

Oil and gas pipeline systems



Legal Notice for Standards

Canadian Standards Association (CSA) standards are developed through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA is a private not-for-profit company that publishes voluntary standards and related documents. CSA has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA and the users of this document (whether it be in printed or electronic form), CSA is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA's and/or others' intellectual property and may give rise to a right in CSA and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.

CSA Standards Update Service

Z662-11

June 2011

Title: *Oil and gas pipeline systems*

Pagination: **555 pages** (xliv preliminary and 511 text), each dated **June 2011**

To register for e-mail notification about any updates to this publication

- go to **www.ShopCSA.ca**
- click on **E-mail Services** under **MY ACCOUNT**
- click on **CSA Standards Update Service**

The **List ID** that you will need to register for updates to this publication is **2421301**.

If you require assistance, please e-mail techsupport@csa.ca or call 416-747-2233.

Visit CSA's policy on privacy at www.csagroup.org/legal to find out how we protect your personal information.

Currently in preview, click buy full version

CSA Standard

Z662-11

Oil and gas pipeline systems



**CANADIAN STANDARDS
ASSOCIATION**

®Registered trade-mark of Canadian Standards Association

*Published in June 2011 by Canadian Standards Association
A not-for-profit private sector organization
5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6
1-800-463-6727 • 416-747-4044*

Visit our Online Store at www.ShopCSA.ca



The Canadian Standards Association (CSA) prints its publications on Rolland Enviro100, which contains 100% recycled post-consumer fibre, is EcoLogo and Processed Chlorine Free certified, and was manufactured using biogas energy.

To purchase CSA Standards and related publications, visit CSA's Online Store at www.ShopCSA.ca or call toll free 1-800-463-6727 or 416-747-4044.

ISBN 978-1-55491-482-1

© Canadian Standards Association — 2011

All rights reserved. No part of this publication may be reproduced in any form whatsoever without the prior permission of the publisher.

Contents

Technical Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials	xxi
Executive Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials	xxiv
Subcommittee on Aluminum Pipeline Systems	xxv
Subcommittee on Coatings	xxvi
Subcommittee on Construction	xxviii
Subcommittee on Design	xxx
Subcommittee on Distribution	xxxii
Editorial Subcommittee	xxxiv
Subcommittee on Materials	xxxv
Subcommittee on Offshore Pipelines	xxxvii
Subcommittee on Operations and Systems Integrity	xxxviii
Subcommittee on Production	xl
Taskforce on Management Systems	xlii
Preface	xliii

1 Scope 1

2 Reference publications and definitions 5

- 2.1 Reference publications 5
- 2.2 Definitions 20

3 Safety and loss management systems, integrity management programs, and engineering assessments for oil and gas industry pipeline systems 31

- 3.1 Safety and loss management system 31
- 3.2 Pipeline system integrity management program 31
- 3.3 Engineering assessments 32
 - 3.3.1 Competence 32
 - 3.3.2 Design and material qualification and acceptance 32
 - 3.3.3 Existing pipeline systems 32
 - 3.3.4 Documentation 33

4 Design 33

- 4.1 General 33
- 4.2 Design conditions 34
 - 4.2.1 General 34
 - 4.2.2 Temperature 34
 - 4.2.3 Sustained force and wind loading 35
 - 4.2.4 Other loading and dynamic effects 35

4.3	Design criteria	36
4.3.1	General	36
4.3.2	Class location assessment areas	36
4.3.3	Class location designations	36
4.3.4	Class location end boundaries	37
4.3.5	Pressure design for steel pipe — General	41
4.3.6	Pressure design for steel pipe — Design factor (F)	41
4.3.7	Pressure design for steel pipe — Location factor (L)	41
4.3.8	Pressure design for steel pipe — Joint factor (J)	43
4.3.9	Pressure design for steel pipe — Temperature factor (T)	43
4.3.10	Pressure design for steel pipe — Allowances	43
4.3.11	Pressure design for steel pipe — Wall thickness	44
4.3.12	Pressure design for components — General	45
4.3.13	Pressure design for components — Closures	46
4.3.14	Pressure design for components — Elbows	46
4.3.15	Pressure design for components — Tees and crosses	46
4.3.16	Pressure design for components — Branch connections	46
4.3.17	Pressure design for components — Integrally reinforced extruded outlet header	47
4.3.18	Pressure design for components — Welded branch connections	48
4.3.19	Pressure design for components — Reinforcement of single openings	50
4.3.20	Pressure design for components — Reinforcement of multiple openings	50
4.4	Valve location and spacing	53
4.5	Selection and limitation of piping joints	54
4.5.1	Buttwelded joints	54
4.5.2	Threaded joints	55
4.5.3	Sleeve, coupled, mechanical interference fit, and other patented joints	55
4.5.4	Additional requirements for mechanical interference fit joints	55
4.6	Flexibility and stress analysis — General stress design	56
4.6.1	Applicability	56
4.6.2	Stress design of restrained and unrestrained portions of pipeline systems	56
4.6.3	Discontinuity stresses	56
4.6.4	Supplemental stress design	57
4.6.5	Hoop stress	57
4.6.6	Steel properties	57
4.7	Flexibility and stress analysis — Stress design for restrained portions of pipeline systems	57
4.7.1	Combined hoop and longitudinal stresses	57
4.7.2	Combined stresses for restrained spans	58
4.7.3	Anchors and restraints	58
4.8	Flexibility and stress analysis — Stress design for unrestrained portions of pipeline systems	58
4.9	Flexibility and stress analysis — Loads on pipe-supporting elements	62
4.9.1	General	62
4.9.2	Supports and braces	62
4.10	Flexibility and stress analysis — Design of pipe-supporting elements	62
4.11	Cover and clearance	62
4.12	Crossings	64
4.12.1	General	64
4.12.2	Crossings of utilities	64
4.12.3	Crossings of roads and railways	64
4.12.4	Crossings of water	67
4.13	Requirements for pipelines in proximity to electrical transmission lines and associated facilities	67
4.13.1	General	67
4.13.2	Effects on pipelines in proximity to high-voltage DC lines	68
4.13.3	Safety requirements	68
4.14	Design of compressor stations over 750 kW and pump stations over 375 kW	68

4.14.1	General	68
4.14.2	Design of compressor stations over 750 kW	69
4.14.3	Design of pump stations over 375 kW	72
4.15	Liquid storage in oil pipeline pump stations, tank farms, and terminals	74
4.15.1	Aboveground tanks over 4000 L	74
4.15.2	Aboveground tanks of 4000 L or less	75
4.15.3	Underground tanks	75
4.15.4	Pressure spheres, bullets, and ancillary vessels	75
4.15.5	Pipe-type storage vessels	75
4.16	Gas storage in pipe-type and bottle-type holders	75
4.16.1	General	75
4.16.2	Aboveground installations	75
4.16.3	Underground installations	76
4.17	Vaults	76
4.17.1	Structural design	76
4.17.2	Location	76
4.17.3	Vault ventilation	76
4.17.4	Drainage and waterproofing	77
4.18	Pressure control and overpressure protection of piping	77
4.18.1	General	77
4.18.2	General design requirements for systems for pressure control and overpressure protection	78
4.18.3	Additional design requirements for pressure-relieving installations	78
4.18.4	Additional overpressure-protection requirements for compressor and pump stations	78
4.19	Instrument, control, and sampling piping	79
4.20	Leak detection capability	80
4.21	Odorization	80
4.22	Requirements for pipelines installed by horizontal directional drilling	80

5 Materials 81

5.1	Qualification of materials	81
5.2	Steel materials and gaskets	81
5.2.1	Design temperatures — Steel materials	81
5.2.2	Notch toughness requirements — Steel pipe	81
5.2.3	Notch toughness requirements — Steel components	85
5.2.4	Steel pipe	85
5.2.5	Steel components — General	86
5.2.6	Steel components — Flanges	88
5.2.7	Bolting	89
5.2.8	Gaskets	89
5.2.9	Steel components — Fittings	90
5.3	Other materials	90
5.3.1	Aluminum piping	90
5.3.2	Polyethylene pipe and fittings	91
5.3.3	Cast iron components	91
5.3.4	Copper and copper-based alloys	91
5.3.5	Stainless steels	92
5.3.6	Fiberglass reinforced composite pipe and fittings	92
5.3.7	Non ferrous flanges	92
5.3.8	Other alloys and composites	92
5.3.9	External protective pipe coatings	92
5.4	Oilfield water service	92
5.5	Cement-mortar linings	92
5.6	Reuse of materials	93
5.7	Records of materials	93

