

PIPELINE RISK ASSESSMENT

The Definitive Approach and Its Role in Risk Management

W. Kent Muhlbauer

ID	From Station	To Station
ACME PL	114.2	121.4
EL (\$/mile-year)	PoF(per mile-year)	failures/mile-yr
\$ 76	0.000768	Thd Pty 0.0003
CoF (\$/incident)		Corrosion Ext 0.0001
\$ 99,000		Corrosion Int 0.0002
		Cracking 0.00006
		Geohaz 0.000008
		Inc Ops 0.00003
		Sabotage 0.00007
		Hazard Area (ft ²) 78,400
		Receptor Dmgs \$ 32,000
		Business Loss \$ 19,000
		Indirect Costs \$ 48,000

Definitive Risk Assessment

3680

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Publisher: Expert Publishing, LLC

Author: W. Kent Muhlbauer

Layout and Artwork: Meredith Foster, Total Communications, Inc

Additional Artwork: Chelsea Ilyse Scott

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I.1 ACRONYMS

ACVG AC (alternating current) Voltage Gradient

AGA American Gas Association

ANSI American National Standards Institute

API American Petroleum Institute

APWA American Public Works Association

ASME American Society of Mechanical Engineers

AST Above ground Storage Tank

CGA Common Ground Alliance

CIS Close Interval Survey

CLSM Controlled Low-Strength Material

CoF Consequence of Failure

CPM Computational Pipeline Monitoring

CP Cathodic Protection

CSA Canadian Standards Association

D/t Diameter to wall thickness ratio

DAMQAT Damage Prevention Quality Action Team

DCS Distributed Control Systems

DCVG DC (direct current) Voltage Gradient

DIN Deutsches Institut für Normung (the German Institute for Standardization)

DIRT Damage Information Reporting Tool

DOT (U.S.) Department of Transportation

DSAW Double Submerged Arc Welding

Dt Ratio Diameter-to-Thickness Ratio

EAC Environmentally Assisted Corrosion

ECDA External Corrosion Direct Assessment

EE Essential Elements

EGIG European Gas Pipeline Incident Group

EL Expected Loss

ERW Electric Resistance Welding

EMAT Electromagnetic Acoustic Transducers

EPA Environmental Protection Agency

EPRG European Pipeline Research Group

ERCB Energy Resources Conservation Board (formerly Alberta Energy and Utilities)

ERW Electric Resistance Weld

ESR Epoxy Sleeve Repair

ERF Estimated Repair Factor

EUB Alberta Energy and Utility Board

FBE Fusion Bonded Epoxy

FFS Fitness For Service

FEA Finite Element Analysis

FMEA Failure Modes and Effects Analysis

FRC Fiber-Reinforced Concrete

GIS Geographic Information System

GMAW Gas Metal Arc Welding

GPR Ground-Penetrating Radar

GPS Global Positioning System

GRI Gas Research Institute

GTAW Gas Tungsten Arc Welding

HAZ Heat Affected Zone

HAZOPS Hazard and Operability Study

HCA High-Consequence Area

HDPE High Density Polyethylene

HF High Frequency

HIC Hydrogen Induced Cracking

HSE Health and Safety Executive (UK)

HUD Housing and Urban Development

HVA High value area

ICS Industrial Control System

ILI In-Line Inspection

IPL Independent Protection Layers

Km Kilometer

LDPE Low Density Polyethylene

Limit states ‘ultimate’ (ULS), ‘leakage’ (LLS), and ‘serviceability’ (SLS)

