Some of the retrofits on the arch-truss span included welding of strengthening plates onto tension members. Welds at the ends of these plates were transverse to the tensile stress. Fickett recommended and implemented Ultrasonic Impact Treatment to these details to mitigate any future likelihood of related fatigue cracking.

The FHWA mandate only requires testing of Fracture Critical Bridges. However, owners should identify other structures that utilize this material. They will want to determine if it's prudent to perform an inspection on those structures to mitigate risks because of weld concerns.

The next steps include ultrasonic testing (UT). The plan also should reflect how much testing should be performed for various welds on the structure and whether the welds are subject to tension, compression, or reversal loading.

NDE testing is a precision process. It requires paint removal that must meet environmental guidelines that differ from one state to another. Niemann notes that many bridges built during the designated era (1959-1978) often used lead paint, now considered hazardous waste.

A review of bridge records will show the existing paint system on the bridge. Many bridges of this age have been repainted or over-coated. Paint removal methods and requirements may vary depending on what type of paint is present on the bridge. Bridges often are located over water. Our team can coordinate with paint companies to make sure the paint doesn't contaminate a body of water and is disposed of properly.

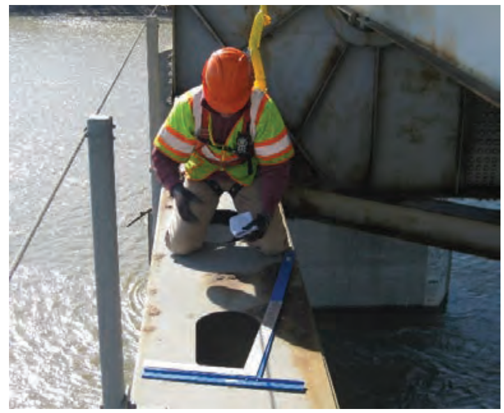
Finally, paint replacement options have to be considered and specified. This work consists of performing spot paint removal and replacement. The spot repaint system needs to be compatible with the existing paint system to mitigate local paint failure in these transition regions.

The duration of time until the next reasonable repaint project for the structure may influence the paint system used to restore these spot removal areas. If the bridge is expected to be repainted in the next ten years, spending the time and cost to repaint with a multi-coat sophisticated paint system on these spot areas may not be worthwhile or cost effective.

Fickett has experienced experts that can assist with these critical decisions. We will work with the owner to review these issues and assist in developing a comprehensive and complete inspection plan. Depending on structure size and the number of welds, the testing process could take several weeks, from paint removal to inspection and paint replacement. Public bridge owners may reduce mobilization and demobilization expenses if multiple bridges are located in the same region.

STEP 4: Perform Weld Testing

Only use professionals with experience in Nondestructive Evaluation in accordance with the AWS D1.5 Bridge Welding Code requirements. Our NDE technicians have the required training and decades of experience performing NDE testing to the standards required for this work. Some inspectors from other industries, such as oil & gas or energy, may perform UT. However, they may not be familiar with applicable standards for bridge testing.

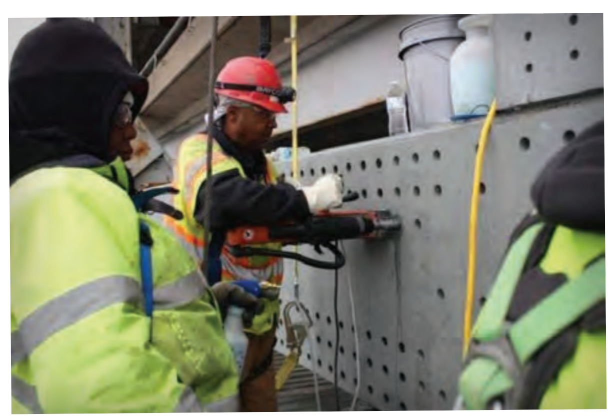


Inspecting the Sherman-Minton Bridge (Fickett Photo)

Before proceeding, Fickett partners with the bridge owner to establish a testing plan. It's necessary to identify the details you're going to test. Owners must decide if they will test at the minimum level required by FHWA or test additional areas.

STEP 5: Prioritize Bridge Repairs

After receiving NDE results, bridge owners will review findings, perform analysis, and prioritize needed repairs. Actions could include drilling holes, additional monitoring, and/or the design of retrofits to reinforce at-risk welds.



Bridge repair on the Sherman Minton Bridge (Construction Equipment Guide Photo)

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **ACTION:** Non-Destructive Testing of Fracture Critical Members Fabricated from AASHTO M244 Grade 100 (ASTM A514/A517) Steel

Date: December 13, 2021

From: Hari Kalla/s/
Associate Administrator, Office of Infrastructure

In Reply Refer To: HIBS

To: Division Administrators
Directors of Field Services

The purpose of this memorandum is to provide direction regarding the in-service inspection, inventory, and testing of butt welds in fracture critical members fabricated from AASHTO M244 Grade 100 (ASTM A514/A517) steel, more commonly known as "T-1" steel.

Constructed between 1960-1961, the I-64 Sherman-Minton Bridge is a fracture critical bridge which consists of two 800-foot tied arch truss main spans that carry six lanes across the Ohio River between Louisville, Kentucky, and New Albany, Indiana. As the result of a 2011 in-service inspection of the bridge, several cracks were found in the butt welds, or their associated heat-affected zones, of the tension ties of both spans, which were fabricated from T-1 steel. Discovery of the cracking resulted in the closure of the bridge. It was subsequently determined that the cracking was very likely caused by hydrogen that was introduced into the weld as the result of inadequate fabrication procedures.

In response to issues discovered on the Sherman-Minton Bridge, FHWA issued Technical Advisory 5140.32 which included recommendations to verify through visual and non-destructive testing, unless this verification had been previously conducted, the soundness of all butt welds in tension components fabricated from T-1 steel where cracks due to a lack of hydrogen control during welding had previously been found.

Link to the complete online document.