6 Installation 93

- 6.1 General 93
- 6.2 Activities on pipeline rights-of-way 94
 - 6.2.1 Clearing, grading, and ground disturbances 94
 - 6.2.2 Pipe and components handling 94
 - 6.2.3 Bends and elbows in steel piping 94
 - 6.2.4 Alignment and welding 95
 - 6.2.5 Protective coatings 95
 - 6.2.6 Ditching and lowering-in 95
 - 6.2.7 Backfilling 96
 - 6.2.8 Internal cleaning 96
 - 6.2.9 Clean-up and restoration 96
 - 6.2.10 Installation of crossings 96
 - 6.2.11 Horizontal directional drilling (HDD) 97
- 6.3 Pipe surface requirements applicable to steel piping 97
 - 6.3.1 Pipe manufacturing defects detected during installation inspection 97
 - 6.3.2 Field repair of gouges and grooves 98
 - 6.3.3 Dents 98
 - 6.3.4 Patching repair 98
 - 6.3.5 Removal of cracks in circumferential butt welds and in fillet welds 98
- 6.4 Electrical test leads on pipeline systems 98
- 6.5 Inspection 99
- 6.6 Precautions to avoid uncontrolled fires 100

7 Joining 100

- 7.1 General 100
- 7.2 Arc and gas welding — General 101
- 7.3 Arc and gas welding — Joint configurations 102
 - 7.3.1 Butt welds 102
 - 7.3.2 Fillet welds 103
- 7.4 Arc and gas welding — Welding equipment 109
- 7.5 Arc and gas welding — Materials 109
 - 7.5.1 Pipe and components 109
 - 7.5.2 Filler metals and fluxes 109
 - 7.5.3 Shielding gases 109
- 7.6 Arc and gas welding — Qualification of welding procedure specifications 110
 - 7.6.1 General 110
 - 7.6.2 Company approval 110
 - 7.6.3 Records 110
 - 7.6.4 Welding procedure specifications 110
 - 7.6.5 Essential changes for qualification of welding procedure specifications 112
- 7.7 Arc and gas welding — Testing for qualification of welding procedure specifications and qualification of welders 115
 - 7.7.1 Welding of test joints 115
 - 7.7.2 Testing of butt welds — General 116
 - 7.7.3 Testing of butt welds — Tension test 120
 - 7.7.4 Testing of butt welds — Nick-break test 120
 - 7.7.5 Testing of butt welds — Root-bend and face-bend tests 121
 - 7.7.6 Testing of butt welds — Side-bend test 122
 - 7.7.7 Testing of fillet welds and branch connection welds — Root-break test 122
 - 7.7.8 Testing of fillet welds and branch connection welds — Macrosection test 125
 - 7.7.9 Tensile strength requirement for fillet welds and branch connection welds test 125
 - 7.7.10 Additional testing of partial-penetration butt welds 125
- 7.8 Arc and gas welding — Qualification of welders 125

- 7.8.1 General 125
- 7.8.2 Qualification range 126
- 7.8.3 Special qualification — Butt welds 127
- 7.8.4 Visual inspection 128
- 7.8.5 Qualification of welders by visual and nondestructive inspection 128
- 7.8.6 Retests 128
- 7.8.7 Records of qualified welders 128
- 7.9 Arc and gas welding — Production welding 128
 - 7.9.1 General 128
 - 7.9.2 Alignment and root gap 129
 - 7.9.3 Grounding 129
 - 7.9.4 Use of line-up clamps — Butt welds 129
 - 7.9.5 Relative movement 129
 - 7.9.6 Bevelled ends 129
 - 7.9.7 Weather conditions 129
 - 7.9.8 Clearance 130
 - 7.9.9 Cleaning between beads 130
 - 7.9.10 Position welding 130
 - 7.9.11 Roll welding 130
 - 7.9.12 Identification of welds 130
 - 7.9.13 Seal welding 131
 - 7.9.14 Fillet welds 131
 - 7.9.15 Preheating, interpass temperature control, controlled cooling, and stress relieving 131
 - 7.9.16 Stress relieving 132
- 7.10 Arc and gas welding — Inspection and testing of production welds 133
 - 7.10.1 General 133
 - 7.10.2 Visual inspection 133
 - 7.10.3 Mandatory nondestructive inspection 134
 - 7.10.4 Nondestructive inspection 134
 - 7.10.5 Destructive testing 135
 - 7.10.6 Disposition of defective welds 135
- 7.11 Arc and gas welding — Standards of acceptability for nondestructive inspection 135
 - 7.11.1 General 135
 - 7.11.2 Weld crown 136
 - 7.11.3 Incomplete penetration of the root bead 136
 - 7.11.4 Incomplete fusion 137
 - 7.11.5 Internal concavity 138
 - 7.11.6 Undercut 138
 - 7.11.7 Incomplete fusion due to cold lap 139
 - 7.11.8 Lack of cross-penetration 140
 - 7.11.9 Elongated slag inclusions 140
 - 7.11.10 Hollow bead 141
 - 7.11.11 Burn-through areas 141
 - 7.11.12 Isolated slag inclusions 142
 - 7.11.13 Spherical porosity 142
 - 7.11.14 Wormhole porosity 143
 - 7.11.15 Cracks and arc burns 143
 - 7.11.16 Unequal leg length — Fillet welds 144
 - 7.11.17 Accumulation of imperfections 144
 - 7.11.18 Weld conditions limiting radiographic interpretation 144
- 7.12 Arc and gas welding — Repair of welds containing repairable defects 144
 - 7.12.1 Partial-penetration butt welds 144
 - 7.12.2 Authorization for repairs 144
 - 7.12.3 Repair procedures 144

- 7.12.4 Removal of arc burns in weld areas 145
- 7.12.5 Removal of cracks in circumferential butt welds and in fillet welds 145
- 7.12.6 Inspection of repairs 145
- 7.13 Arc and gas welding — Materials and equipment for radiographic inspection 146
 - 7.13.1 General 146
 - 7.13.2 Radiographic procedure 146
 - 7.13.3 Radiation sources 146
 - 7.13.4 Imaging media 146
 - 7.13.5 Screens 146
 - 7.13.6 Image quality indicators 146
 - 7.13.7 Comparator shims 147
- 7.14 Arc and gas welding — Production of radiographs 148
 - 7.14.1 Radiation source location 148
 - 7.14.2 Geometric relationship 148
 - 7.14.3 Size of radiation field 149
 - 7.14.4 Location of image quality indicators 149
 - 7.14.5 Radiographic image identification markers 149
 - 7.14.6 Processing of radiographic images 150
 - 7.14.7 Radiation protection 150
 - 7.14.8 Radiographers 150
 - 7.14.9 Retention of radiographic records 150
- 7.15 Arc and gas welding — Ultrasonic inspection of circumferential butt welds in piping 151
 - 7.15.1 Methods 151
 - 7.15.2 Terminology 151
 - 7.15.3 General 151
 - 7.15.4 Equipment and supplies — General 151
 - 7.15.5 Equipment and supplies — Additional requirements for mechanized inspection systems 151
 - 7.15.6 Qualification of ultrasonic inspectors 152
 - 7.15.7 Calibration 152
 - 7.15.8 Inspection procedure for production welds 153
 - 7.15.9 Inspection procedure for production welds — Additional requirements for mechanized inspection 153
 - 7.15.10 Standards of acceptability for ultrasonic inspection 154
 - 7.15.11 Ultrasonic inspection reports and records 154
- 7.16 Mechanical interference fit joints 155
 - 7.16.1 General 155
 - 7.16.2 Qualification of joining procedure specifications 155
 - 7.16.3 Qualification of operators 156
 - 7.16.4 Inspection procedures 156
- 7.17 Welding on in-service piping 157
 - 7.17.1 General 157
 - 7.17.2 Fillet welds and branch connection welds on liquid-filled piping or flowing-gas piping and direct deposition welds on flowing-gas piping 157
 - 7.17.3 Essential changes for qualification of welding procedure specifications intended for welding on in-service piping 158
 - 7.17.4 Fillet welds and branch connection welds — Face bend test 162
 - 7.17.5 Fillet welds and branch connection welds — Macroexamination and hardness tests 162
 - 7.17.6 Qualification of welding procedure specifications and welders for direct deposition welds 165
 - 7.17.7 Nondestructive inspection of welds made on in-service piping 167
- 8 Pressure testing 169**
 - 8.1 General 169
 - 8.2 Safety during pressure tests 169
 - 8.3 Compressor and pump station piping 170

