Radiographic Examination Procedure

RTD Quality Services Inc
1431-70 Avenue Edmonton AB, Canada

Client	:	Kinder Morgan Canada Inc.
Project	:	TMX Anchor Loop
NDE Contractor	:	RTD Quality Services Inc
Scope	:	Radiographic Examination
Based on	:	CSA Z662-2003 Oil & Gas Pipeline Systems

			CGSB 3319-ACCP 1754	
0	15.08.2007	Rick Torok CGSB Level-II	John McCanna CGSB Level-III	SHANE MEGORAN 17TH AUG 2007
Rev No.	Date	RTD Prepared by:	RTD Approved by:	Client Approved by:

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1.0 Introduction

Radiography is used to detect features of a component or assembly that exhibit differences in thickness or physical density compared to the surrounding material. Radiographic Inspection is used extensively on castings and weldments, particularly where there is a critical need to ensure freedom from internal flaws.

2.0 Purpose

The purpose of this procedure is to detail the methodology used for Radiographic Examination of welds completed for the TMX Anchor Loop Pipeline Project, following the requirements of CSA Z662-2003 Oil & Gas Pipeline Systems Standard.

3.0 Scope

3.1 This procedure applies to radiographic examination of girth welds produced in the field, at a fabrication facility and for Welder / Procedure Qualifications. Radiographic examination will be in compliance with the Canadian Standards Association CSA Z662-2003 Oil & Gas Pipeline Systems Standard and utilize X-Ray equipment for producing radiation.

3.2 This procedure addresses the general requirements for radiography of:

- Girth Butt welds completed utilizing either the GMAW, SMAW or FCAW welding technique's.
- Shop fabricated welds completed using either SMAW and/or FCAW welding techniques designed and/or performed under CSA Z662-03 and related ASME BPV Code Section V (NDE), when approved by the Company.

3.3 This procedure has been produced to enforce the applicable codes & standards, provide clarification where options exist and to specify general requirements. Specific details and/or requirements for individual projects are to be addressed separately.

4.0 Referenced Documents

- CSA Z662-2003, "Oil & Gas Pipeline Systems"
- ASME Boiler & Pressure Vessel Code (BPV) Section V
- Regulation 182/2003 Radiation Protection, Province of Alberta
- CAN/CGSB-48.9712-2006/ISO 9712:2005, NDT-Qualification & Certification of Personnel
- ASTM E999-99, Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing.
- RTD Radiation safety Manual
- ASTM E747-97, Standard Practice for Design & manufacture of Wire IQI's
- ISO 1027, Standard Practice for Design & manufacture of Wire IQI's
- ASTM E1025-98, Standard Practice for Design & manufacture of Hole IQI's

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5.0 Personnel Qualifications

- Senior Technicians shall be certified (minimum) to RT Level II in accordance with the requirements of CAN/CGSB 48.9712-2000
- Only personnel certified to Level II or higher shall interpret the test results.
- Personnel operating a radioisotope device shall meet the requirements of "Qualified Operator", as defined by the CNSC, "Canadian Nuclear Safety Commission".

6.0 Principle

A source of radiation is placed on one side of a test piece and a recording medium (film) is placed on the other side. Radiation from the source side is absorbed by the test piece as the radiation passes through it; any potential flaw and the surrounding material absorb different amounts of radiation. Thus, the radiation that reaches the film in a potential flaw area is different from the amount that impinges on the adjacent areas. This produces on the film a latent image of the flaw that, when the film is developed, can be seen as a "indication" of different photographic density from that of the image of the surrounding material.

7.0 Safety

All safety precautions and requirements are to be followed, before and during all examinations, in accordance with, all client specific Health and Safety programs, RTD Radiation Safety Practices and Provincial Regulations were applicable.

Large doses of X-rays can damage skin and blood cells, can produce blindness and sterility, and in massive doses can cause severe disability or death. Protection of personnel, not only those engaged in radiographic work but also those in the vicinity of radiographic inspection, is of major importance. To ensure a safe working environment for everyone involved, the following guidelines must be followed:

- Every worker shall be informed of the hazards of working in an area where exposure is possible.
- Adequate precautions shall be taken to protect the Radiographer(s), Qualified Operator(s) and any other person in the area.
- The Radiographer(s) and/or Qualified Operator(s) shall be responsible for making sure that the areas affected by radiation are surveyed and the limits of hazards posted.
- All radiation protection and monitoring shall comply with the applicable requirements of Government Regulations, applicable codes and/or Client Specific requirements.
- Only workers directly involved with radiation inspection shall be in the immediate area of work.
- Where required by contract requirements, a 360º amber rotating light shall be used when exposures are in progress.

