Proceedings of 2022 14th International Pipeline Conference

(IPC2022)

Volume 1

September 26-30, 2022 Calgary, Alberta, Canada

> Conference Sponsor Pipeline Division

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Two Park Avenue * New York, N.Y. 10016

© 2022, The American Society of Mechanical Engineers, 2 Park Avenue, New York, NY 10016, USA (www.asme.org)

All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of the publisher.

INFORMATION CONTAINED IN THIS WORK HAS BEEN OBTAINED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS FROM SOURCES BELIEVED TO BE RELIABLE. HOWEVER, NEITHER ASME NOR ITS AUTHORS OR EDITORS GUARANTEE THE ACCURACY OR COMPLETENESS OF ANY INFORMATION PUBLISHED IN THIS WORK. NEITHER ASME NOR ITS AUTHORS AND EDITORS SHALL BE RESPONSIBLE FOR ANY ERRORS, OMISSIONS, OR DAMAGES ARISING OUT OF THE USE OF THIS INFORMATION. THE WORK IS PUBLISHED WITH THE UNDERSTANDING THAT ASME AND ITS AUTHORS AND EDITORS ARE SUPPLYING INFORMATION BUT ARE NOT ATTEMPTING TO RENDER ENGINEERING OR OTHER PROFESSIONAL SERVICES. IF SUCH ENGINEERING OR PROFESSIONAL SERVICES ARE REQUIRED, THE ASSISTANCE OF AN APPROPRIATE PROFESSIONAL SHOULD BE SOUGHT.

ASME shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B7.1.3). Statement from the Bylaws.

For authorization to photocopy material for internal or personal use under those circumstances not falling within the fair use provisions of the Copyright Act, contact the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923, tel: 978-750-8400, www.copyright.com.

Requests for special permission or bulk reproduction should be addressed to the ASME Publishing Department, or submitted online at: https://www.asme.org/publications-submissions/journals/information-for-authors/journalguidelines/rights-and-permissions

ISBN: 978-0-7918-8656-4

CONTENTS

Pipeline Safety Management Systems

Competency

Building Digital Competencies and Cultivating Innovation in an Integrity Environment Karmun Doucette and Janine Woo	IPC2022-87051	1
The Future Pipeline Engineer: Educated, Trained, and Qualified in a Virtual World <i>Michelle Unger, Karen Collins, and Phil Hopkins</i>	IPC2022-87100	10
Industry/Pipeline Performance		
CSA EXP16: Human and Organizational Factors for Optimal Pipeline Performance Claudine Bradley and Sue Capper	IPC2022-86832	30
Management System Enabled ESG Performance Mark S. Jean and Eric Grant	IPC2022-86870	36
Pipeline Safety/Integrity		
Pipeline Repair Planning Using a Digital Environment to Improve Integrity Tasks William Sharman, Phillip Sander, Owen Hall, Jonathan Martin, and John Spurlock	IPC2022-87094	46
Ingenuity and Curiosity to Supercharge Your Pipeline Safety Management System Frank Gareau, Arash Ilbagi, and Brian Dew	IPC2022-87750	53
Reframing PSMS in the Context of Operational Risk Management and ESG Sustainability <i>Michael Marshall and Martin Fingerhut</i>	IPC2022-87773	63
Risk-Based/Informed Decision Making		
Risk Based Asset Management Model for a Natural Gas Transmission Pipeline Martin Hommes, Eric Jager, Paul Kassenberg, Oleg Borisov, and Jan Ribberink	IPC2022-85980	70
Risk-Based Hoop Stress Factors for Pressure Design Riski Adianto, Maher Nessim, and Balek Ngandu	IPC2022-86815	78
Learnings From Implementing an API 1173 Compliant Management System Dale Potter and Mark S. Jean	IPC2022-86868	90
A Risk-Based Safety Class System for Onshore Pipelines	IPC2022-87099	100

A Risk-Based Safety Class System for Onshore Pipelines Maher Nessim, Mark Stephens, and Howard Yue IPC2022-87099

A Risk-Based Design Approach for Uncased Pipe Under Roads and Railways Hafeez Nathoo, Maher Nessim, and Mark Stephens	IPC2022-87102	112
Diagnosis and Recognition of Pipeline Damage Defects Based on Neural Network Algorithm	IPC2022-87163	122
Min Zhang, Yanbao Guo, Deguo Wang, and Qiang Du		