- 8.4 Instrument and control piping 170
- 8.5 Test-head assemblies 170
- 8.6 Testing procedures and techniques 172
- 8.7 Piping to be operated at pressure greater than 700 kPa 173
 - 8.7.1 Strength and leak tests 173
 - 8.7.2 Pressure-test mediums 173
 - 8.7.3 Minimum strength and leak test pressures 174
 - 8.7.4 Maximum strength and leak test pressures 174
 - 8.7.5 Duration of tests 175
 - 8.7.6 Maximum operating pressures 175
 - 8.7.7 Pressure-test measurements and records 176
- 8.8 Piping intended to be operated at pressures of 700 kPa or less 177
 - 8.8.1 Strength and leak tests 177
 - 8.8.2 Pressure-test mediums 178
 - 8.8.3 Minimum leak test pressures 178
 - 8.8.4 Maximum leak test pressures 178
 - 8.8.5 Duration of tests 178
 - 8.8.6 Maximum operating pressures 178
 - 8.8.7 Pressure-test measurements and records 178
- 8.9 Leaks and ruptures during pressure tests 179
- 8.10 Disposal of pressure-test mediums 179
- 8.11 Cleaning and drying 179
- 8.12 Tie-ins of tested sections 180
- 9 Corrosion control 180**
 - 9.1 General 180
 - 9.2 Selection of external protective coatings for buried or submerged piping 181
 - 9.3 Application and inspection of external protective coatings for buried or submerged piping 185
 - 9.4 Storage, handling, transportation, and installation of coated pipe and components 186
 - 9.5 Cathodic protection — Design and installation 186
 - 9.6 Electrical isolation 186
 - 9.7 Electrical interference 187
 - 9.7.1 Direct current 187
 - 9.7.2 Alternating current and lightning 187
 - 9.8 Corrosion control test stations 187
 - 9.9 Operation and maintenance of impressed current and sacrificial cathodic protection systems 188
 - 9.10 Internal corrosion control 189
 - 9.10.1 General 189
 - 9.10.2 Mitigation 189
 - 9.10.3 Monitoring 190
 - 9.11 Corrosion control records 190
- 10 Operating, maintenance, and upgrading 190**
 - 10.1 General 190
 - 10.2 Safety 190
 - 10.2.1 Training programs 190
 - 10.2.2 Employee information 190
 - 10.2.3 Supervisor responsibility 190
 - 10.2.4 Hazards 190
 - 10.2.5 Security 191
 - 10.2.6 Work sites 191
 - 10.2.7 Firefighting and special equipment 191
 - 10.2.8 In-service pipelines 191
 - 10.2.9 Additional precautions for pipeline systems transporting high-vapour-pressure hydrocarbons 191
 - 10.2.10 Fluids containing H₂S 192

- 10.2.11 Carbon dioxide pipelines 192
- 10.3 Integrity of pipeline systems 192
 - 10.3.1 Integrity of existing pipeline systems 192
 - 10.3.2 Environmental effects 193
 - 10.3.3 Leak detection for liquid hydrocarbon pipeline systems 194
 - 10.3.4 Leak detection for gas pipeline systems 194
 - 10.3.5 Leak detection for oilfield water pipeline systems 194
 - 10.3.6 Pipeline system incident investigations 195
 - 10.3.7 Change in service fluid 195
 - 10.3.8 Upgrading to a higher maximum operating pressure 195
 - 10.3.9 Pressure testing existing piping 196
- 10.4 Records 196
 - 10.4.1 General 196
 - 10.4.2 Pipeline systems 197
 - 10.4.3 Pipeline emergency records 197
 - 10.4.4 Pipeline system incidents 198
 - 10.4.5 Pressure-test records 198
- 10.5 Operating and maintenance procedures 198
 - 10.5.1 General 198
 - 10.5.2 Pipeline emergencies 199
 - 10.5.3 Pipeline identification 199
 - 10.5.4 Signs at stations and other facilities 200
 - 10.5.5 Ground disturbance 201
 - 10.5.6 Odorization 201
- 10.6 Right-of-way inspection and maintenance 201
 - 10.6.1 Pipeline patrolling 201
 - 10.6.2 Vegetation control 202
 - 10.6.3 Exposed facilities 202
 - 10.6.4 Crossings 202
- 10.7 Change of class location 203
- 10.8 Crossings of existing pipelines 203
- 10.9 Operation and maintenance of facilities and equipment 204
 - 10.9.1 Compressor and pump stations 204
 - 10.9.2 Aboveground tanks and pressure vessels 204
 - 10.9.3 Underground storage 205
 - 10.9.4 Pipe-type and bottle-type gas holders and pipe-type storage vessels 206
 - 10.9.5 Pressure-control, pressure-limiting, and pressure-relieving systems 206
 - 10.9.6 Valves 207
 - 10.9.7 Vaults 207
 - 10.9.8 Quick opening closures 207
- 10.10 Evaluation of imperfections 207
 - 10.10.1 General 207
 - 10.10.2 Corrosion imperfections in pipe 208
 - 10.10.3 Gouges, grooves, and arc burns in pipe 209
 - 10.10.4 Dents in pipe 211
 - 10.10.5 Pipe body surface cracks 211
 - 10.10.6 Weld imperfections in field circumferential welds 212
 - 10.10.7 Weld imperfections in mill seam welds and mill circumferential welds 212
- 10.11 Permanent repair methods 212
 - 10.11.1 General 212
 - 10.11.2 Grinding repairs 213
 - 10.11.3 Piping replacements 214
 - 10.11.4 Repair sleeves 214
 - 10.11.5 Defect removal by hot tapping 217

10.11.6	Direct deposition welding	217
10.12	Temporary repair methods	217
10.12.1	General	217
10.12.2	Composite reinforcement repair sleeves	222
10.13	Maintenance welding	222
10.13.1	General	222
10.13.2	In-service piping	222
10.14	Pipeline hot taps	223
10.14.1	General	223
10.14.2	Pipe preparation	223
10.14.3	Parameters	223
10.15	Deactivation and reactivation of piping	224
10.15.1	Deactivation of piping	224
10.15.2	Reactivation of piping	224
10.16	Abandonment of piping	224
11	Offshore steel pipelines	225
11.1	Applicability	225
11.2	Design — General	225
11.3	Design information	225
11.3.1	Pipeline route	225
11.3.2	Route survey and data acquisition	228
11.3.3	Pipeline operating conditions	229
11.4	Design and load conditions	229
11.5	Functional loads	230
11.6	Environmental loads	230
11.6.1	General	230
11.6.2	Wind forces	231
11.6.3	Hydrodynamic loads — General	231
11.6.4	Wave-induced and current-induced hydrodynamic loads	231
11.6.5	Loads due to ice conditions and regional ice features	232
11.6.6	Seismic activity	233
11.6.7	Loads arising from marine growth	233
11.6.8	Indirect environmental loads	233
11.6.9	Accidental loads	233
11.7	Design analysis	233
11.8	Design for mechanical strength	234
11.8.1	Design criteria for installation	234
11.8.2	Design criteria for pressure testing	235
11.8.3	Design criteria for operation	235
11.8.4	Determination of stresses	236
11.8.5	Pipe wall thickness specification	237
11.8.6	Strain-based design	237
11.8.7	Strain-based design criteria	238
11.9	Design for thermal expansion	239
11.10	Design for on-bottom stability	239
11.11	Design for fatigue life	240
11.12	Design for free spans, anchoring, and supports	240
11.13	Design for shore approaches	240
11.14	Design for components	240
11.15	Design for crossings	241
11.16	Pipeline components and fabrication details	241
11.16.1	General	241
11.16.2	Supports, braces, anchors, and buckle arresters	241

