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Pipeline Construction:
Quality Issues and Solutions Action Plans

Training Guidance for Welding & Coating
Workers & Inspectors



The INGAA Foundation, Inc.

Training Guidance for Welding & Coating Workers & Inspectors

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Team Members

Paul R Amato, Iroquois Pipeline, Group Lead

Tarry Hutton, NiSource

David McMurray, Wilcrest

Cliff McPherson, Panhandle

Craig Meier, Sunland Construction

Kirk Peterman, Panhandle

Summary and Introduction

Construction specifications, establish specific requirements for completing field construction activities in a manner compliant with codes and the Operators special requirements. However, these specifications and procedures are lengthy documents often written in “contract language.” As a result, contractors and operators often develop their own interpretations and documentation to train skilled construction workers.

As an outcome of the INGAA Foundation’s October 15, 2009 Pipeline Construction, Fabrication, Testing Workshop these guidelines were developed. The objective of this guideline is to develop simple but effective training guidance for construction management and workers to ensure consistent and compliant construction practices. These guidelines identify some minimum general key elements that should be considered during construction inspections. Project specific requirements should still be followed. Tables 1, 2 and 3 provide inspection guidance templates that align with these elements to assist the inspectors as follows:

Table 1 is an inspection and test plan (ITP) for QA/QC of welders and weld inspection.

Table 2 is an ITP guidance document on key QA/QC elements for weld joint and pipe coating workers and inspectors;

Table 3 is an ITP guidance document for QA/QC for tie-in coating transition areas; and

Pocket guides for tables 1, 2 and 3 have been developed for printing and easy use in the field by welding and coating workers and inspectors. These are attached.

Table 4 is a listing of the construction, coating and welding inspection issues compiled by PHMSA during its inspection of 35 projects. The issue areas in this table relate to PHMSA’s determinations and are an important advisory to welding and coating workers and inspectors.

These Key Elements / Templates may be used as a check list or reminder to verify an understanding of the key issues and associated documentation, where needed, is complete for those issues. For example, Operator Qualification (“OQ”) requirements are mentioned. Although this white paper does not specify the OQ documentation requirements, the intent is to remind inspectors they should review the necessary OQ documentation for each project to ensure they are adequate (e.g. there already is a Field Verification Report). Therefore this document is not intended to place additional documentation burdens but remind the inspector to check OQ paperwork.

It also should be noted **these key elements are not to replace the complete project specific documentation.** They are intended to be focus points and / or simple guides to be used. The Acceptance Criteria are guidelines to be used in the absence of Company specific requirements. They are not an effort to supersede or establish existing criteria. The Project Procedure and applicable codes & standards are to be used for actual criteria for the specific projects.

The following pages provide an example of Key Elements / Templates for Welding and Field Applied Coating.

Table 1 | Welding QA/QC ITP

Item No.	Activity	Project Welding Procedure	Frequency	Acceptance Criteria	Project Responsibilities		Action/Record
					Contractor Responsibility (QC)	Operator Responsibility (QA)	
1	Safety JSA	Safety Manual	Daily ¹	Ensure ALL employees are wearing proper PPE for the relevant task at hand	X	X	<ul style="list-style-type: none"> • Tailgate safety¹ • Appropriate P.P.E • Complete & sign JSA
2	Verify Weld Procedure	Project Welding Manual	As needed	Applicable weld procedure Correct WPS and PQR for weld	X	X	<ul style="list-style-type: none"> • Determine proper weld procedure & notify welders • Verify WPS applies to essential variables • Welder Foreman Report
3	Verify Qualified Welders	Operator Specification	<ul style="list-style-type: none"> • Prior to welding • Change of Welder and/or Procedure 	<ul style="list-style-type: none"> • Welder Qualification Log • Verify Operator Qualification Requirements (as applicable) 	X	X	<ul style="list-style-type: none"> • Verify welders qualified to procedure per Welder Qualification Log • Welder Foreman Report • Field Verification Report or similar (as needed)
4	Pipe Inspection	Operator Specification	Each joint	Pipe free of debris	X	--	<ul style="list-style-type: none"> • Swab each joint • No record
5	Bevel Prep	Weld Procedures	Each joint	Clean bevel per Weld Procedure	X	X	<ul style="list-style-type: none"> • Buff bevel • No record
6	Pre heat	Weld Procedures	Each joint	Minimum as specified and verified by temp stick or equivalent.	X	X	<ul style="list-style-type: none"> • Pre heat bevel • No record • Temp stick
7	Line up	Weld Procedures	Each joint	<ul style="list-style-type: none"> • Root opening 1/16" • Seams 2"-4" offset • High-low 1/16" & Weld Procedure 	X	X	<ul style="list-style-type: none"> • Appropriate use of line up clamp • No record
8	Inter-pass Temperature	Weld Procedures	Each joint	Minimum as specified and verified by temp stick or equivalent.	X	X	<ul style="list-style-type: none"> • Temp stick