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8.0 Equipment & Materials

8.1 Radiation Sources

The source of radiation shall be an x-ray emitting machine.

X-ray machines operating at any voltage that achieves the required radiographic quality and meets the requirements of the applicable codes and/or specifications shall be used to produce the x-radiation.

8.2 Film

Structurix Agfa G1 films will be selected on the basis of the ability to meet sensitivity requirements specified by the governing standard and/or client specifications.

Whenever more than one film is utilized, the adjacent film shall overlap by a minimum of 50 mm in order to provide sufficient coverage.

Film shall have sufficient width to provide adequate coverage on each side of the weld.

8.3 Film Density

Films shall be exposed so that the density is between 2.0 and 4.0 throughout the area of interest. Localized areas due to weld reinforcement may not be lower than 1.5.

The unexposed base density of the film is to be checked weekly as a minimum and shall not exceed 0.30. This piece of unexposed film is to be recorded on the Radiographic Report and added to the appropriate film box and/or film envelope.

8.4 Image Quality Indicators (IQI)

Image quality indicators used to measure sensitivity shall be the wire type and conform to ASTM E747 and/or ISO 1027, unless otherwise specified.

Image Quality Indicators used for compliance to ASME B31.3, shall be the hole-type, in accordance with ASTM E1025.

The IQI shall be radiographically similar to the material being examined.

When utilizing a single exposure (SWX/SWV), three (3) IQI's shall be placed evenly around the circumference, 120º intervals. When utilizing (DWX/SWV) exposures, two (2) IQI's shall appear on each film, within 25mm of film edge. When utilizing multiple film cassettes, the image of one IQI shall appear on each film.

For double-wall, single-image radiographs, the IQI shall be placed on the film side.

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8.5 Comparator Shims

Comparator shims shall be used to evaluate undercut in the welds. The design of the shim shall be as described in CSA Z662-2003. The radiographic image of the shim shall be free of IQI's, lead markers or other images.

Shims shall be made of material radiographically similar to the material being inspected.

The depth of the undercut shall be evaluated by comparing the density of the film image undercut to the density of the notch depths in the comparator shim.

The utilizing multiple film exposures, the image of at least one comparator shim shall appear on each radiograph. When utilizing single exposure techniques, three (3) comparator shims shall be used, placed at 120^{o} intervals.

8.6 Viewing Facilities

Viewing facilities shall provide subdued background lighting of an intensity that will not cause troublesome reflections, shadows, or glare on the radiograph.

Equipment used to view radiographs for interpretation shall be High Intensity Viewers, which provide a variable light source sufficient for the essential IQI to be visible for the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretations. Final Interpretation shall be done on dry film.

8.7 Densitometer

A calibrated densitometer shall be used to evaluate that the film density's are within specified limits. All densitometers shall be calibrated as a minimum, on a 90 day basis. Confirmation of densitometer calibration status shall be performed prior to performing any evaluations.

9.0 Surface Preparation

Surfaces shall satisfy the requirements of the applicable materials specifications or referencing code section, with additional conditioning, if necessary, by any suitable process to such a degree that the resulting radiographic image due to any surface irregularities cannot mask or be confused with the image of any discontinuity.

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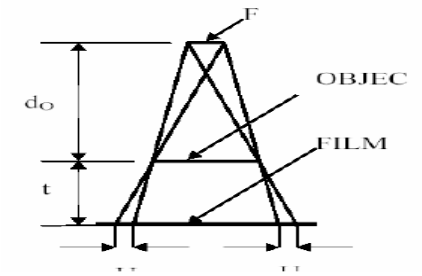
10.0 Geometry (Geometric Unsharpness)

The focus-film distance necessary to reduce geometric unsharpness to a negligible amount depends upon the film, focal spot size and the object-film distance. Geometric unsharpness is shown in figure 1 and is given by the following equation:

$$U_g = F\ t\ /\ d_o$$

Where:
U_g = geometric unsharpness,
F = size of radiation source,
t = specimen thickness, when in contact with the film, and
d_o = source - object distance



11.0 Identification of Radiographs

Films shall be clearly identified by lead numbers, letters or flash cards, or any other method approved by both RTD and the Client to ensure that the location of the weld and any discontinuities in the weld can be quickly and accurately located.