11.16.3	Mechanical connectors	241
11.16.4	Welded branch connections and reinforcements	241
11.16.5	Reducers	242
11.16.6	Weight-coating	242
11.16.7	Thermal insulation	243
11.17	Pipeline pressure control	243
11.18	Leak detection	243
11.19	Emergency shutdown valve	243
11.20	Materials	244
11.20.1	General	244
11.20.2	Pipe	244
11.20.3	Fittings, flanges, and valves	244
11.21	Installation	245
11.21.1	General	245
11.21.2	Transportation, handling, and storage of materials	245
11.21.3	Ancillary equipment and specialty items	245
11.21.4	Installation procedures	245
11.21.5	Installation inspection	246
11.21.6	Repair of pipe and components prior to installation	246
11.21.7	Repair of pipelines after installation	247
11.21.8	As-built surveys	247
11.21.9	Commissioning	247
11.22	Welding	247
11.22.1	General	247
11.22.2	Qualification of welding procedures	247
11.22.3	Testing of welded joints — Pipe butt welds	248
11.22.4	Production welding	248
11.22.5	Underwater welding	248
11.23	Mechanical connectors	249
11.24	Pressure testing	249
11.24.1	General	249
11.24.2	Testing of mechanical connector assemblies	249
11.24.3	Test pressure	249
11.24.4	Pressure-test medium	250
11.24.5	Safety during pressure tests	250
11.24.6	Pressure-test records	250
11.25	Corrosion control	250
11.25.1	General	250
11.25.2	External corrosion control — Protective coatings	250
11.25.3	External corrosion control — Cathodic protection systems	251
11.25.4	Internal corrosion control	251
11.25.5	Maintenance of cathodic protection systems	251
11.25.6	Records	252
11.26	Operating and maintenance	252
11.26.1	General	252
11.26.2	Manual of operating procedures	252
11.26.3	Contingency manual	253
11.26.4	Communication systems	253
11.26.5	Inspection and patrolling of pipelines	253
11.26.6	Leak detection	254
11.26.7	Valves	254
11.26.8	Control and safety devices	254
11.26.9	Safety	254
11.26.10	Repair of pipelines	255

11.26.11	Records	255
11.26.12	Pipeline deactivation and reactivation	255
12	Gas distribution systems	255
12.1	General	255
12.2	Applicability	255
12.3	Gas containing hydrogen sulphide	255
12.4	Design	256
12.4.1	Steel piping	256
12.4.2	Polyethylene piping — Design pressure	258
12.4.3	Polyethylene piping — Design limitations	260
12.4.4	Polyethylene piping — Design pressure of components	260
12.4.5	Metallic piping materials — Other than steel	260
12.4.6	Plastic piping materials — Other than polyethylene	261
12.4.7	Cover	261
12.4.8	Pipelines within road and railway rights-of-way	262
12.4.9	Limitations on operating pressure — General	263
12.4.10	Limitations on operating pressure — Piping within customers' buildings	263
12.4.11	Pressure control and overpressure protection	263
12.4.12	Distribution system valves — General	265
12.4.13	Distribution system valves — Valve location and spacing	265
12.4.14	Distribution system valves — Service shutoffs	265
12.4.15	Customers' meters and service regulators	266
12.4.16	Distribution systems within buildings	267
12.4.17	Liquefied petroleum gas (LPG) pipeline systems	268
12.5	Materials	268
12.5.1	Steel pipe, tubing, and components	268
12.5.2	Polyethylene pipe, tubing, and components	268
12.5.3	Cast iron pipe and valves	269
12.5.4	Polyamide (PA) piping systems	269
12.6	Installation	269
12.6.1	General	269
12.6.2	Steel piping	269
12.6.3	Polyethylene piping — General	269
12.6.4	Polyethylene piping — Inspection and handling	270
12.6.5	Polyethylene piping — Direct burial	270
12.6.6	Polyethylene piping — Insertion in casing	271
12.6.7	Polyethylene piping — Bends and branches	271
12.6.8	Cast iron piping	271
12.6.9	Copper piping	272
12.6.10	Installation of service lines — Drainage	272
12.6.11	Installation of service lines into or under buildings	272
12.6.12	Installation of service lines — Additional installation requirements for polyethylene service lines	273
12.6.13	Trenchless installations	273
12.7	Joining	274
12.7.1	General	274
12.7.2	Steel pipe joints and connections — Essential changes for qualification of welding procedure specifications	274
12.7.3	Steel pipe joints and connections — Qualification of welders	274
12.7.4	Steel pipe joints and connections — Inspection of field welds	277
12.7.5	Steel pipe joints and connections — Inspection of tie-in welds	277
12.7.6	Steel pipe joints and connections — Steel pipe joints within buildings	277
12.7.7	Polyethylene pipe joints and connections — General	277

- 12.7.8 Polyethylene pipe joints and connections — Joining by heat fusion 277
- 12.7.9 Polyethylene pipe joints and connections — Joining by electrofusion 278
- 12.7.10 Polyethylene pipe joints and connections — Joining by mechanical methods 278
- 12.7.11 Cast iron pipe joints 279
- 12.7.12 Joints in copper pipe and tubing 279
- 12.7.13 Service line connections 280
- 12.8 Pressure testing 280
- 12.8.1 Piping in distribution systems intended to be operated at pressures in excess of 700 kPa 280
- 12.8.2 Piping within customers' buildings 281
- 12.8.3 Polyethylene piping 281
- 12.8.4 Test-head assemblies 282
- 12.9 Corrosion control 282
- 12.9.1 Steel piping 282
- 12.9.2 Cast iron piping 282
- 12.9.3 Copper piping 282
- 12.9.4 Corrosion inspection 282
- 12.10 Operating, maintenance, and upgrading 283
- 12.10.1 Marking of piping 283
- 12.10.2 Distribution system maintenance 283
- 12.10.3 Pressure recording for distribution systems 284
- 12.10.4 Valve maintenance 284
- 12.10.5 Pressure-control, pressure-limiting, and pressure-relieving devices 284
- 12.10.6 Repair procedures for steel distribution pipeline systems 284
- 12.10.7 Maintenance welding 285
- 12.10.8 Squeezing of polyethylene and polyamide pipe for pressure-control purposes 285
- 12.10.9 Maintenance and repair requirements for polyethylene, polyamide, and polyvinyl chloride pipe and tubing 285
- 12.10.10 Static electricity dissipation 286
- 12.10.11 Pressure upgrading of distribution piping 287
- 12.10.12 Operating and maintenance procedures for cast iron piping 287
- 12.10.13 Pipeline emergencies 287
- 12.10.14 Ground disturbances 287
- 12.10.15 Class location 287

13 Reinforced composite, thermoplastic-lined, and polyethylene pipelines 287

- 13.1 Reinforced composite pipelines 287
- 13.1.1 General 287
- 13.1.2 Design 288
- 13.1.3 Materials 291
- 13.1.4 Installation 292
- 13.1.5 Joining 293
- 13.1.6 Pressure testing 294
- 13.1.7 Operation 295
- 13.1.8 Pipeline repairs 295
- 13.2 Thermoplastic-lined pipelines 295
- 13.2.1 General 295
- 13.2.2 Design 295
- 13.2.3 Materials 297
- 13.2.4 Installation 298
- 13.2.5 Joining liners 298
- 13.2.6 Flange connections 298
- 13.2.7 Pressure testing 299
- 13.2.8 Operation and maintenance 299
- 13.3 Polyethylene pipelines 300

- 13.3.1 General 300
- 13.3.2 Design 300
- 13.3.3 Materials 304
- 13.3.4 Installation 305
- 13.3.5 Joining procedure and qualification 305
- 13.3.6 Joining personnel — Competency requirements 306
- 13.3.7 Joining inspection 308
- 13.3.8 Pressure testing 310
- 13.3.9 Operation and maintenance 311

14 Oilfield steam distribution pipelines 312

- 14.1 General 312
- 14.2 Design 313
 - 14.2.1 General 313
 - 14.2.2 Straight pipe under internal pressure 313
 - 14.2.3 Pipe bends 314
 - 14.2.4 Limits of calculated stresses due to sustained loads and displacement strains 314
 - 14.2.5 Expansion, flexibility, and support 314
 - 14.2.6 Corrosion and erosion allowances 315
 - 14.2.7 Wall thickness tolerance 315
- 14.3 Materials 315
 - 14.3.1 General 315
 - 14.3.2 Material testing 315
 - 14.3.3 Pipe 316
 - 14.3.4 Fittings other than bends 316
 - 14.3.5 Flanges 317
 - 14.3.6 Valves 317
 - 14.3.7 Transition pieces 317
 - 14.3.8 Pipe bends — General 317
 - 14.3.9 Pipe bends — Qualification and production 318
 - 14.3.10 Piping supports 318
- 14.4 Joining 318
- 14.5 Pressure testing 319
 - 14.5.1 General 319
 - 14.5.2 Aboveground pipelines 319
 - 14.5.3 Underground pipelines 320
- 14.6 Corrosion control 320
- 14.7 Commissioning and operation 320