¹ Any employee that does not attend the morning JSA/Safety tailgate, needs to review and sign, prior to working

Table 1 (Continued)

Item No.	Activity	Project Welding Procedure	Frequency	Acceptance Criteria	Project Responsibilities		Action/Record
					Contractor Responsibility	Representative Responsibility	
9	Speed of Travel ²	Weld Procedures	As Needed	Range is inches/min per WPS/PQR	--	X	<ul style="list-style-type: none"> Stopwatch
10	Amperage ²	Weld Procedures	As Needed	Range is amps per WPS/PQR	--	X	<ul style="list-style-type: none"> Multi meter
11	Volt ²	Weld Procedures	As Needed	Range Volts per WPS	--	X	<ul style="list-style-type: none"> Multi meter
12	Repair of Defects- Cracks/Arc Burns	Repair Procedure	As Needed	Welding Inspector approval	X	X	<ul style="list-style-type: none"> Visual and NDE Inspection NDE report NDE Visual. Specific procedure for repair on repair if allowed by Operator
13	Field Transitions	Operator Specification	As Needed	Per operator specification depending on < or > 20% specified yield strength	X	X	<ul style="list-style-type: none"> Visual and NDE Inspection NDE report
14	Weld Acceptance	Weld Procedures & NDE Procedure	Each weld	<ul style="list-style-type: none"> API 1104 B31.8 NDE Procedures 	--	X	<ul style="list-style-type: none"> Visual and NDE Inspection NDE report
15	Check consumables and Welding Equipment	Operator Specification	Daily	<ul style="list-style-type: none"> Proper consumable storage Welding equipment in proper condition 	X	X	<ul style="list-style-type: none"> No record

² Note: travel, amperage and volts vary for bead, hot pass and filler passes (inform welders to follow WPS)

Table 2 | Weld Joint / Pipe Coating QA/QC ITP

Item No.	Activity	Project Procedure	Frequency	Acceptance Criteria	Contractor Responsibility (QC)	Operator Responsibility (QA)	Action/Record
1	Safety "JSA" Prior to performing ANY duties the coating foreman must ID ALL Hazards	Safety Manual	Daily ¹	Ensure ALL employees are wearing proper PPE for the relevant task at hand	X	X	<ul style="list-style-type: none"> • Tailgate safety¹ • Appropriate P.P.E (Including: Blasting Hood/Fresh Air Canister/Air Lines) • Complete & sign JSA
2	Applicator qualifications	Manufacturers Specifications	Per Project	<ul style="list-style-type: none"> • Understanding of manufacturing installation techniques • Verification of Operator Qualification as applicable 	X	X	<ul style="list-style-type: none"> • Demonstrates knowledge of manufacturing installation methods / techniques • Field Verification report or equivalent
3	Inspection & Surface prep,	Weld Joint	Documentation - 2 per shift (minimum) Inspection – per occurrence	<ul style="list-style-type: none"> • Test Pipe to see if non-visible contaminants exist. Clean as per Operator specification. • Blasted to a "NEAR WHITE" finish • Surface Profile will be checked and documented 	X	X	<ul style="list-style-type: none"> • Inspect & Examine pipe for non-visible contaminants. • Blast and check profile • Remove all Frayed/Loose coating near cutback • Brush Blast existing FBE • Daily coating foreman report.
4	Coating Application	Weld Joint	Documentation - 2 per shift (minimum) Application – per occurrence	<ul style="list-style-type: none"> • As per application specification. Pipe temperature should be 5 degrees above dew point. • Pre-heat pipe as per specification 	X	X	<ul style="list-style-type: none"> • Document temperatures • Do not handle, lower in, or backfill until completely cured • Measure dew point temperature, surface preparation, relative humidity, pipe temperature and mill thickness • Daily coating foreman report

¹ Any employee that does not attend the morning JSA/Safety tailgate, needs to review and sign, prior to working