Project Management, Design, Construction, and Environmental Issues

Project Construction

Fatigue Analysis of Pipe Hammering During Construction Roger Chen, Joseph Anthony, and Kenny Farrow	IPC2022-86754	129
Full-Scale Coating Abrasion Test to Supplement Laboratory Testing David B. Futch and David D'Ambrosio	IPC2022-87106	136
Effectiveness of Subsurface Drainage for Mitigation of Landslides Affecting Pipelines Mohammad Rashidi, Ali Ebrahimi, and Arash Mosaiebian	IPC2022-87107	142
Settlement Risk Assessment and Monitoring for Direct Pipe® Construction Beneath Critical Infrastructure Urso A. Campos, Jonathan L. Robison, Gary W. Castleberry, and Amin Azimi	IPC2022-87129	153
Exploratory Data Analyses on CFRP Wrapped HDD Overbend Subjected to Combined Loading <i>Farhad Davaripour, Kshama Roy, and Pooneh Maghoul</i>	IPC2022-87299	157
Project Design		
Pump Station Design II: A Tale of Two Pump Stations Jim Horner	IPC2022-81585	165
Finite Element Analysis of Cold Field Bends for Sour Service Applications Ismael Ripoll, Carlos Sicilia, and Kevin Williams	IPC2022-83791	176
Assessing Soil Corrosivity for Buried Structural Steel: Field Study Yannick Beauregard, Julie Lehew, Andrea Mah, Lexya Hansen, and Matthew Neuner	IPC2022-86173	186
Design and Finite Element Analysis (FEA) of Bulkheads for a Pipe-in-Pipe Flowline: Application of ASME Boiler and Pressure Vessel Code Mehdi Shekarforoush, Hamid Hoorzad, Jaspreet Hothi, and Mario Forcinito	IPC2022-87070	198
Methodologies for Conversion of New Natural Gas Pipelines to Hydrogen Service in North America <i>Kristian Olsen, Guy Shulhan, and Pietro Di Zanno</i>	IPC2022-87316	204
Pipeline Crossing Significant Elevation Difference Terrain Design Te Ma, Tiantian Wu, Sean Qiao, and Taylor Harper	IPC2022-87832	214

Strain-Based Design and Assessment

Characterization of Strain Demand

Geospatial Database Development: Supporting Geohazard Risk Assessments Through Real-Time Data and Geospatial Analytics <i>Clayton Johnson, Stephen Schmidt, Justin Taylor, and John deLaChapelle</i>	IPC2022-87139	220
Materials, Welding, Testing, and Strain Capacity		
Pipe-CLSM Interface Bond Strength From Axial Pullout Testing Caroline Zulkoski, Dharma Wijewickreme, and Douglas Honegger	IPC2022-86117	227
Comprehensive Pipeline Record and Inspection Data Review and Assessment in Response to Safety Advisory on Girth Weld Strain-Induced Failures <i>Craig Arbeau, Alasdair Clyne, Arti Bhatia, and Andy Young</i>	IPC2022-87237	234
SBDA and Project Applications		
Development of an Online Calculation Tool for Safety Evaluation of Pipes Subjected to Ground Movements <i>Qian Zheng, Weichen Qiu, Noah Ergezinger, Yong Li, Nader Yoosef-Ghodsi,</i> <i>Matt Fowler, and Samer Adeeb</i>	IPC2022-86485	243
Application of Strain Based Assessment in Support of Operational and Mitigation Decisions Banglin Liu, Yong-Yi Wang, and Xiaotong Chen	IPC2022-87337	254
Risk and Reliability		
Risk and Reliability		
Modelling Accidental Impact Threats to Natural Gas Storage Wells Shawn Smith, Alex Fraser, Mari Shironishi, Dan Neville, and Dan Shapiro	IPC2022-86734	262
A New GIS-Based Method to Estimate Annual Probability of Pipeline Failure Resulting From Landslides Based on Actual Failure Locations Patricia Varela, Sam Cheng, Rodolfo Sancio, Doug Cook, Alex McKenzie- Johnson, and Smitha Koduru	IPC2022-86749	272
Probabilistic Corrosion Assessment for Natural Gas Storage Wells Brent Ayton, Thomas Dessein, Alex Fraser, Mari Shironishi, Travis Sera, and Daniel Shapiro	IPC2022-86794	284
A Quantitative Risk Assessment Framework for Natural Gas Storage Wells Thomas Dessein, Brent Ayton, Alex Fraser, Shawn Smith, Mari Shironishi, and Travis Sera	IPC2022-86833	295