15 Aluminum piping 321

- 15.1 General 321
- 15.2 Applicability 321
- 15.3 Design 321
 - 15.3.1 Pressure design for aluminum pipe 321
 - 15.3.2 Pressure design for components 323
 - 15.3.3 Piping joints 324
 - 15.3.4 Aluminum properties 324
 - 15.3.5 Uncased railway crossings 324
 - 15.3.6 Effects on pipelines in proximity to low-voltage alternating current lines and associated facilities 325
- 15.4 Materials 325
 - 15.4.1 Design temperatures 325
 - 15.4.2 Notch toughness 325
 - 15.4.3 Aluminum pipe and components 325

- 15.5 Installation of aluminum piping 326
 - 15.5.1 Bends and elbows 326
 - 15.5.2 Attachment of test leads 326
 - 15.5.3 Storage and handling of aluminum pipe and fittings during installation 326
 - 15.5.4 Ambient temperature 326
 - 15.5.5 Burial of coiled aluminum pipe by ploughing 326
 - 15.5.6 Plain dents 327
- 15.6 Joining 327
 - 15.6.2 Arc welding 328
 - 15.6.3 High energy joining — General 328
 - 15.6.4 High energy joining — Qualification of joining procedure specifications 328
 - 15.6.5 High energy joining — Qualification of personnel 328
 - 15.6.6 High energy joining — Inspection and testing of high energy joints for qualification of joining procedure specifications and personnel 328
 - 15.6.7 High energy joining — Production welding 329
 - 15.6.8 High energy joining — Inspection and testing of high energy joints 329
 - 15.6.9 Mechanical interference fit joints 329
- 15.7 Pressure testing 330
- 15.8 Corrosion control 330
 - 15.8.1 Test lead attachment 330
 - 15.8.2 Installation of cathodic protection systems 330
 - 15.8.3 Corrosive medium 331
- 15.9 Operating, maintenance, and upgrading 331
 - 15.9.1 Evaluation of imperfections and repair of piping containing defects 331
 - 15.9.2 Maintenance welding 332
 - 15.9.3 Pipeline hot taps 332
- 15.10 Sour service 332
 - 15.10.1 General 332
 - 15.10.2 Material properties 332
 - 15.10.3 Exposure to iron sulphides 332
 - 15.10.4 Location factor 332
 - 15.10.5 Sectionalizing valves 333
 - 15.10.6 Nondestructive inspection 333
 - 15.10.7 Integrity management program 333
 - 15.10.8 Construction 333
 - 15.10.9 Operating and maintenance 333
 - 15.10.10 Records 333

16 Sour service pipelines 333

- 16.1 General 333
- 16.2 Sour service — Specific definition 334
- 16.3 Design 334
 - 16.3.1 Design parameters 334
 - 16.3.2 Design information 334
 - 16.3.3 Stress design 335
 - 16.3.4 Anchors and restraints 335
 - 16.3.5 Threaded joints 335
 - 16.3.6 Pipe-type and bottle-type holders and pipe-type storage vessels 335
- 16.4 Materials 335
 - 16.4.1 Environmental cracking 335
 - 16.4.2 Material provisions 335
 - 16.4.3 Marking 335
 - 16.4.4 Nonferrous materials 336
- 16.5 Construction 336

16.5.1	Deviations	336
16.5.2	Records	336
16.5.3	Inspection plan	336
16.6	Joining	336
16.6.1	Carbon equivalent	336
16.6.2	Change in carbon equivalent	336
16.6.3	Butt welds of unequal thickness	336
16.6.4	Weld hardness requirements	337
16.6.5	Deposited weld metal composition limitations	337
16.6.6	Alignment	337
16.6.7	Preheat	337
16.6.8	Backwelding	337
16.7	Corrosion and corrosion control	337
16.7.1	Supplemental mitigation requirements	337
16.7.2	Mitigation and monitoring program	337
16.7.3	Design and sizing of pigs	338
16.8	Operation and maintenance	338
16.8.1	Procedures	338
16.8.2	Records	338
16.8.3	Repair methods	338
16.8.4	Hydrogen charging	338
16.8.5	Direct deposition welding	338
16.8.6	Change management process	338
16.8.7	Changes in service conditions	338
16.8.8	Integrity management program	338
16.9	Gas and multiphase pipelines	339
16.9.1	Additional requirements	339
16.9.2	Design	339
16.9.3	Joining	339
16.9.4	Operating and Maintenance	339
16.10	Additional requirements for gas pipelines only	340
16.10.2	Mechanical interference fit joints	340
16.10.3	Start-up corrosion mitigation	340

17 Composite-reinforced steel pipelines 340

17.1	General	340
17.2	Applicability	340
17.3	Specific definitions	341
17.4	Design	341
17.4.1	Stress distribution	341
17.4.2	Maximum operating pressure	341
17.4.3	Design pressure	341
17.4.4	External pressures and loadings	342
17.4.5	Stress limits	342
17.4.6	Design temperature	342
17.4.7	Engineering assessment	343
17.5	Materials and manufacture	343
17.5.1	Steel pipe	343
17.5.2	Fibre-reinforced composite	343
17.5.3	Composite-reinforced steel pipe manufacture	344
17.6	Installation	345
17.6.1	Field bending	345
17.6.2	Damage	345
17.6.3	Crossings	345

- 17.7 Joining 346
 - 17.7.1 General 346
 - 17.7.2 Joint reinforcement 346
 - 17.7.3 Transitions to steel pipe 346
 - 17.7.4 Qualification of joining procedure specifications 346
- 17.8 Pressure testing 346
- 17.9 Corrosion control 346
- 17.10 Operation and maintenance 347

Annexes

- A** (informative) — Safety and loss management system 350
- B** (informative) — Guidelines for risk assessment of pipelines 358
- C** (informative) — Limit states design 366
- D** (informative) — Guidelines for in-line inspection of piping for corrosion imperfections 395
- E** (informative) — Recommended practice for liquid hydrocarbon pipeline system leak detection 398
- F** (informative) — Slurry pipeline systems 403
- G** (informative) — Precautions to avoid explosions of gas-air mixtures 406
- H** (normative) — Pipeline failure records 408
- I** (informative) — Oilfield steam distribution pipelines — Alternate provisions 423
- J** (informative) — Recommended practice for determining the acceptability of imperfections in fusion welds using engineering critical assessment 427
- K** (informative) — Standards of acceptability for circumferential pipe butt welds based upon fracture mechanics principles 429
- L** (informative) — Alternative or supplementary test methods for coating property and characteristics evaluation 443
- M** (informative) — Guidance for system control, monitoring and protection of liquid pipelines 445
- N** (informative) — Guidelines for pipeline system integrity management programs 450
- O** (informative) — Reliability-based design and assessment (RBDA) of onshore non-sour service natural gas transmission pipelines 461

Tables

- 4.1** — Class location designations 37
- 4.2** — Location factor for steel pipe 42
- 4.3** — Joint factor for steel pipe 43
- 4.4** — Temperature factor for steel pipe 43
- 4.5** — Least nominal wall thickness for steel carrier pipe 44
- 4.6** — Design of welded branch connections 48
- 4.7** — Valve spacing, km 54
- 4.8** — Flexibility and stress intensification factors 60
- 4.9** — Cover and clearance 63
- 4.10** — Least nominal wall thickness for steel casing pipe in cased crossings and carrier pipe in uncased crossings 65
- 4.11** — Maximum pipe diameter to wall thickness (D/t) ratio for uncased railway crossings 66
- 5.1** — Pipe body notch toughness for steel pipe 82
- 5.2** — Pipe threshold stress values 83
- 5.3** — Limitations for pipe and components 86
- 5.4** — Cement-mortar lining thickness tolerances 92
- 7.1** — Equivalent ASME P-1 group numbers for welding procedures for piping materials 102
- 7.2** — Compliance factor (F) — Carbon equivalent formula 111
- 7.3** — Essential changes for qualification of welding procedure specifications (not applicable for welding on in-service piping) 113
- 7.4** — Type and number of test specimens for butt welds 116
- 7.5** — Number of root-break or macrosection test specimens for fillet welds and branch connection welds 124

