RADIOGRAPHIC TESTING INSPECTION PROGRAM

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North Carolina Department of Transportation

Manufactured Products Group

Materials and Tests Unit

Version 1.0 (REV. 10/10/24)

DOCUMENT CONTROL

The RADIOGRAPHIC TESTING INSPECTION PROGRAM is reviewed during use for adequacy and updated as necessary by the NCDOT Materials and Tests Unit, Manufactured Products Group.

Electronic

Portable Document Format (PDF) has been selected as the primary distribution format. The official version of this program is available on the NC Department of Transportation website.

Hard Copy

Users who choose to print a copy of this manual are responsible for ensuring use of the most current version.

REVISION LOG

Revision Date	Description	Approval By
September 15, 2000	Radiographic Inspection of Groove Welds	DEG
February 16, 2003	Radiographic Inspection of Groove Welds	SCW
February 9, 2011	Radiographic Inspection of Groove Welds	SCW
October 10, 2024	Radiographic Testing Inspection Program	SRP

CONTENTS

INTRODUCTION

PURPOSE

This program is provided to serve as guide and source of reference for the NCDOT minimum requirements for radiographic testing of groove welds.

Radiographic testing of groove welds shall conform to the current edition of the North Carolina Department of Transportation Standard Specifications for Roads and Bridges, Special Provisions, AWS D1.1 and AWS D1.5, as applicable.

SCOPE

This program affects the fabrication facilities, non-destructive testing (NDT) agencies, NCDOT Materials and Tests office, and consultants who are involved in the testing, quality control and/or quality assurance testing of groove welds.

DEFINITIONS

For a complete listing of definitions please see Annex A of this document.

REFERENCES

AASHTO: American Association of State Highway and Transportation Officials

- AASHTO LRFD Bridge Design Specification
- AASHTO LRFD Bridge Construction Specifications
- AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges
- AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals

AWS: American Welding Society

- AASHTO/AWS D1.5 Bridge Welding Code
- AWS D1.1 Structural Welding Code – Steel
- AWS Radiographic Interpreter Textbook

ASNT: American Society for Nondestructive Testing

- Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing

ASTM: American Society for Testing and Materials

- ASTM E94, Standard Guide for Radiographic Examination Using Industrial Radiographic Film
- ASTM E999, Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing
- ASTM E1025, Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators [IQI] used for Radiography
- ASTM E1032, Standard Practice for Radiographic Examination of Weldments Using Industrial X- Ray Film
- ASTM E1079, Standard Practice for Calibration of Transmission Densitometers
- ASTM E1316, Standard Terminology for Nondestructive Examinations
- ASTM E1254, Standard Guide for Storage of Radiographs and Unexposed Industrial Radiographic Film
- ASTM E1390, Standard Specification for Illuminators Used for Viewing Industrial Radiographs
- ASTM E1742, Standard Practice for Radiographic Examination
- ASTM E1815, Standard Test Method for Classification of Film Systems for Industrial Radiography

SAFETY

Radiographic testing involves hazardous materials, operations, and equipment. It is the sole responsibility of the contractor to maintain all regulatory requirements when performing radiographic operations.

GENERAL INFORMATION

1.0 PERSONNEL CERTIFICATION

1.1. Personnel performing Nondestructive Testing (NDT) other than visual examination shall be certified as NDE Level II in conformance with the latest edition of the American Society for Nondestructive Testing's (ASNT) recommended practice number (SNT-TC-1A).

1.2. The Employer's program shall meet all established guidelines of SNT-TC-1A for the qualification of NDT personnel.

1.3. The fabricator's program shall provide qualification/certification for radiographic film interpretation for quality control (QC) personnel whose firm has subcontracted NDT operations. An acceptable alternative would be the American Welding Society (AWS) Certified Radiographic Interpreter (CRI) certification.

1.4. In addition, all personnel performing NDT for final weld acceptance shall be subject to the Department's practical proficiency test.

2.0 RADIOGRAPHIC TESTING

2.1. Sources

2.1.1 X-Ray Units, 600 kVp potential maximum, and Iridium 192 may be used as a source for all Radiographic Testing provided, they have adequate penetrating ability. Cobalt 60 shall be used as a Radiographic Testing source only when the steel being radiographed exceeds 3" in thickness. Other radiographic sources shall be subject to the approval of the Engineer.