Item No.	Activity	Project Procedure	Frequency	Acceptance Criteria	Contractor Responsibility (QC)	Operator Responsibility (QA)	Action/Record
5	Pipe Coating Inspection	Weld Joint / Pipe Coating	Each joint	<ul style="list-style-type: none"> • No damage • All coated pipe shall be tested to locate holidays. After the holidays are patched, and just before pipe is lowered into the ditch-- reinspect. • Check for appropriate coating thickness. • Utilize holiday detector with voltage setting (FBE – 2,000 volts DC, dual coat & two part epoxy – 100 volts DC per mil of coating) shall be verified. • The holiday detectors batteries must be checked daily and replaced/recharged if required. • Calibrate holiday detector daily 	X	X	<ul style="list-style-type: none"> • Visual Inspect • Jeep
6	Coating repair	Weld Joint/Pipe Coating	As needed	Repair with patch stick, epoxy gun or two part epoxy in accordance with Operator specifications.	X	X	<ul style="list-style-type: none"> • Record as per operator requirements
7	Storage & Handling	Operator Specification	Daily	Maintained and stored in accordance with manufacturing specifications.	X	--	<ul style="list-style-type: none"> • Ensure proper Storage

- Any employee that does not attend the morning JSA/Safety tailgate, needs to review and sign, prior to working

Table 3 | Tie In Coating Transition Area QA/QC ITP

Item No.	Activity	Project Procedure	Frequency	Acceptance Criteria	Contractor Responsibility	Operator Responsibility	Action/Record
					(QC)	(QA)	
1	Safety "JSA" Prior to performing ANY duties the coating foreman must ID ALL Hazards	Safety Manual	Daily ¹	Ensure ALL employees are wearing proper PPE for the relevant task at hand	X	X	<ul style="list-style-type: none"> • Tailgate safety¹ • Appropriate P.P.E (Including: Blasting Hood/Fresh Air Canister/Air Lines) • Complete & sign JSA • Excavation safety review
2	Applicator qualifications	Manufacturers Specifications	Per Project	<ul style="list-style-type: none"> • Understanding of manufacturing installation techniques • Verification of Operator Qualification as applicable 	X	X	<ul style="list-style-type: none"> • Demonstrates knowledge of manufacturing installation methods / techniques • Field Verification report or equivalent
3	Inspection & Surface preparation,	Transition Area from existing to new coating	Documentation - 2 per shift (minimum) Inspection – per occurrence	<ul style="list-style-type: none"> • Test Pipe to see if non-visible contaminants exist. Clean as per Operator specification. • Blasted to a "NEAR WHITE" finish • Surface Profile will be checked and documented 	X	X	<ul style="list-style-type: none"> • Inspect & Examine pipe for non-visible contaminants. • Blast and check profile • Remove all Frayed/Loose coating near cutback • Brush Blast existing FBE • Daily coating foreman report.
4	Coating Application	Transition from existing to new coating	Documentation - 2 per shift (minimum) Application – per occurrence	<ul style="list-style-type: none"> • As per application specification. Pipe temperature should be 5 degrees above dew point. • Pre-heat pipe as per specification. Pipe temperature should be 5 degrees above dew point • Overcoat per operator specification 	X	X	<ul style="list-style-type: none"> • Document temperatures • Do not handle, lower in, or backfill until completely cured • Measure dew point temperature, surface preparation, relative humidity, pipe temperature and mill thickness • Daily coating foreman report

¹ Any employee that does not attend the morning JSA/Safety tailgate, needs to review and sign, prior to working

5	Pipe Coating Inspection	Weld Joint	Each weld	<ul style="list-style-type: none"> • No damage • All coated pipe shall be tested to locate holidays. After the holidays are patched, and just before pipe is lowered into the ditch-- reinspect. • Check for appropriate coating thickness. • Utilize holiday detector with voltage setting (FBE – 2,000 volts DC, dual coat & two part epoxy – 100 volts DC per mil of coating) shall be verified. • The holiday detectors batteries must be checked daily and replaced/recharged if required. • Calibrate holiday detector daily 	X	X	<ul style="list-style-type: none"> • Visual Inspect • Jeep
6	Coating repair	Weld Joint	As needed	Repair with patch stick, epoxy gun or two part epoxy in accordance with Operator specifications.	X	X	<ul style="list-style-type: none"> • Record as per operator requirements
7	Storage & Handling	Operator Specification	Daily	Maintained and stored in accordance with manufacturing specifications.	X	--	<ul style="list-style-type: none"> • Ensure proper Storage

¹ Any employee that does not attend the morning JSA/Safety tailgate, needs to review and sign, prior to working