Probabilistic Analysis Applied to the Risk of SCC Failure Scott Riccardella, Owen Malinowski, Pete Riccardella, Steve Potts, Sean Moran, Kelly Thompson, and Ann Reo	IPC2022-86906	309
Advanced Reliability Analysis at Slope Crossings Matthew Fowler, Kachi Ndubuaku, and Nader Yoosef-Ghodsi	IPC2022-86908	315
Analysis of Dynamic System Risks Where Pipelines Cross Slow-Moving Landslides Michael Porter, Joel Van Hove, and Pete Barlow	IPC2022-86982	325
Distribution Pipeline Risk Framework Jason Skow, Ryan Stewart, Rob McPherson, and Kent Schoenroth	IPC2022-87066	334
Estimating Pipeline Probability of Failure Due to External Interference Damage Using Machine Learning Algorithms Trained on In-Line Inspection Data James White, Katherine Taylor, Jonny Martin, Steven Carrell, and Roland Palmer-Jones	IPC2022-87093	340
Bayesian Failure Rate Estimation for the Reliability and Risk Assessment of Energy Pipelines Markus Dann, Dongliang Lu, Colin Dooley, and Hassan Tayyab	IPC2022-87113	350
Alternative Sampling Plans for Verification of Pipeline Material Properties: Frequentist and Bayesian Statistical Approaches Jed Ludlow	IPC2022-87115	359
An Integrated Model for Predicting Stress Corrosion Cracking of Buried Pipelines Guanlan Liu, Francois Ayello, Gary Vervake, Justin Beck, Ramgopal Thodla, and Narasi Sridhar	IPC2022-87136	368
Addressing Data Gaps for Facility Reliability Assessments Using Non-Hierarchical Cluster Analysis <i>Ryan Stewart, Martin Di Blasi, and Thomas Dessein</i>	IPC2022-87145	376
Relative Risk of Alternating Current Power Line Faults Affecting Nearby Pipelines Ryan Stewart, Devin Bear, and Jason Skow	IPC2022-87148	385
Accounting for Undetected In-Line Inspection Features in the Risk Assessment of Axial Crack and Corrosion Threats Mahmoud Ibrahim, Khurram Shahzad, Saheed Akonko, Smitha Koduru, and Steven Bott	IPC2022-87156	392
Ranking Models for Managing the Integrity of Ageing Pipelines Luca Bacchi, Marco Medoro, and Giampaolo Annoni	IPC2022-87195	400
Influence of Model Error as Epistemic Uncertainty in Reliability-Based Integrity Management Smitha Koduru, Mahmoud Ibrahim, Khurram Shahzad, and Sherif Hassanien	IPC2022-87203	409
Implementation and Validation of Reliability-Based Crack Assessment for Natural Gas Pipelines Wei Xiang, Shenwei Zhang, Jason Yan, Elvis Sanjuan Riverol, and Kyle Myden	IPC2022-87208	420
Machine Learning-Based Severity Assessment of Pipeline Dents Huang Tang, Jialin Sun, and Martin Di Blasi	IPC2022-87211	430

Onshore Pipeline Safety Consequence Modelling in Support of the Development of a Risk-Based Safety Class System Mark Stephens, Howard Yue, Ann Halford, and Niall Foster	IPC2022-87217	440
Reliability Assessment of Pipeline Third Party Damage Mahsa Mehranfar, Millan Sen, Christopher Lam, and Steven Bott	IPC2022-87232	451
Considering Roadway Traffic in Quantitative Risk Assessment for Natural Gas Pipelines Dongliang Lu, Tammeen Siraj, Karen Warhurst, Konstantinos Dimitriadis, and Matt Towers	IPC2022-87251	459
Reliability-Based Self-Imposed Pressure Restriction / Derate Pressure Estimation for Corrosion and Crack Jason Yan, Shenwei Zhang, Joe Saunders, and Chris Blackwell	IPC2022-87252	469
Subset Simulation of Pipeline Corrosion, Crack, and Dent Defects Considering Multiple Limit States With Large-Scale Validation Daryl Bandstra, Alex Fraser, and Juan S. Rojas	IPC2022-87255	479
Comparison of Machine Learning Models for Quantitative Risk Modelling of Pipeline Systems Daryl Bandstra, Juan S. Rojas, Alex Fraser, and Mari Shironishi	IPC2022-87258	490
Characterization of Through-Wall Cracks and Resulting Leakage Rates in Pipelines Elaheh Ebrahimnia, Shawn Prasad, Amandeep Virk, Khurram Shahzad, Muntaseer Kainat, and Saheed Akonko	IPC2022-87262	501
Prioritizing Retrofits of Non-Piggable Transmission Pipelines Using an Internal Corrosion Structural Reliability Model Gabriel Langlois-Rahme, Daryl Bandstra, Vincent Iacobellis, and Miaad Safari	IPC2022-87273	509
Reliability Model to Predict Likelihood of Failure of Facility Auxiliary Piping Assets Syed Haider, Millan Sen, and Doug Lawrence	IPC2022-87276	519
Systematic Assessment of Risk Control Effectiveness Eric Grant, Shreya Ambasta, and Mark Jean	IPC2022-87280	527
Optimizing the Prioritization of First-Time ILIs Using Quantitative Risk and Machine Learning Brenn Snider, Wei Xiang, Billy Zhang, and Sergiu Lecut	IPC2022-87309	536
Assessing Geohazard Probability of Pipeline Failure: Lessons and Improvements From the Last 10 Years Sarah Newton, Joel Van Hove, Michael Porter, and Gerald Ferris	IPC2022-87319	545
Incorporating Measurement Uncertainty Into Machine Learning-Based Grade Predictions Joel Anderson, Nathan Switzner, Jeffrey Kornuta, and Peter Veloo	IPC2022-87347	552
Framework for Pipeline Stress Corrosion Cracking Susceptibility Using Inspection & Mitigation Results: A Bayesian Approach	IPC2022-87372	560