2.1.2 The radiographic technique will be in accordance with the applicable AWS D1.1 or AWS D1.5 code requirements and as modified herein.

2.1.3 The maximum width allowable to be tested in a single exposure is 24".

2.2 Radiographic Film

2.2.1 The film shall be ASTM system Type 1 or Type II per ASTM E1815 and shall be from dated stock.

2.2.2 The minimum film size for any welds associated with steel bridge girders will be 4 ½" X 10". Maximum film size shall be 7" X 17" unless larger film is approved by the Engineer or his representative.

2.3 Lead Screens

2.3.1 Lead foil screens shall conform to ASTM E94.

2.3.2 **Fluorescent screens shall be prohibited.**

2.4 Film Identification

2.4.1 Information required to be on the film:

2.4.1.1 NCDOT Contract Number

2.4.1.2 Fabricator's Name [Initials are acceptable].

2.4.1.3 Fabricator's Shop Job Number

2.4.1.4 Date

2.4.1.5 Testing Company's Name [Initials are acceptable].

2.4.1.6 Lead Technician's Name [Initials are acceptable].

2.4.1.7 Weld identification

2.4.1.7.1 Weld identification shall be generated using the component(s) as found on the Department approved drawings and the location of the splices. Weld identification shall start at the Fabricators working end of the member.

2.5 Film Marking

2.5.1 Lead Letters and Numbers **shall** be used for marking and identification.

2.5.2 Lead letters and numbers will be of the same size and font [type] [style].

2.5.3 Light flashing for identification is permitted only for High Mast Pole applications and shall not interfere with the readability of the film. Making corrections with any type of marker is not permitted.

2.5.4 Lead read points will be of a consistent type and will be evenly spaced and use alphanumeric labeling.
Example: A to B, B to C, or 1 to 2 ,2 to 3. Etc.

2.5.5 Read points will be spaced so that the read point is no less than one inch from the edge of the processed film. Read points and identification letters, numbers, and IQIs shall be used in a consistent manner and placed as straight and neatly as possible.

2.5.6 On a web splice the initial read point will begin at the tension side. On all welds subject to radiographic testing [RT] the location markers shall be evenly spaced.

2.5.7 Read Points shall be marked on the steel with a durable marker or crayon at the location of where the lead letter/number read point was placed. The piece mark of the weld splice shall be marked on the steel with a durable marker or crayon near the weld splice. i.e.: 1A1TFA, 3AB3BFC, etc.

2.5.8 Film used to validate weld repairs shall have R1, R2 or R3 as applicable added following the piece mark to identify weld repair number. i.e.: 2C5TFA R1 [R2 R3, etc.] Weld repairs are limited to a maximum of R3.

2.5.9 If a weld repair is made in an area where a rejectable discontinuity appears on two films, typically an area where two films overlap, both films will be re-shot.

2.5.10 If a rejectable discontinuity appears on two films, after the weld repair, both films will be re-shot.

2.5.11 **Steel stencils/stamps are not permitted.**

2.6 Image Quality Indicator (IQI)

2.6.1 IQI's shall be used in accordance with the AWS D1.5 Bridge Welding Code and/or the AWS D1.1 Structural Welding Code as applicable.

2.6.2 IQI's shall be of the hole type. Wire type image quality indicators shall not be used.

2.6.3 IQI's shall be placed on the source side of the film. For tubular applications, IQI's may be placed on the film side, as permitted under AWS D1.1.

2.6.4 All IQI's shall show the required sensitivity.

2.7 Edge Blocks

2.7.1 Edge blocks shall be used when radiographing butt welds greater than 1/2 "in thickness. The edge blocks shall have a length sufficient to extend beyond each side of the centerline for a minimum distance equal to the weld thickness, but not less than 2 inches, and shall have a thickness equal to or greater than the thickness of the weld.

2.7.2 The minimum width of the edge blocks shall be equal to half the weld thickness, but not less than 1 inch. The edge blocks shall be centered on the weld with a snug fit against the plate being radiographed allowing no more than 1/16" gap.

