MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
DIGITAL RADIOGRAPHY IN STRUCTURAL STEEL FABRICATION

STR:MJF 1 of 4 APPR:SCK:REL:03-14-22
FHWA:APPR:04-11-22

a. Description. This special provision allows the use of digital or conventional radiography for the testing and acceptance of structural welds.

b. Materials. Conventional radiographs and digital images used in radiographic testing of welds in structural steel fabricated in accordance with section 707 of the Standard Specifications for Construction.

c. Construction. Perform radiographic testing (RT) per subsection 707.03.C.10 of the Standard Specifications for Construction and Clause 8 of the *AASHTO/AWS D1.5M/D1.5:2020 Bridge Welding Code (hereafter referred to as AWS D1.5)*. Convert conventional analog film, if used, to digital images for final acceptance and project record per the below section.

1. General Requirements. Convert conventional radiographs to digital images (digitized) for final record using equipment and a written procedure for digitizing film in accordance with the requirements herein. Weld acceptance may be based on conventional radiographs or properly validated or revalidated digital images. Records must include documented method of acceptance, documented verification of the digitizing system, and standard RT reports (reader sheets).

2. Written Procedure. The written procedure must include provisions for converting film to digital images and for accepting welds based on either the original conventional film or the digital image. MDOT approval and satisfactory demonstration of the procedure is required prior to testing and accepting production welds.

3. Essential Variables. The procedure must include the following parameters and information.

A. Digitizing System Description.

(1) Manufacturer and model number of digitizing system.

(2) Physical size of the usable area of the image monitor.

(3) Film size capacity of the scanning device.

(4) Spot size(s) of the film scanning system.

(5) Image display pixel size as defined by the vertical/horizontal resolution limits of the monitor.

(6) Luminance of the video display.

(7) Data storage medium. Store processed digital images on a Write Once Read Many (WORM) optical drive or equivalent reproducible electronic media.

B. Digitizing Technique.

(1) Digitizer spot size (in microns) to be used. The spot size of the digitizing system must be:

(a) 70 microns or smaller for film exposed with energies up to 1 Mega electron-volt (MeV); or

(b) 100 microns or smaller for film exposed with energies over 1 MeV.

(2) Loss-less data compression technique (if used).

(3) Method of image capture verification.

(4) Image processing operations.

(5) System verification.

(6) Time period for system verification. Verify system performance at the beginning of each digitizing shift and reverified at the end of the shift or 12 continuous hours or any time a malfunction is suspected.

4. System Performance Requirements. Verify system parameters are within the following limits. Reverify the system for any changes to system settings that could affect these parameters.

A. Spatial resolution. Ensure the system is capable of resolving a pattern of 7 line pairs/millimeter (lp/mm) for systems digitizing with a spot size of 70 microns or less, or 5 lp/mm for spot sizes greater than 70 microns.

B. Contrast sensitivity (density range obtained). The system must have a minimum contrast sensitivity of 0.02 optical density.

C. Dynamic range. The system must have a minimum dynamic range of 3.5 optical density.

D. Spatial linearity. The system must return measured dimensions within 3 percent of the actual dimensions on the reference film.

5. Verifying System Performance. Establish a reference radiograph in accordance with *ASTM E1936*. Evaluate each system performance parameter using the test targets as detailed herein.

A. Spatial Resolution. Select at least two of the converging line pair images (0 degree, 45 degree, and 90 degree line pairs) near the opposite corners of the digitizing field and one image near the center of the digitized reference film. Record the spatial

resolution in each position and for each orientation as the highest indicated spatial frequency (as determined by the reference lines provided) where all of the lighter lines are observed to be separated by the darker lines. Report the system resolution as the poorest spatial resolution obtained from all of the resolution images evaluated.

B. Contrast Sensitivity. Use the contrast sensitivity images and the digitized stepped density scale images to evaluate the detectability of each density step (the observed density changes must be indicative of the system's capability to discern 0.02 density differences). Evaluate the detectability of each density step and the difference between steps.

C. Dynamic Range. Determine the dynamic range of the digitization system by finding the last visible density step at both ends of the density strip. Measure the dynamic range to the nearest 0.50 optical density.

D. Spatial Linearity. Set the digitization system to read the inch scale on the reference film. Then use the measurement tool to measure the scale in a vertical direction and horizontal direction. Divide the actual dimension by the measured dimension to find the percentage of error in the horizontal and vertical directions.

6. Calibration Record. Document the system performance verification for each combination of essential variables on calibration record to be included in the final report.

7. Personnel Requirements. Provide evidence of qualified personnel involved in the digital imaging process and the interpretation of results and acceptance of system performance as follows:

A. Level II RT and Level III RT as required by the Bridge Welding Code except as noted in subsection c.7.D.

B. Specific training and practical experience in the digital imaging process and interpreting results and acceptance of system performance as defined in the Contractor's written practice and documented in the individual certification records.

C. Minimum 40 hours training and one month of practical experience in the digital imaging process technique.

D. Function-specific training and experience of personnel performing functions to support the digital imaging process that do not require Level II or III certification.

8. Procedure Demonstration. Ensure the written procedure is demonstrated to the satisfaction of the Engineer or designated representative. Ensure the demonstration is documented in the final report as described herein.

9. Acceptance of Digital Images.

Visually examine each radiographic film for foreign material and artifacts (e.g., scratches or water spots) in the area of interest. Note in the report, or annotate on the digital image, any identified foreign material or artifacts.

Compare each digital image to its radiograph for acceptance or rejection by a qualified Level

II or Level III RT technician.

Delete rejected images or images that were invalidated due to a failed system reverification and re-digitize the film.

Base final weld acceptance on either the analog film prior to digitizing or on the digital image per Clause 8, Part B of AWS D1.5.

10. Records. Document all information pertaining to the original conventional film on the final report and processed as part of the digital record. Replace the conventional film with the final report and digital images as the permanent project record. Prior to destroying/recycling film, as backup, make a duplicate copy of the data storage medium according to Clause 8.12.4 to be retained per Clause 8.12.3 of AWS D1.5.

Submit a pdf copy of the interpretation reports (reader sheets) for each image per Clause 8.12.2 of AWS D1.5 and of the final report of digitization described herein. Submit a full set of digital images for all welds subject to RT, formatted and archived according to Clause 8.12.4 of AWS D1.5. Transfer any portable hard-drives used for archiving to the QA Inspector for delivery to MDOT, and notify MDOT.

Include the following information on the final report.

A. Spatial Resolution.

B. Contrast Sensitivity.

C. Frequency of System Verification.

D. Dynamic Range.

E. Traceability technique from original component to film to displayed digital image, including original radiographic report(s). (The original radiographic reader sheet may be digitized to fulfill this requirement).

F. Condition of Original Radiographic Film.

G. Procedure Demonstration.

H. Spatial Linearity.

I. System Performance Parameters.

J. Personnel Performing the Digitization and Evaluation.

d. Measurement and Payment. The completed work, as described, will not be paid for separately, but will be included in other pay items in the contract.