When more than one film is used to inspect a complete circumferential weld, the identification markers shall appear on each film and the weld marker location shall be common to two successive films to ensure that the entire weld has been examined and that overlap is evident.

Where applicable, the location markers shall be placed in a clockwise direction on the downstream side of the weld and the zero marker shall correspond to the 12 o'clock position. The number belt spacing of lead numbers shall be 50mm.

Using the numbering sequence specified by Kinder Morgan Canada Inc, each weld is to be assigned a unique number for Quality Control & Traceability. Repaired welds shall be identified by adding the suffix "R" to the weld number. Each successive repair (if applicable) will be added to the suffix, "R2", etc. Welds which have been cut out will require a suffix "CO" added to the original weld number.

As a minimum, information on each film should include:

- Project Name
- Diameter & Wall Thickness
- Weld Number
- Date of Inspection
- Radiography Procedure Number
- Radiographers Name

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12.0 Processing of Radiographs

Processing of radiographic film and the use of film processing chemistry shall be in accordance with manufactures recommendations. All chemicals used shall be stored and discarded in strict compliance with RTD Policy. Chemistry change forms (see attachment #2) shall be filled out and posted in each mobile lab. MSDS information on all Darkroom Chemistry is to be available in the mobile lab. Farmers Reagent or similar solutions for density reductions shall not be permitted.

13.0 Quality of Radiographs

All radiographs shall be free from mechanical, chemical, and/or other blemishes to the extent that they do not mask and are not confused with the image of any discontinuity in the area of interest of the object being radiographed. Such blemishes include, but are not limited to:

- Fogging
- Processing defects such as streaks, watermarks, or chemical stains.
- Scratches, finger marks, crimps, dirtiness, static marks, smudges, or tears.
- False indications due to defective screens.

14.0 Radiographic Techniques

Radiographic techniques for each Radiography Crew shall be demonstrated and qualified for each respective pipe diameter, wall thickness and radiation method before the start of production welding commences. The single wall (panoramic) exposure shall be used whenever practical to do so. One acceptable radiograph is to be produced for each technique. All results are to be recorded on the RTD Radiographic Procedure Form (see attachment #3) and keep on file with the associated film.

15.0 Records & Reports

All details of the radiographic examination are to be recorded daily on the radiographic report (see attachment #4). Assessment of weld quality in accordance with the requirements of the acceptance criteria provided, are to be reported. Copies to be provided to the Client as instructed. Records of radiographic procedures, qualifications, unexposed base film & production welds are to be packaged in film boxes and identified with Project Name, Project Number, Range of weld numbers, Dates of Inspection, Box Number, NDE Contractor and Radiographers Names. Each box shall contain a copy of the radiographic report for each weld. Radiographs of replacement welds are to be placed in the same slot as the original (cut-out) weld. All repair films and/or re-shot films are to be packaged with the original films.

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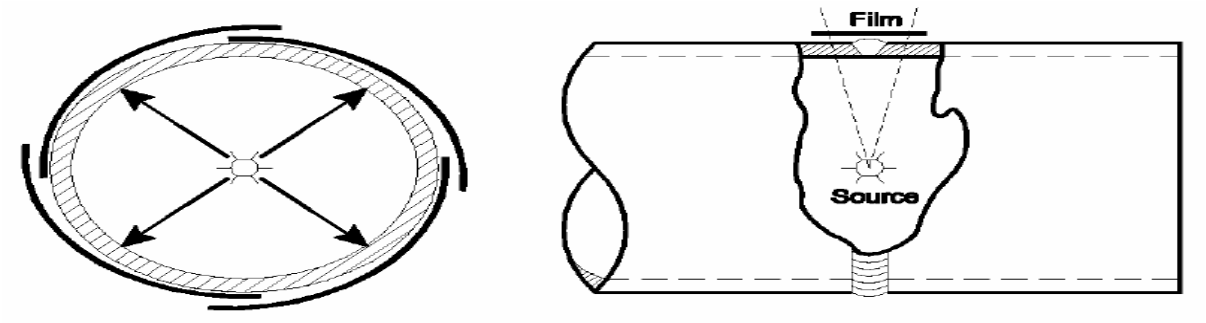
Attachment 1 –Example of Radiographic Technique Sheets