2.7.3 Edge blocks shall be made of radiographically clean steel and the surface shall have a finish of ANSI 125 or smoother.

2.8 Processing

2.8.1 Processing times shall be the maximum per manufacturer's recommendations.

2.9 Density

2.9.1 Density Shall be as specified as applicable in the AWS D1.1 and/or AWS D1.5 welding codes.

3.0 EXAMINIATION REQUIREMENTS

3.0 General

3.0.1 If not otherwise detailed on Stamped Approved Drawings or by Special Provisions the following requirements apply.

3.0.2 Exposures that result in an unreadable film will be reshot during that work shift.

3.1 Bridge Applications

3.1.1 All Flange Butt Weld Splices will be 100% radiographically tested.

3.1.2 All flanges with a transition in thickness will be tested from the sloped side.

3.1.3 Flanges with a transition in width may require made to fit edge blocks.

3.1.4 All web butt splice welds will be Radiographically Tested 1/6th the depth of the web in the tension including the opposite web side and 25% of the remainder. If a defect is found in the test length of the weld, the entire weld shall be examined.

3.1.5 Flanges and webs with one splice only need TF, BF or W after the piece mark.

Example: A member with a piece mark 1A1 has 3 splices in the top and bottom flange and 2 web splices. Beginning at the working end the first top flange splice is 1A1. TFA, the second is 1A1TFB and the third is 1A1TFC. The same applies to the bottom flange 1A1BFA,1A1BFB, and 1A1 BFC. The web would be 1A1 WA and 1A1 WB.

3.2 High Mount Standards

3.2.1 Radiographically test the longitudinal seam welds within 6" of the base plate and within 6" of the larger end of the outer tube of the slip fit joint area. The 6" of the weld examined shall include the edge. The entire radiographic film shall meet the governing requirements of the code. See Section 1401 of the *Standard Specifications* for radiographic test requirements and acceptable joint efficiency requirements.

4.0 FILM READING AND INTEPRETATION

4.1. Illuminator

4.1.1. The Fabricator shall provide a suitable variable intensity illuminator (viewer) with spot review or masked spot-review capability in accordance with ASTM E 1390.

4.1.2. The viewer shall incorporate a means for adjusting the size of the spot under examination. The viewer shall have sufficient capacity to properly illuminate radiographs with an H & D density.

4.2. Before a weld subject to RT is accepted, all its radiographic film or digital images, including any showing defects prior to repair and those showing acceptable final quality, shall be submitted to the QA Inspector for review. QA review does not relieve the Contractor and/or Fabricator of the project specific requirements. The radiographic film or digital images shall be accompanied by the report interpreting the results and signed by the Contractor's RT technician and QC designated personnel.

4.3. The Radiographic Contractor shall read, interpret, and generate a report representing the film.

4.4. The fabricator shall read and interpret the film.

4.5. The fabricator will show acceptance of the film by signing and dating the report.

4.6. The fabricator will provide the film and report to the NCDOT Engineer or their representative. Once reviewed the film and reports will remain with The Department.

5.0 RADIOGRAPHIC REPORTS

5.1. No additional assembly shall be performed until the film for those individual members has been approved by the Engineer or his representative.

5.2. Reports will be formatted to include at least the information found on M&T Form 4210, see Annex B of this document.

5.3. Each exposure will be reported individually, including any film made in an overlapped film exposure.

5.4. Acceptable/Rejectable discontinuities shall be identified in the report based on the interpreter's evaluation. i.e.: Slag, Porosity, Lack of Fusion, etc.

5.5. Film artifacts, streaks, scratches and similar shall be reported. Excessive film artifacts may be cause for rejection of the image.

5.6. Film will be cataloged per piece mark in such a manner to prevent scratching or other damage to the film. The film and report will be packaged together. The film representing a piece mark will be placed in a paper interleaf. The paper interleaf will have the piece mark representing that film on it.

5.7. All films represented in the report will be placed together in an envelope or a box which will be marked with the testing agency's name, fabricators name, shop job number, NCDOT Contract Number and date.