- 7.6** — Outside crown height 136
 - 7.7** — Maximum acceptable amount of spherical porosity 142
 - 7.8** — Image quality indicator selection criteria for X-ray radiography 147
 - 7.9** — Image quality indicator selection criteria for gamma radiography 148
 - 7.10** — Essential changes for qualification of welding procedure specifications (WPS) intended for welding on in-service piping 159
 - 7.11** — Number of face-bend test specimens 162
 - 7.12** — Number of test specimens for qualification of procedures and welders for direct deposition welding 166
 - 8.1** — Test requirements for steel piping intended to be operated at pressures greater than 700 kPa 177
 - 9.1** — Selection of external coating systems 183
 - 10.1** — Limitations on acceptable permanent repair methods 219
 - 11.1** — Design factors 238
 - 12.1** — Chemical design factor (F_c) for thermoplastic pipe and tubing in the presence of liquid hydrocarbons or methanol 259
 - 12.2** — Cover 262
 - 12.3** — Essential changes for qualification of welding procedure specifications 275
 - 12.4** — Leak test pressure within buildings 281
 - 13.1** — Reinforced composite pipes 290
 - 13.2** — Material classification and minimum property values 302
 - 13.3** — Service fluid factor (F) 302
 - 13.4** — Design temperature factor (T) 303
 - 13.5** — Expansion allowance under test pressure 311
 - 14.1** — Minimum nominal wall thickness of threaded pipe nipples 317
 - 15.1** — Circumferential joint factor 322
 - 15.2** — Temperature factor 323
 - 15.3** — Alloy factor 323
 - 15.4** — Linear coefficient of thermal expansion and modulus of elasticity 324
 - 15.5** — Limitations for acceptable pipe and components 325
 - 15.6** — Minimum bend radius 327
 - 17.1** — Visual acceptance criteria for fibre-reinforced composite 348
 - 17.2** — Damage severity and repair guidelines for fibre-reinforced composite 349
-

Figures

- 1.1** — Scope diagram — Oil industry pipeline systems 3
- 1.2** — Scope diagram — Gas industry pipeline systems 4
- 4.1** — Class location end boundaries, determined by dwelling-unit density 39
- 4.2** — Integrally reinforced extruded outlet headers 49
- 4.3** — Details for openings with complete encirclement types of reinforcement 50
- 4.4** — Reinforcement of branch connections 52
- 7.1** — Examples of end preparations and combinations of end preparations 103
- 7.2** — Buttwelding details between items having unequal thickness 104
- 7.3** — Fillet weld details 106
- 7.4** — Welding details of opening with localized type of reinforcement 107
- 7.5** — Welding details for branch-to-run pipe connection 108
- 7.6** — Location of test specimens for butt welds 117
- 7.7** — Tension test specimen 118
- 7.8** — Nick-break test specimen 118
- 7.9** — Root-bend or face-bend test specimen 119
- 7.10** — Side-bend test specimen 119
- 7.11** — Permissible dimensions for slag inclusions in the fracture surfaces of nick-break test specimens 121
- 7.12** — Jig for guided-bend tests 122

- 7.13** — Location of root-break or macrosection test specimens for fillet welds and branch connection welds 123
- 7.14** — Root-break or macrosection test specimens 124
- 7.15** — Incomplete penetration of the root bead 137
- 7.16** — Incomplete fusion 137
- 7.17** — Internal concavity 138
- 7.18** — Comparator shim 139
- 7.19** — Incomplete fusion due to cold lap 140
- 7.20** — Lack of cross-penetration 140
- 7.21** — Hollow bead 141
- 7.22** — Spherical porosity 143
- 7.23** — Location of test specimens 164
- 7.24** — Face-bend test specimen 165
- 7.25** — Test specimens for direct deposition welding 167
- 10.1** — Method of deriving the longitudinal length of corrosion 210
- 11.1** — Scope diagram 226
- 11.2** — Subsea completion to platform and platform to shore (typical arrangement) 227
- 11.3** — Landward jetty system and offshore loading/unloading system (typical arrangement) 227
- 11.4** — Artificial island (typical arrangement) 228
- 11.5** — Single-point mooring system (typical arrangement) 228
- 12.1** — Scope diagram 257
- 13.1** — Typical reinforced composite to steel transition 294
- 13.2** — Typical flange configuration for pipe liner 296

Technical Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials

T.J. Pesta	Energy Resources Conservation Board, Calgary, Alberta	<i>Chair</i>
K.G. Goerz	Shell Canada Energy, Calgary, Alberta	<i>Vice-Chair</i>
G.R. Johnson	FortisBC Energy Inc., Surrey, British Columbia	<i>Vice-Chair</i>
T.C. Slimmon	Ezefflow Inc., Calgary, Alberta	<i>Vice-Chair</i>
J. Abes	Det Norske Veritas Canada Ltd., Calgary, Alberta	
J. Adams	TransGas Ltd., Regina, Saskatchewan	
A.J. Afaganis	EVRAZ Inc. NA, Calgary, Alberta	
O. Alonso	Technical Standards and Safety Authority, Toronto, Ontario	
T. Bourque	Tenaris Prudential, Calgary, Alberta	
B.L. Brown	Pipe Line Contractors Association of Canada, Oakville, Ontario	<i>Associate</i>
R.R. Bryant	Union Gas Limited, Chatham, Ontario	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
R.I. Coote	Coote Engineering Limited, Calgary, Alberta	
M. Davies	Kinder Morgan Canada Inc., Calgary, Alberta	
J.W. Dusseault	Cenovus Energy Inc., Calgary, Alberta	
M.C. Enwright	Husky Energy Inc., Calgary, Alberta	

J.A. Fournell	QAi Quality Assurance Inc., Edmonton, Alberta	
B.E. Fowlie	Nu-Trac Management Consulting Ltd., Calgary, Alberta	
R.J. Fox	Enbridge Gas Distribution, Richmond Hill, Ontario	
L.H. Gales	Transportation Safety Board of Canada, Gatineau, Québec	<i>Associate</i>
M.F. Hallihan	Calgary, Alberta	
G.A. Harms	Three Streams Engineering Ltd., Calgary, Alberta	<i>Associate</i>
J. Harvey	EnCana Corporation, Calgary, Alberta	<i>Associate</i>
J.C. Ho	ConocoPhillips Canada Calgary, Alberta	
S.D. Ironside	Enbridge Pipelines Inc., Edmonton, Alberta	<i>Associate</i>
S. Kenny	Memorial University of Newfoundland, St. John's, Newfoundland and Labrador	<i>Associate</i>
H. Kraft	Alliance Pipeline Ltd., Calgary, Alberta	
W. Kresic	Enbridge Pipelines Inc., Edmonton, Alberta	
K.T. Lau	ABSA, Edmonton, Alberta	
T. Lawrence	TMK IPSCO Inc., Downers Grove, Illinois, USA	
J. Mackenzie	Kiefner and Associates, Inc., Bellingham, Washington, USA	
T.W. McQuinn	New Brunswick Energy and Utilities Board, Saint John, New Brunswick	
G. Mills	Spectra Energy Gas Transmission, Calgary, Alberta	
D.B. Milmine	DM Professional Services Ltd., Calgary, Alberta	
B.W. Nesbitt	National Energy Board, Calgary, Alberta	

P. Noiseux	Gaz Métro Inc., Montréal, Québec	
R. Paccagnan	ATCO Pipelines, Edmonton, Alberta	
R.B. Partington	Alberta Agriculture and Rural Development, Edmonton, Alberta	
W.F. Partington	Ledcor Pipeline Limited, Edmonton, Alberta	
J. Paviglianiti	National Energy Board, Calgary, Alberta	<i>Associate</i>
D. Petursson	Manitoba Hydro, Winnipeg, Manitoba	
J. Renaud	Régie du bâtiment du Québec, Montréal, Québec	
A.B. Rothwell	Brian Rothwell Consulting Inc., Calgary, Alberta	<i>Associate</i>
Z. Saad	Canadian Energy Pipeline Association, Calgary, Alberta	<i>Associate</i>
J. Sandison	Energy Consultants International Inc., Winnipeg, Manitoba	
P. Singh	Bredero Shaw LLC, Houston, Texas, USA	
C. Skocdopole	Aluminum Pipe Systems, Eckville, Alberta	
D. Tchir	ATCO Gas, Edmonton, Alberta	
B. Wilson	Acuren Group Inc., Calgary, Alberta	
J. Zhou	TransCanada PipeLines Limited, Calgary, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