Welding QA/QC ITP – Pocket Guide

Welding QA/QC ITP – Pocket Guide				
Activity	Project Welding Procedure	Frequency	Acceptance Criteria	Action / Record
Safety JSA	Safety Manual	Daily	Ensure ALL employees are wearing proper PPE for the relevant task at hand	Tailgate safety
				Appropriate PPE
				Complete & sign JSA
Verify Weld Procedure	Project Welding Manual	As needed	Applicable weld procedure Correct WPS and PQR for weld	Determine proper weld procedure & notify welders
				Verify WPS applies to essential variables
				Welder Foreman Report
Verify Qualified Welders	Complete Section	Prior to welding	Welder Qualification Log	Verify welders qualified to procedure per Welder Qualification Log
		Change of Welder and/or Procedure	Verify Operator Qualification Requirements (as applicable)	Welder Foreman Report
				Field Verification Report or similar (as needed)
Pipe Inspection		Each joint	Pipe free of debris	Swab each joint No record
Bevel Prep	Weld Procedures	Each joint	Clean bevel per Weld Procedure	Buff bevel
				No record
Pre heat	Weld Procedures	Each joint	Minimum of 250° F Verified by temp stick or equal.	Pre heat bevel
				No record
				Temp stick
Line up	Weld Procedures	Each joint	Root opening 1/16"	Use of line up clamp
			Seams 2"-4" offset	No record
			High-low 1/16" & Weld Procedure	
Time between Bead/Root & Start of hot pass/2nd Bead	Weld Procedures	Each joint	Max time is 5 minutes	Stopwatch

Welding QA/QC ITP – Pocket Guide				Page 2
Activity	Project Welding Procedure	Frequency	Acceptance Criteria	Action / Record
Speed of Travel	Weld Procedures	Each joint	Range is inches/min per WPS / PQR	Stopwatch
Amperage	Weld Procedures	Each joint	Range is amps per WPS/PQR	Multi meter
Volt	Weld Procedures	Each joint	Range Volts per WPS	Multi meter
Max time between End of Hot Pass & Start of other	Weld Procedures	As Needed	Per operator specification	Record as per operator requirements
Repair of Defects, Cracks / Arc Burns	Repair Procedure	As Needed	Welding Inspector Approval	Visual and NDE Inspection
				NDE report NDE
				Visual.
				Specific procedure for repair or repair if allowed by Operator
Field Transitions	Operator Specification	As Needed	Per Stated Procedure depending on < or > 20% specified yield strength	Visual and NDE Inspection NDE report
Weld Acceptance	Weld Procedures	Each weld	API 1104	Visual and NDE Inspection
	& NDE Procedure		B31.8	NDE report
			NDE Procedures	
Check consumables and Welding Equipment		Daily	Proper consumable storage	Record as per operator requirements
			Welding equipment in proper condition	

Weld Joint / Pipe Coating QA/QC ITP – Pocket Guide

Weld Joint / Pipe Coating QA/QC ITP – Pocket Guide				
Activity	Project Procedure	Frequency	Acceptance Criteria	Action / Record
Safety "JSA"	Safety Manual	Daily	Ensure ALL employees are wearing proper PPE for the relevant task at hand	Tailgate safety
Prior to performing ANY duties the coating foreman must ID ALL Hazards				Appropriate PPE (Including: Blasting Hood/Fresh Air Canister/Air lines)
Applicator qualifications	Manufacturers Specifications	Per Project	Understanding of manufacturing installation techniques	Demonstrates knowledge of manufacturing installation methods / techniques
			Verification of Operator Qualification as applicable	Field Verification report or equivalent
Inspection & Surface preparation	Weld Joint	Documentation - 2 per shift (minimum)	Test Pipe to see if non-visible contaminates exist. Clean as per Operator specification.	Inspect & Examine pipe for non-visible contaminates.
			Blasted to a "NEAR WHITE" finish	Blast and check profile
		Inspection – per occurrence	Surface Profile will be checked and documented	Remove all Frayed/Loose coating near cutback
				Brush Blast existing FBE
Coating Application	Weld Joint	Documentation - 2 per shift (minimum)	As per application specification. Pipe temperature has to be 5 degrees above dew point.	Document temperatures
			Pre-heat pipe as per specification	Do not handle, lower in, or backfill until completely cured
		Application – per occurrence		
				Daily coating foreman report