Annex A: DEFINITIONS

Activation: The process of causing a substance to become artificially radioactive by subjecting it to bombardment by neutrons or other particles.

Anode: The positive electrode in an X-ray tube. In an X-Ray tube, the anode carries the target.

Area of Interest: The specific portion of the object image on a radiograph that is to be evaluated.

Back Scattered Radiation: The radiation that is scattered more than 90 degrees with respect to the incident beam.

Cassette: A light-tight container for holding radiographic film with or without intensifying screens.

Cathode: The negative electrode of an X ray tube.

Clearing Time: The time needed for the first stage of fixing of a film, during which the cloudiness disappears.

Collimator: A device of radiation-absorbent material intended for defining the direction and angular divergence of the radiation beam.

Composite Film Viewing: The viewing of two or more superimposed radiographs from a multiple film exposure.

Contrast (radiographic): The measure of the difference in film blackening resulting from various X-ray intensities transmitted by the object and recorded as density differences in the image. In other words, the difference in film blackening from one area to another is contrast.

Curie (Ci): A unit of radioactivity. The radioactivity of any material which is disintegrating at a rate of 3.7×10^{10} atoms/sec. The disintegration rate of radon is approximately 3.7×10^{10} atoms/sec.I curie.

Decay (radioactive): The spontaneous change of a nucleus and emission of a particle or photon. For a definite quantity of a nuclide, the rate of decay is usually expressed in terms of half-life.

Defect: One or more flaws whose aggregate size, shape, orientation, location, or properties do not meet specified acceptance criteria and are therefore rejectable.

Definition (image definition): The sharpness of delineation of image details in a radiograph. Generally used qualitatively.

Densitometer: A device for measuring the optical density of radiograph film.

Density (film): The quantitative measure of film blackening when light is transmitted or reflected.

Developer (radiographic): A chemical solution which reduces exposed silver halide crystals to metallic silver.

Discontinuity: A lack of continuity or cohesion; an intentional or unintentional interruption in the physical structure or configuration of a material or component.

Edge-blocking material: Material applied around a specimen or in cavities to obtain a more uniform absorption, to reduce extraneous scattered radiation, and to prevent local over-exposure, e.g., fine lead shot (see also "Blocking medium").

Evaluation: A review, following interpretation of the indications noted, to determine whether they meet specified acceptance criteria.

Exposure (radiographic exposure): The subjection of a recording medium to radiation for the purpose of producing a latent image. Radiographic exposure is commonly expressed in terms of milliampere-seconds or millicurie-hours for a known source-to-film distance.

False indication: An NDT indication that is interpreted to be caused by a condition other than a discontinuity or imperfection. (See: Artifact)

Film badge: A package of photographic film worn like a badge by workers in the nuclear industry to measure exposure to ionizing radiation. The absorbed dose can be calculated by the degree of film darkening caused by the irradiation.

Film holder: A light-tight carrier for films and screens. (See "cassette")

Fixer: A chemical solution which dissolves unexposed silver halide crystals from developed film emulsions.

Flaw: An imperfection or discontinuity that may be detectable by nondestructive testing and is not necessarily rejectable.

Gamma Radiation: High-energy, short wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma rays are very penetrating and are shielded by dense materials such as lead. Gamma rays are similar to X rays.

Gamma radiography: Radiography using a gamma-ray source.

Gamma rays: Electromagnetic ionizing radiation, emitted by specific radioactive materials.

Geometric Unsharpness: Unsharpness of a radiographic image arising from the finite size of the source of radiation. Its magnitude also depends on the distances of source to-object and object-to-film. Also called geometric blurring or penumbra.

Half-Life: The time in which half the atoms of a radioactive substance will have disintegrated, leaving half the original amount. Half the residue will disintegrate in another equal period of time. The half- life values for radioisotopes vary widely.

High Radiation Area: Any area, accessible to personnel, in which radiation levels can result in an individual receiving a dose equivalent in excess of 0.1 rem in one hour at 11.8 in. (30 cm) from the radiation source or from any surface that the radiation penetrates.

Indication: The response or evidence from a nondestructive examination that requires interpretation to determine relevance.

Interpretation: The determination of whether indications are relevant, nonrelevant, or false.