LOPA Level Of Protection Analysis	PRCI Pipeline Research Council International, Inc.
LUT Look Up Table	PFD Probability of Failure on Demand
MAOP Maximum Allowable Operating Pressure	PL Protection Layer
MAWP Maximum Allowable Working Pressure	PSA Petroleum Safety Authority (Norway)
MFL Magnetic Flux Leakage	psi Pounds Per Square Inch
mi Mile	PVC Poly Vinyl Chloride
MOP maximum operating pressure	PXX abbreviation for conservatism level: P50, P99.9, etc
MPI Magnetic Particle Inspection	QA/QC Quality Assurance/Quality Control
MPY mils per year	QRA Quantitative Risk Assessment
NAPSR National Association of Pipeline Safety Representatives	RBD Reliability Based Design
NDE Non-Destructive Examination	ROV Remotely Operated Vehicle
NDT Non-Destructive Testing	ROW Right Of Way
NEB National Energy Board (Canada)	RPR Rupture Repair Ratio
NOP Normal Operating Pressure	SCADA Supervisory Control And Data Acquisition
NPS Nominal Pipe Size	SCC Stress Corrosion Cracking
NRA Nuclear Regulatory Agency	SLOD Significant Likelihood Of Death
NTSB National Transportation Safety Board	SIL Safety Integrity Layer
OD Outer/Outside Diameter	SME Subject Matter Expert
OPS Office of Pipeline Safety	SMYS Specified Minimum Yield Strength
OSHA Occupational Safety and Health Administration	SSC Sulphide Stress Corrosion
PCS Process Control System	TSB Transportation Safety Board of Canada
PE Polyethylene	TTF Time To Failure
PGD Permanent Ground Deformation	UAV Unmanned Airborne Vehicle
PHA Process Hazard Analysis	UKOPA UK Onshore Pipeline Operators Association
PHMSA Pipeline and Hazardous Materials Safety Administration	ULCC Utility Location and Coordinating Council
PIPES Pipeline Inspection, Protection, Enforcement, and Safety Act	UST Underground Storage Tank
PLC Programmable Logic Controller	UT Ultrasonic Testing
PLRMM <i>Pipeline Risk Management Manual, 3rd edition</i>	UTS Ultimate Tensile Strength
PoD Probability of Damage	Yr Year
PoF Probability of Failure	
PP Polypropylene	
PPTS Pipeline Performance Tracking System	
PRA Probabilistic Risk Assessment	

CAUTION

This text describes an approach to comprehensive pipeline risk assessment. While the underlying methodology has been proven over years of practice, not every nuance of application is documented here. The user must understand that, as with all technical approaches, a qualified person must oversee its use and accepts sole responsibility for any and all results of applying methodologies described herein and their subsequent uses.

PREFACE

Formal risk management has become an essential part of pipelining. As an engineered structure placed in a constantly changing natural environment, a pipeline can be a complex thing. Good risk assessment is an investigation into that complexity; providing an approachable, understandable, manageable incorporation of the physical processes potentially acting on a pipeline: external forces, corrosion, cracking, human errors, material changes, etc.

Recent work in the field of pipeline risk assessment has resulted in the development of methodologies that overcome limitations of the previous techniques while also reducing the cost of the analyses. Alternative approaches simply no longer compete. This more-defensible, more-efficient, more-useful, i.e., definitive, approach is detailed here.

This text recommends the abandonment of some previous risk assessment methodologies. Our reasons for building and using certain older models are no longer valid. We no longer have to take short-cuts to work around computer processing limitations or to approximate underlying scientific/engineering principles. We don't need extensive component failure histories to produce absolute estimates of risks, as once believed, nor do we have to use data that is so generalized that it does not fairly represent the specific assets being studied. We now have strong, reliable, and easily applied methods to estimate actual risks, and no longer must accept the compromises generated by intermediate scoring schemes or statistics-centric approaches.

A goal of this book is to provide an intuitive, transparent, and robust approach to help a reader put together an efficient risk assessment tool and, with that, optimize the management of pipeline risks.

Therefore, this book is also about risk management—not just risk assessment. Risk is a fuzzy topic, and managing risk involves numerous social and psychological issues. It is by no means a strictly technical endeavor. This book advocates a single, very efficient risk assessment methodology, developed and tuned over years of applications, as the starting point of risk management. The practice of risk assessment can now be fairly standardized.

However, it is a disservice to the reader to imply that there is only one correct risk management approach. Those embarking on a formal pipeline risk management process should realize that, once an improved risk understanding is obtained, they have many options with which to react to that risk. This should not be viewed as negative feature, in my opinion. The choices in technical, business, and social problem-solving surrounding risk management makes the process challenging and exciting.

So, my advice to the reader is simple: arm yourself with this 'next generation' knowledge of how to measure risk, adopt an investigative mind set—good risk management requires sleuthing!—and then, enjoy the journey!