TECHNIQUE A

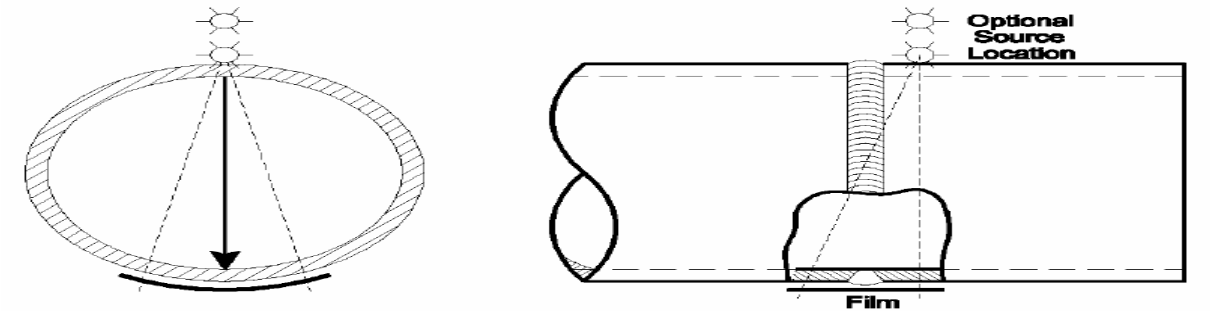
Figure A-1: Exposure Arrangement for Single Wall Exposure – Center Alignment



Exposure:	Single Wall - Center Alignment
Viewing:	Single Wall
Minimum Number of Exposures:	As Many as Necessary for Complete Coverage
Radiation Source:	X-Radiation or Gamma Radiation
X-ray Voltage and Focal Spot Size (X-ray):	See Individual Report
Isotope Type and Physical Size:	See Individual Report
Base Material Type and Thickness:	See Individual Report
Minimum Source to Object Distance:	½ Inside Diameter

TECHNIQUE E

Figure E-1: Exposure Arrangement for Double Wall Exposure – Single Wall Viewing



Exposure:	Double Wall Contact
Viewing:	Single Wall
Minimum Number of Exposures:	Minimum of three (3) at 120 degrees to each other or as many as necessary for complete coverage
Radiation Source:	X-Radiation or Gamma Radiation
X-ray Voltage and Focal Spot Size (X-ray):	See Individual Report
Isotope Type and Physical Size:	See Individual Report
Base Material Type and Thickness:	See Individual Report
Minimum Source to Object Distance:	70 mm (2 ¾ inches)
Maximum Source to Film Distance:	As per Figure E-1

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Attachment 2 –Example of Chemistry Change Form

RTD QUALITY SERVICES INC.
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FAX: (780) 440-2538

FILM CHEMISTRY RECORD

Date:	Page:	of	
Technician:		Crew Type:	
RTD Job #:		Unit #:	

Date	Wash	Fix	Stop	Developer	# of Welds

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Attachment 3 – Example of RTD Radiographic Procedure Form

Radiographic Procedure Specifications

Project:
Client:

1. **Weld Details**

Materials:		Welding Procedure :
Pipe Diameter:	Wall Thickness:	Bevel Configuration:

2. **X-ray Radiography Details / Gamma-Ray Radiography Details**

Technique	Viewing
SWX – Single Wall X-Ray	SWV – Single Wall Viewing
RTD RT Procedure	**Technique**
RT-001	A