Intensifying Screen: A material used in radiographic production to convert a part of the ionizing radiation into light or electrons and that, when in contact with a recording medium during exposure, improves the quality of the radiograph, and/or reduces the exposure time required to produce a radiograph or both.

Latitude (radiographic): Latitude most closely aligned with contrast is commonly called the "scale" of the film. Latitude is the range of thickness of material that can be recorded on the radiograph within the useful reading range of film density. A radiograph with high contrast has little latitude, and conversely, a radiograph with low contrast has great latitude.

Location marker: A number or letter made of lead (Pb) or other highly radiation attenuative material that is placed on an object to provide traceability between a specific area on the image and the part.

Nondestructive Testing (NDT): The development and application of technical methods to examine materials or components in ways that do not impair future usefulness and serviceability in order to detect, locate, measure and evaluate flaws; to assess integrity, properties and composition; and to measure geometrical characteristics.

Nonrelevant indication: An NDT indication that is caused by a condition or an intentional discontinuity that does not require evaluation.

Radiation area: Any area, accessible to personnel, in which radiation levels may result in an individual receiving a dose equivalent more than 0.005 rem in one hour at 11.8 in. (30 cm) from the radiation source or from any surface that the radiation penetrates.

Radiographer: Any individual who either performs or, in attendance at a site where a sealed source or sources are being used, personally supervises radiographic operations, and who is responsible to the licensee for assuring compliance with the requirements of safety regulations and the conditions of the licenses.

Shim: A material, typically placed under the IQI, which is radiologically like the object being imaged.

Source: A machine or radioactive material that emits penetrating radiation.

Source size: An indication of the radioactive intensity of a radioactive mass typically in units of Bequerels (formerly in Curies).

Source-to-film distance (SFD): The distance between the source of radiation and the film along the path of the beam of radiation.

Stop bath: A mild acetic acid solution used to arrest film development.

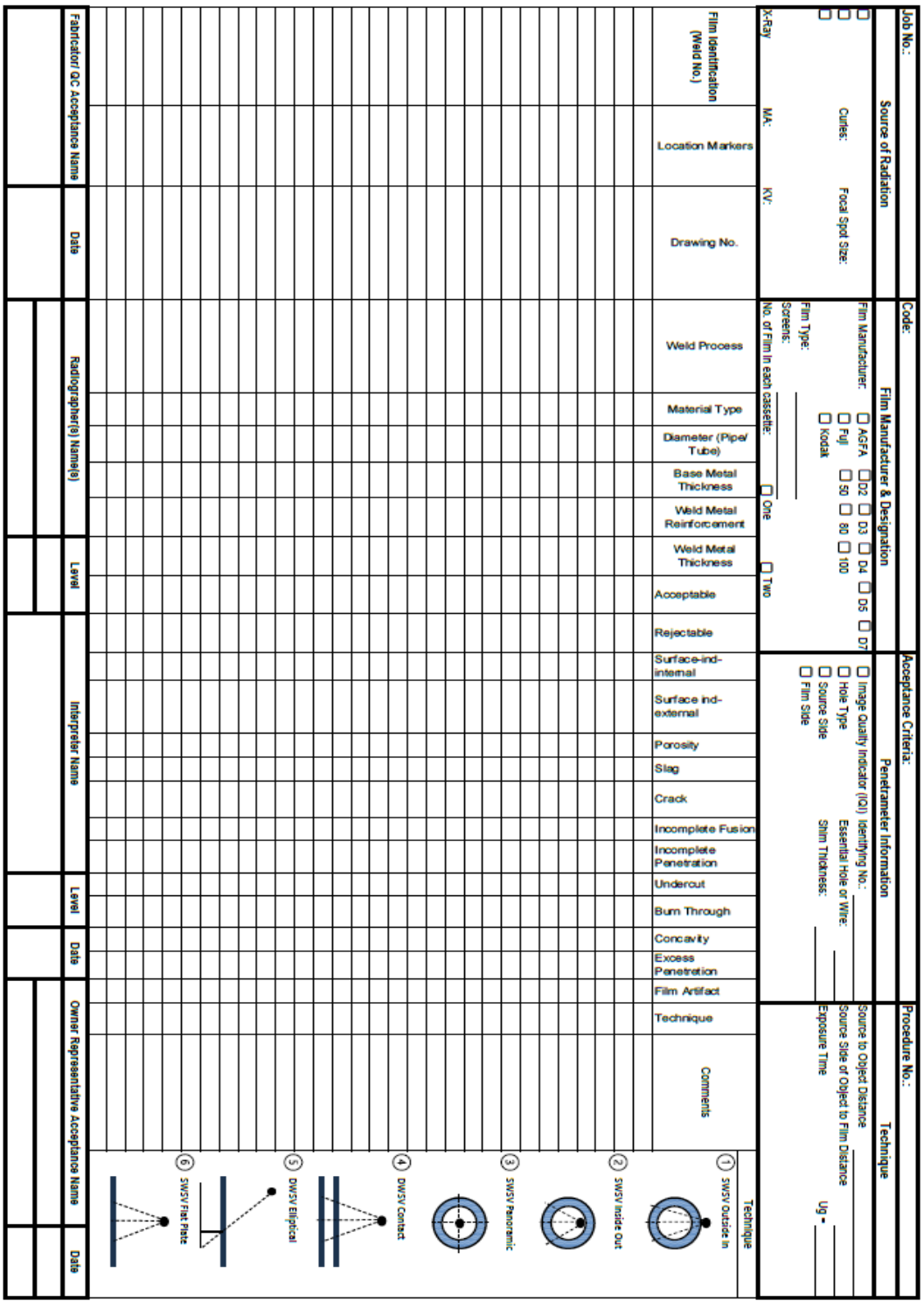
Survey: An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources or radiation under a specific set of conditions. When appropriate, such an evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation.