Oleg Shabarchin, Smitha Koduru, and Sherif Hassanien

Probabilistic Surviving Population Remaining Life and Inspection Timing Guidance IPC2022-97332 569 Lyndon Lamborn, Mark Neuert, Ernest Kwok, Mahmoud Ibrahim, and Bradley Krug

Emerging Fuels and Greenhouse Gas Emissions

Emerging Fuels and Greenhouse Gas Emissions: General

Adapting Existing Quantitative Risk Assessment Tools for the Energy Transition Matthew Horn, Tara Franey, and Jeremy Fontenault	IPC2022-84761	580
Performance of Twelve Different Equations of State for Natural Gas and Hydrogen Blends Kamal K. Botros and Larry Jensen	IPC2022-86297	588
Balancing Hydrogen Networks Safely: A Method for Calculating Linepack Potential Without Causing Integrity Risk Due to Hydrogen-Enhanced Fatigue Onno Wesselink, Alfons Krom, and Martin van Agteren	IPC2022-86674	604
Safety Considerations for the Transport of Hydrogen Gas in Line Pipes and Induction Bent Pipes Georgi Genchev, Juliane Mentz, Holger Brauer, Christoph Kalwa, Elke	IPC2022-86888	611
Performance of Five Different Natural Gas and Hydrogen Blending Mixer Designs via CFD Kamal K. Botros, Mohammad Shariati, and Swaran Sandhawalia	IPC2022-86895	619
Implementation of Ductility and Microstructural Attributes for Evaluation of Fracture and Fatigue Performance of API X Grades in High Pressure Gaseous Hydrogen Transmission Pipeline Environments <i>Douglas Stalheim, Andrew Slifka, Matthew Connolly, Enrico Lucon, Aaron</i> <i>Litschewski, and Pello Uranga</i>	IPC2022-87069	633
Safe Repurposing of Vintage Pipelines for Hydrogen in North America Daniel Sandana, Neil Gallon, Ollie Burkinshaw, and Arti Bhatia	IPC2022-87088	643
Susceptibility of a Virtual Pipeline Network to Fatigue and Cracking Threats in Hydrogen Service Ollie Burkinshaw, Daniel Sandana, Neil Gallon, and Arti Bhatia	IPC2022-87089	657
Optimizing Blended Hydrogen Uniformity Within Natural Gas Pipeline Distribution Networks <i>Guohua Li, Michelle Moyer, and Hamid Bidmus</i>	IPC2022-87097	668
Consequence Modeling of Hypothetical Releases From Carbon Dioxide (CO ₂) Transport Pipelines Jeremy Fontenault and Tara Franey	IPC2022-87131	676
Effects of Hydrogen Embrittlement on the Fracture Toughness of High-Strength Steel Structures Sylvester Agbo, Farhad Davaripour, and Kshama Roy	IPC2022-87174	686

Integrity Assessment of Linepipes for Transporting High Pressure Hydrogen Based on ASME B31.12 <i>Nobuyuki Ishikawa, Takahiro Sakimoto, Junji Shimamura, Jiawei Wang, and</i> <i>Yong-Yi Wang</i>	IPC2022-87180	692
In-Service Welding Onto Methane/Hydrogen Mixture Pipelines William A. Bruce, Otto Jan Huising, Matt Boring, Bill Amend, and Melissa Gould	IPC2022-87202	701
Internal Corrosion Considerations for Hydrogen Embrittlement Inhibitors Susmitha Purnima Kotu, Christopher Kagarise, Christopher D. Taylor, and Shane Finneran	IPC2022-87335	709
Feasibility Journey - Repurposing Existing Natural Gas Pipelines to Transport Hydrogen – Natural Gas Blends Saba N. Esmaeely, Shane Finneran, and Tara Podnar McMahan	IPC2022-87353	716
Develop Standard Testing Approach for Evaluation of Materials Compatibility in Hydrogen Service Ashwini Chandra, TJ Prewitt, and Shane Finneran	IPC2022-87359	724
Different Ways to Reduce Greenhouse Gas Emission in Pipelines Jun Zhang, John Anderton, and Adrian Kane	IPC2022-87391	731