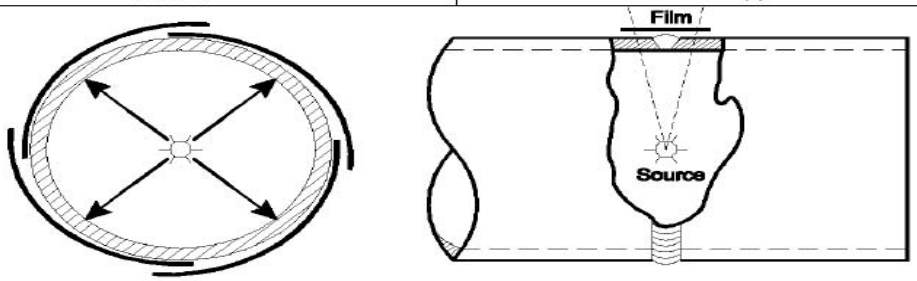

Illustration: 1 film, 50mm overlap

Beam Angle: 20+90-25 degree true radial			Effective Focal Spot Size:		
X-ray Unit Rating:	**kV**	**mA**	Test Conditions:	**kV**	**mA**
Exposure Time:	**min**	**mAm**	Ug Factor:		

3. **General Radiography Details**

SFD:	Screen Type: (Pb) lead	Screen Thickness: 0.027mm front 0.027mm back
Film Class:	Film Size:	Film Brand:
Film Type:	Penetrameter:	Chemistry Brand:
Dev. Temp:	Dev. Time:	Fix Time:
Wash Time:	# of Films Per Weld:	Date:
Radiographer:	Signature:	CGSB Level II

4. **Radiograph Evaluation**

Sensitivity:	Unexposed Base Density:
Base Metal Density:	Weld Area Density:
Film Identification:	
Processing Defects Noted:	Weld Defects Noted:
Penetrameter/IQI Placement as per CSA Z662-03	
Remarks: Required Wire –	
Visible Wire –	
Prepared by (Print):	Code: CSA Z-662 - 2003
Approved by (Print):	Company:
Signature:	Date:

Technique A	Single Wall Exposure – Center Alignment	Mainline Procedure

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Attachment 4 – Example of RTD Radiographic Report Form

RTD Quality Services Inc.
1431 – 70 Avenue
Edmonton, Alberta T6P 1N5
Tel: (780) 440 – 6600
Fax: (780) 440 - 2538

Date: _____
Page: _____ of _____
Report No.: R

RADIOGRAPHIC TESTING REPORT

Client/Contractor: _____ RTD Job #: _____
Project: _____ RTD Procedure: _____
Location: _____ Code/Specification: _____
Client Job #/P.O.#: _____ Item(s) Inspected: _____

Material : Type: _____ Thickness: _____ Weld Reinforcement: _____
Additional Comments : _____
Exposure: ☐ Single Wall ☐ Double Wall Viewing: ☐ Single Wall ☐ Double Wall RTD Technique: _____
Additional Comments : _____
Film: Manufacturer _____ Type _____ Size _____ Qty/Cassette _____ Total # of Film _____
Pentrameter Type: ☐ Wire _____ ☐ Hole _____
Source: ☐ X-Ray ☐ Gamma Type: ☐ Iridium 192 ☐ Cobalt 60 ☐ Tube ☐ Selenium 75 Source Size: _____ Focal Spot Size: _____ Screens: 0.005" ☐ Front ☐ Back 0.010" ☐ Front ☐ Back
SFD : _____ Processing: ☐ Manual ☐ Automatic Screen Type: ☐ Pb ☐ Flouromettalic
Processing: ☐ Time _____ ☐ Temperature _____

IP	Incomplete Penetration	Ck	Crack	ER	Excess Reinforcement	LC	Low Cover	AB	Arc Burn	A	Acceptable
LF	Lack of Fusion	S	Slag	IC	Internal Concavity	HB	Hollow Bead	V	Visual	R	Rejectable
BT	Burn Through	P	Porosity	IU	Internal Undercut	EU	External Undercut	WS	Welder Symbol		

	Film ID	Size	Sch	IP	LF	BT	CK	S	P	ER	IC	IU	LC	HB	EU	AB	Comments	A	R
1																			
2																			
3																			
4																			
5																			
6																			
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Client Name
Client Signature

Start Time: _____
End Time: _____
Distance: ☐ Km ☐ Miles
Total Hours: _____
Consumables: ☐ Yes ☐ No

Tech. Name: _____ Cert #: _____
Tech. Signature: _____
☐ CGSB ☐ ASNT ☐ SNT Level: _____ Disc.: _____
Assistant Name: _____ Cert #: _____
☐ Level 1 ☐ QO ☐ CEDO ☐ Trainee ☐ Other

* Results are an interpretation of the inspection method, not a guarantee. Client signature indicates acceptance of report, results and applicable charge.