Survey meter: A portable instrument which measures dose rate of exposure or radiation intensity.

Useful density range: The practical range of optical density on a radiograph. Maximum density is determined by the film illuminator and the minimum by the loss in flaw sensitivity.

Wetting agent: A substance that reduces the surface tension of a liquid, thereby reducing the formation of air bubbles.

Annex B: RADIOGRAPHIC INSPECTION REPORT



MT Form 4210
ANNEX B
Fabricator:
Address:

North Carolina Department of Transportation
Materials and Tests Unit, Structural Materials Group
1801 Blue Ridge Road, Raleigh, NC 27607
Tel: 919-329-4000 - Fax: 919-733-5742

RADIOGRAPHIC INSPECTION REPORT

Contract No.:
Welding Specification:

Job No.: | Code: | Acceptance Criteria: | Procedure No.:

Source of Radiation | Film Manufacturer & Designation | Penetrameter Information | Technique

Curies: | Focal Spot Size: | X-Ray | MA: | KV:

Film Manufacturer: ☐ AGFA ☐ Fuji ☐ Kodak | ☐ D2 ☐ D3 ☐ D4 ☐ D5 ☐ D7 | ☐ 50 ☐ 80 ☐ 100

Film Type:
Screens:
No. of Film in each cassette: ☐ One ☐ Two

☐ Image Quality Indicator (IQI) Identifying No.:
☐ Hole Type
☐ Source Side
☐ Film Side
Essential Hole or Wire:
Shim Thickness:

Source to Object Distance
Source Side of Object to Film Distance
Exposure Time
Ug =

Film Identification (Weld No.)	Location Markers	Drawing No.	Weld Process	Material Type	Diameter (Pipe/ Tube)	Base Metal Thickness	Weld Metal Reinforcement	Weld Metal Thickness	Acceptable	Rejectable	Surface-ind-internal	Surface ind-external	Porosity	Slag	Crack	Incomplete Fusion	Incomplete Penetration	Undercut	Burn Through	Concavity	Excess Penetration	Film Artifact	Technique	Comments

Technique

① SWSV Outside In
② SWSV Inside Out
③ SWSV Panoramic
④ DWSV Contact
⑤ DWSV Elliptical
⑥ SWSV Flat Plate

Fabricator/ QC Acceptance Name	Date	Radiographer(s) Name(s)	Level	Interpreter Name	Level	Date	Owner Representative Acceptance Name	Date