Weld Joint / Pipe Coating QA/QC ITP – Pocket Guide				Page 2
Activity	Project Procedure	Frequency	Acceptance Criteria	Action / Record
Pipe Coating Inspection	Weld joint / pipe coating	Each joint	No damage	Visual Inspect
			All coated pipe shall be tested to locate holidays. After the holidays are patched, and just before pipe is lowered into the ditch–reinspect.	Jeep
			Check for appropriate coating thickness.	
			Utilize holiday detector with voltage setting (FBE – 2,000 volts DC, dual coat & two part epoxy – 100 volts DC per mil of coating) shall be verified.	
Coating repair	Weld joint / pipe coating	As needed	The holiday detectors batteries must be checked and replaced/recharged if required daily.	Record as per operator requirements
			Calibrate holiday detector daily	
Storage & Handling	Weld joint / pipe coating	Daily	Maintained and stored in accordance with manufacturing specifications.	Ensure proper Storage

Tie In Coating Transition Area QA/QC ITP – Pocket Guide

Tie In Coating Transition Area QA/QC ITP – Pocket Guide							
Activity	Project Procedure	Frequency	Acceptance Criteria	Action / Record			
Safety "JSA"	Safety Manual	Daily	Ensure ALL employees are wearing proper PPE for the relevant task at hand	Tailgate safety			
Prior to performing ANY duties the coating foreman must ID ALL Hazards				Appropriate PPE (Including: Blasting Hood/Fresh Air Canister/Air Lines)			
				Complete & sign JSA			
				Excavation safety review			
Applicator qualifications	Manufacturers Specifications	Per Project	Understanding of manufacturing installation techniques Verification of Operator Qualification as applicable	Demonstrates knowledge of manufacturing installation methods / techniques Field Verification report or equivalent			
Inspection & Surface prep	Transition Area from existing to new coating	Documentation -2 per shift (minimum)	Test Pipe to see if non-visible contaminants exist. Clean as per Operator specification. Blasted to a "NEAR WHITE" finish	Inspect & Examine pipe for non-visible contaminants. Blast and check profile			
		Inspection – per occurrence	Surface Profile will be checked and documented	Remove all Frayed/Loose coating near cutback Brush Blast existing FBE Daily coating foreman report.			
			Coating Application	Transition from existing to new coating	Documentation -2 per shift (minimum)	As per application specification. Pipe temperature has to be 5 degrees above dew point. Overcoat will start and finish a minimum distance away from the transition area	Document temperatures
					Application – per occurrence	Pre-heat pipe as per specification Pipe temperature has to be 5 degrees above dew point Overcoat per operator specification	Do not handle, lower in, or backfill until completely cured Measure dew point temperature, surface preparation, relative humidity, pipe temperature and mill thickness Daily coating foreman report

Tie In Coating Transition Area QA/QC ITP – Pocket Guide				Page 2
Activity	Project Procedure	Frequency	Acceptance Criteria	Action / Record
Pipe Coating Inspection		Each weld	No damage	Visual Inspect
			All coated pipe shall be tested to locate holidays. After the holidays are patched, and just before pipe is lowered into the ditch.	Jeep
			Check for appropriate coating thickness.	
			Utilize holiday detector with voltage setting (FBE – 2,000 volts DC, dual coat & two part epoxy – 100 volts DC per mil of coating) shall be verified.	
			The holiday detectors batteries must be checked and replaced/recharged if required daily.	
			Calibrate holiday detector daily	
Coating repair	Weld Joint	As needed	Repair with patch stick, epoxy gun or two part epoxy in accordance with Operator specifications.	Record as per operator requirements
Storage & Handling		Daily	Maintained and stored in accordance with manufacturing specifications.	Ensure proper Storage

Table 4 | Issues Identified During PHMSA Inspection of 35 Construction Projects

Issue Areas	# Found	Issue Areas	# Found
Coating - 117			
Coating - Fusion Bonded Epoxy Issues	18	Coating - Electronic Defect Detectors - (Jeeping)	36
• Coating over mud or rust	3	• Failing to follow manufacturer's instructions	6
• Application temperature too hot or cold	3	• Low voltage setting on holiday detector	5
• Heat damage to the factory FBE coating	3	• Inadequate training of inspectors and contractors	4
• Failing to follow manufacturer's instructions	2	• Jeeping over tape and fiberboard stuck to the pipe	4
• Sand blast technique - no correct bevel / overlap at factory coating	2	• Failing to adequately clean the pipe before jeeping	4
• Coating in high wind with blowing dirt	2	• Failing to visually inspect pipe for coating defects	2
• Water in the pipe during heating	1	• Using damaged (bent) detector springs	2
• Coating specifications not available to inspectors	1	• High resistance in electrical circuit	2
• Girth weld coating not fully bonded to pipe	1	• Jeeping at too fast a speed per the spec or manufacturer	2
Coating - Melt Stick	36	• Jeeping over coating repairs before they are dry	2
• Failing to follow manufacturer's instructions	9	• Detector failing to identify defects	1
• Not adequately heating pipe before application	9	• Detector not calibrated per manufacturer	1
• Inadequate surface preparation - abrasion	7	Coating - Two Part Epoxy Issues	27
• Use on defects larger than 0.5 in ²	6	• Failing to follow manufacturer's instructions	8
• Application over two part epoxy	3	• Inadequate surface prep - abrasion	4
• Improper accelerated drying by patting	1	• Application after epoxy starts to set	5
• Use on bare metal	1	• Inadequate mixing of the epoxy	5
		• Applying above or below recommended temp - or not pre-heating pipe	4
		• Using unapproved IR temperature sensors	1
Welding - 87			
Mechanized Welding	37	Manual Welding	50
• Coating damage caused by welding band	5	• Not following procedures	6
• Incomplete weld procedure qualification	4	• Lack of inspector oversight	6
• Pre-heat crew not using Tempilstiks	3	• Early clamp release	5
• Pipe size - Hi-Lo alignment issues	3	• Arc burns due to poor welding practices	5
• NDT falling behind main gang	3	• Incorrect pre-heat or interpass temp	4
• Lack of padding between pipe and skids	3	• Inadequate visual weld inspection	4
• Incorrect or inadequate placement of skid cribbing	3	• Improper storage of low hydrogen rods	3
• Lack of inspector oversight	3	• Welding inspectors not in possession of welding procedures	3
• Not following procedures	2	• Use of 'hinging' technique to aid with pipe line-up	3
• Incorrect pre-heat or interpass temp	2	• Pipe size - Hi-Lo alignment issues	3
• Improper use of Tempilstik - too near weld	1	• Improper gas flow rate for gas shielded processes	2
• Amps and Volts measured at machine not weld (only long leads)	1	• Inadequate defect repair tracking	2
• Moving pipe during root bead welding	1	• Incomplete qualification documents for welders	2
• Initial high defect rates	1	• Amps and Volts measured at machine not weld (for long leads)	1
• Inadequate defect repair tracking	1	• Inadequate defect removal on repair welds	1
• Inadequate quality and documentation of MUT	1		

Issues Identified During PHMSA Inspection of 35 Construction Projects

Issue Areas	# Found	Issue Areas	# Found
Excavation - 20			
• Inadequate use of rock shield, padding machines or selective backfill	5	• Insufficient pipeline weights	1
• Insufficient burial depth(to code or waiver)	3	• Excavating over the pipe without protection	1
• Ditch profile not matching pipeline causing inadequate support	3	• Not reviewing as-built drawings for parallel pipelines	1
• Dents caused by placing pipe on rocks	3	• No One-Call notifications	1
• Erosion of cover at streams	1		
Nondestructive Testing - 20			
• Essential wire or hole not visible on radiograph	3	• NDT records not adequate or up to date	3
• Testing to achieve only the minimum requirements of 192 or 195	1	• Incomplete qualification documents for technicians	2
• Poor radiographic technique - not meeting 1104 requirements	3	• Inadequate interpretation of radiographic results	2
• Not meeting the minimum 10% NDT requirements	2	• Film density not in spec	3
Pipe and Miscellaneous Issues - 40			
Pipe	12	Bending	9
• Pit defects in the pipe body	4	• Ripples out of tolerance	4
• Laminations	3	• Pipe seam not in neutral axis	2
• Pipe sizing issues and variability/damage to pipe ends	3	• Inadequate construction specification	1
• Low tensile strength and/or thin wall in some pipe	2	• Not using internal mandrel when required by procedures	1
Hydrostatic Testing	4	• Not following procedures	1
• Poor test in winter due to freezing of pressure equipment	1	Lowering	7
• Cracks discovered in girth welds during hydro test	1	• Inadequate boom spacing per the ECA requirements	5
• Improper pressure maintenance during hydro test	1	• Unrepaired coating defects at lowering	1
• Long seam failure	1	Operation - Insufficient line markers	1
Design	3	Inadequate Operator Qualification Documentation If Applicable	1
• Incorrect pipe wall thickness for class location	2	Post Construction Documentation	1
• Inadequate testing documentation for pipeline components	1	End Facing	1
		Stringing - Long seam alignment/orientation	1