Executive Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials

T.J. Pesta	Energy Resources Conservation Board, Calgary, Alberta	<i>Chair</i>
K.G. Goerz	Shell Canada Energy, Calgary, Alberta	<i>Vice-Chair</i>
G.R. Johnson	Fortis BC, Surrey, British Columbia	<i>Vice-Chair</i>
T.C. Slimmon	Ezeflow Inc., Calgary, Alberta	<i>Vice-Chair</i>
R.R. Bryant	Union Gas Limited, Chatham, Ontario	
J.A. Fournell	QAi Quality Assurance Inc., Edmonton, Alberta	
R.J. Fox	Enbridge Gas Distribution, Richmond Hill, Ontario	
M.F. Hallihan	Calgary, Alberta	
G.A. Harms	Three Streams Engineering Ltd., Calgary, Alberta	
S.D. Ironside	Enbridge Pipelines Inc., Edmonton, Alberta	
S. Kenny	Memorial University of Newfoundland, St. John's, Newfoundland and Labrador	
J. Paviglianiti	National Energy Board, Calgary, Alberta	
A.B. Rothwell	Brian Rothwell Consulting Inc., Calgary, Alberta	
C. Skocdopole	Aluminum Pipe Systems, Eckville, Alberta	
J. Zhou	TransCanada PipeLines Limited, Calgary, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

Subcommittee on Aluminum Pipeline Systems

C. Skocdopole	Aluminum Pipe Systems, Eckville, Alberta	<i>Chair</i>
B. Ryder	Campbell Ryder Engineering Ltd., Edmonton, Alberta	<i>Vice-Chair</i>
R. Andriuk	Altime Engineering Ltd., St. Albert, Alberta	
G. Firth	Corrpro Canada Inc., Edmonton, Alberta	
N. Lesage	AltaGas Utilities Inc., Leduc, Alberta	
D. Lesik	ATCO Pipelines, Edmonton, Alberta	
R.B. Partington	Alberta Agriculture and Rural Development, Edmonton, Alberta	
T. Starodub	Manitoba Hydro, Winnipeg, Manitoba	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

In addition to the members of this committee, the following individuals made valuable contributions to the development of this Standard:

M. Hess	Altime Engineering Ltd., St. Albert, Alberta
J. Livingston	Federation of Alberta Gas Co-ops, Spirit River, Alberta

Subcommittee on Coatings

J.A. Fournell	QAi Quality Assurance Inc., Edmonton, Alberta	<i>Chair</i>
K. Adams	3M Corrosion Protection Products Division, Warren, Texas, USA	
J.I. Andersson	Husky Energy Inc., Calgary, Alberta	
J. Baron	J. Baron Project Services Inc., High River, Alberta	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
B. Elliott	Shaw Pipe Protection Ltd., Edmonton, Alberta	
A. Glowach	Glowach Pipe Coating Consultant, Beaumont, Alberta	
D. Grzyb	Energy Resources Conservation Board, Calgary, Alberta	
T. Jeffers	DuPont Powder Coatings USA Inc., Houston, Texas, USA	
S. Jehlicka	Enbridge Gas Distribution, Toronto, Ontario	
G.R. Johnson	FortisBC Energy Inc., Surrey, British Columbia	
J. Klementis	Alliance Pipeline Ltd., Calgary, Alberta	
L. Lai	LKLL Consulting Services, Mississauga, Ontario	
D. Lawrence	Enbridge Pipelines Inc., Edmonton, Alberta	
D.J.B. Morrison	TransCanada PipeLines Limited, Calgary, Alberta	
D.P. Ochitwa	National Energy Board, Calgary, Alberta	
S. Papavinasam	CANMET/Materials Technology Laboratory, Ottawa, Ontario	

K. Recsky	FortisBC Energy Inc., Kelowna, British Columbia
J. Shore	Union Gas Limited, Chatham, Ontario
G. Van Boven	Spectra Energy Transmission, Vancouver, British Columbia
A. Van Der Veen	TransCanada PipeLines Limited, Calgary, Alberta
I. Ward	Shell Global Solutions Canada, Calgary, Alberta
D. Wong	ShawCor Ltd., Toronto, Ontario
L. Pelan	Canadian Standards Association, Mississauga, Ontario

Project Manager

Subcommittee on Construction

J. Paviglianiti	National Energy Board, Calgary, Alberta	<i>Chair</i>
H. Wallace	Energy Resources Conservation Board, Calgary, Alberta	<i>Vice-Chair</i>
T. Bridgewater	Calgary, Alberta	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
W. Celis	Saskatchewan Ministry of Energy & Resources, Regina, Saskatchewan	
R. Fafara	TransCanada PipeLines Limited, Calgary, Alberta	
D. Fedoration	Singleton Associated Engineering Ltd., Calgary, Alberta	
T. Fiddler	Enbridge Pipelines Inc., Edmonton, Alberta	
G.A. Harms	Three Streams Engineering Ltd., Calgary, Alberta	
R.M. Huntley	RMH Welding Consulting Inc., Calgary, Alberta	
M. Hylton	Cimarron Engineering Limited, Calgary, Alberta	
G.R. Johnson	FortisBC Energy Inc., Surrey, British Columbia	
M.A. Kereliuk	Qualimet Inc., Edmonton, Alberta	
L. Lawler	Enbridge Gas Distribution, Toronto, Ontario	
A. Loyer	CogniSpecs Consulting Ltd., Calgary, Alberta	
R. Mayer	Spectra Energy Transmission, Halifax, Nova Scotia	
R. Ostrom	Pipeline Welding Solutions Inc., Edmonton, Alberta	
W.F. Partington	Ledcor Pipeline Limited, Edmonton, Alberta	

R. Peters Ludwig and Associates Ltd.,
Edmonton, Alberta

B. Torgunrud SaskEnergy,
Regina, Saskatchewan

B. Wilson Acuren Group Inc.,
Calgary, Alberta

D.G. Yantz CWB Group,
Edmonton, Alberta

L. Pelan Canadian Standards Association,
Mississauga, Ontario

Project Manager

Subcommittee on Design

J. Zhou	TransCanada Pipelines Limited, Calgary, Alberta	<i>Chair</i>
T. Zimmerman	Enbridge Pipelines Incorporated, Edmonton, Alberta	<i>Vice-Chair</i>
J. Adams	TransGas Ltd., Regina, Saskatchewan	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
T. Caveny	WorleyParsons Canada, Edmonton, Alberta	
P. Colwell	Union Gas Limited, Chatham, Ontario	
D. Horsley	BP Exploration and Production Technology, Calgary, Alberta	
G.A. Kanzaki	FortisBC Energy Inc., Surrey, British Columbia	
S. Kenny	Memorial University of Newfoundland, St. John's, Newfoundland and Labrador	
P. Kormann	Kormann & Associates Inc., Calgary, Alberta	
S.C. Lee	Energy Resources Conservation Board, Calgary, Alberta	
M. Nelson	Oil and Gas Commission, Fort St. John, British Columbia	
B.W. Nesbitt	National Energy Board, Calgary, Alberta	
M.A. Nessim	C-FER Technologies, Edmonton, Alberta	
M. Rew	Canadian Natural Resources Limited, Calgary, Alberta	
G. Shulhan	Cimarron Engineering Limited, Calgary, Alberta	
R. Steiner	Paramount Resources Ltd., Calgary, Alberta	

C. Steneker	Imperial Oil Limited, Calgary, Alberta	
T. Tomkiw	Husky Oil Operations Limited, Calgary, Alberta	
J.S. van de Panne	KEYERA Energy, Calgary, Alberta	
S.A. Van Sickle	Enbridge Gas Distribution, Toronto, Ontario	
R.H. Wartlik	Spectra Energy Transmission, Vancouver, British Columbia	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

In addition to the members of this committee, the following individuals made valuable contributions to the development of this Standard:

J. Broyles	Enbridge Pipelines Incorporated, Edmonton, Alberta
D.S. Da Silva	WorleyParsons Canada, Edmonton, Alberta

Subcommittee on Distribution

R.J. Fox	Enbridge Gas Distribution, Richmond Hill, Ontario	<i>Chair</i>
O. Alonso	Technical Standards and Safety Authority, Toronto, Ontario	
P. Blazic	SaskEnergy, Saskatoon, Saskatchewan	
G. Butson	Robert B. Somerville Co. Limited, King City, Ontario	
S. Coulombe	Gaz Métro Inc., Montréal, Québec	
P. Delano	ATCO Gas, Edmonton, Alberta	
C. Dubeau	Union Gas Limited, Chatham, Ontario	
N. Lesage	AltaGas Utilities Inc., Leduc, Alberta	
T.W. McQuinn	New Brunswick Energy and Utilities Board, Saint John, New Brunswick	
K. Mills	Energy Consultants International Inc., Winnipeg, Manitoba	
G. Palermo	Palermo Plastics Pipe (P3) Consulting, Friendsville, Tennessee, USA	
R.B. Partington	Alberta Agriculture and Rural Development, Edmonton, Alberta	
J. Renaud	Régie du bâtiment du Québec, Montréal, Québec	
C. Rollings	Heritage Gas Limited, Dartmouth, Nova Scotia	
T. Starodub	Manitoba Hydro Winnipeg, Manitoba	
P. Tassie	FortisBC Energy Inc., Vernon, British Columbia	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

In addition to the members of this committee, the following individuals made valuable contributions to the development of this Standard:

J. Harradine

Union Gas Limited,
Chatham, Ontario

H. Klaver

British Columbia Safety Authority,
New Westminster, British Columbia

Editorial Subcommittee

A.B. Rothwell	Brian Rothwell Consulting Inc., Calgary, Alberta	<i>Chair</i>
A.J. Afaganis	EVRAZ Inc. NA, Calgary, Alberta	
J. Fournell	QAi Quality Assurance Inc., Edmonton, Alberta	
J. Mackenzie	Kiefner and Associates Inc., Bellingham, Washington, USA	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

Subcommittee on Materials

S.D. Ironside	Enbridge Pipelines Inc., Edmonton, Alberta	<i>Chair</i>
A.J. Afaganis	EVRAZ Inc. NA, Calgary, Alberta	
J.I. Andersson	Husky Energy Inc., Calgary, Alberta	
H.G. Bentley	WFF Fittings & Flanges (Canada) Ltd., Calgary, Alberta	
T. Bourque	Tenaris Prudential, Calgary, Alberta	
D.M. Duan	TransCanada PipeLines Limited, Calgary, Alberta	
J.A. Fournell	QAi Quality Assurance Inc., Edmonton, Alberta	
D. Horsley	BP Exploration and Production Technology, Calgary, Alberta	
M. Ishkanian	Stream-Flo Industries Ltd., Edmonton, Alberta	
J. Klementis	Alliance Pipeline Ltd., Calgary, Alberta	
R.B. Kruger	Tenaris Global Services (Canada) Ltd., Calgary, Alberta	
T.H. Lawrence	TMK IPSCO Inc., Downers Grove, Illinois, USA	
S.C. Lee	Energy Resources Conservation Board, Calgary, Alberta	
M.Q. Li	Cameron Canada Corporation, Edmonton, Alberta	
D.B. Milmine	DM Professional Services Ltd., Calgary, Alberta	
K. Ocean	Enbridge Gas Distribution Toronto, Ontario	
D.P. Ochitwa	National Energy Board, Calgary, Alberta	

V. Sizov	Cenovus Energy Inc., Calgary, Alberta	
T.C. Slimmon	Ezefflow Inc., Calgary, Alberta	
W.R. Tyson	Natural Resources Canada, Ottawa, Ontario	
G. Van Boven	Spectra Energy Transmission, Vancouver, British Columbia	
I. Ward	Shell Global Solutions Canada, Calgary, Alberta	
M. Whitehouse	Union Gas Limited, Chatham, Ontario	
K. Widenmaier	TransCanada PipeLines Limited, Calgary, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

Subcommittee on Offshore Pipelines

S. Kenny	Memorial University of Newfoundland, St. John's, Newfoundland and Labrador	<i>Chair</i>
P. Bryce	Brytech Consulting Inc., Delta, British Columbia	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
B.W. Nesbitt	National Energy Board, Calgary, Alberta	
M.J. Paulin	INTECSEA Canada, St. John's, Newfoundland and Labrador	
J. Zhou	TransCanada PipeLines Limited, Calgary, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

Subcommittee on Operations and Systems Integrity

G.A. Harms	Three Streams Engineering Ltd., Calgary, Alberta	<i>Chair</i>
J. Kopec	TransCanada Pipelines Ltd., Calgary, Alberta	<i>Vice-Chair</i>
C. Billinton	FortisBC Energy Inc., Kelowna, British Columbia	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
W. Celis	Saskatchewan Ministry of Energy & Resources, Regina, Saskatchewan	
R.I. Coote	Coote Engineering Limited, Calgary, Alberta	
S.J. Croall	Winnipeg, Manitoba	
T.B. DeLong	Kinder Morgan Canada Inc., Calgary, Alberta	
E. Dowdle	Acuren Group Inc., Edmonton, Alberta	
A. Hobbins	ConocoPhillips Canada Ltd., Grande Prairie, Alberta	
L. Hunt	Spectra Energy Transmission, Vancouver, British Columbia	
T.P. Kelly	Canada Natural Resources Limited, Calgary, Alberta	
G. Leclerc	Gaz Métro Inc., Montréal, Québec	
D.R. Mann	TransGas Ltd., Regina, Saskatchewan	
R.A. Marsden	Cenovus Energy Inc., Calgary, Alberta	
R.G. Mora	National Energy Board, Calgary, Alberta	
J.D. Norris	JD Pipeline Consulting, Calgary, Alberta	

M.T. Reed	Alliance Pipeline Ltd., Calgary, Alberta	
B. Sadoway	TransCanada PipeLines Limited, Airdrie, Alberta	
M. Santander	Husky Energy Inc., Calgary, Alberta	
M. Thompson	Enbridge Pipelines Inc., Edmonton, Alberta	
K. Thorn	Enbridge Gas Distribution Toronto, Ontario	
S. Walker	Union Gas Limited, Chatham, Ontario	
H. Wallace	Energy Resources Conservation Board, Calgary, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

In addition to the members of this committee, the following individual made valuable contributions to the development of this Standard:

B. Kukulski Calgary, Alberta

Subcommittee on Production

K.G. Goerz	Shell Canada Energy, Calgary, Alberta	<i>Chair</i>
D. Carnes	Canadian Natural Resources Limited, Calgary, Alberta	<i>Vice-Chair</i>
J.I. Andersson	Husky Energy Inc., Calgary, Alberta	
O. Baker	KEYERA Energy, Calgary, Alberta	
J. Baron	J. Baron Project Services Inc., High River, Alberta	
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
M.C. Enwright	Husky Energy Inc., Calgary, Alberta	
K. Gordon	Imperial Oil Resources, Calgary, Alberta	
S. Gosse	EnCana Corporation, Calgary, Alberta	
D. Grzyb	Energy Resources Conservation Board, Calgary, Alberta	
J.C. Ho	ConocoPhillips Canada, Calgary, Alberta	
A.L. Johnson	Nexen Inc., Calgary, Alberta	
K. Parsonage	BC Oil and Gas Commission, Fort St. John, British Columbia	
D.A. Schmidt	Apache Canada, Calgary, Alberta	
D. Storrow	Cimarron Engineering Limited, Calgary, Alberta	
D. Sronic	ABSA, Edmonton, Alberta	
R. Szopa	Enerplus Corp., Calgary, Alberta	
I.A. Ward	Shell Global Solutions Canada, Calgary, Alberta	

J. Whittaker	Cenovus Energy Inc., Calgary, Alberta	
B. Wilson	Acuren Group Inc., Calgary, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

In addition to the members of this committee, the following individuals made valuable contributions to the development of this Standard:

F. Cox	Acuren Group Inc., Calgary, Alberta	
J. Hanna	Flint Energy Services Ltd., Calgary, Alberta	
J. Healey	Husky Energy Inc., Calgary, Alberta	
D. Ivey	Flint Energy Services Ltd., Kitscoty, Alberta	
W. Korrall	Flint Global Poly, Edmonton, Alberta	
B.M. McWhirter	ABSA, Edmonton, Alberta	
K. Miller	Husky Energy Inc., Calgary, Alberta	
I. Powell	A.H. McElroy (Canada) Ltd., Edmonton, Alberta	
C. Skocdopole	Aluminum Pipe Systems, Eckville, Alberta	

Taskforce on Management Systems

J.A. Fournell	QAi Quality Assurance Inc., Edmonton, Alberta	<i>Chair</i>
R. Caesar	BC Ministry of Energy, Victoria, British Columbia	
D. Carnes	Canadian Natural Resources Limited, Calgary, Alberta	
B.E. Fowlie	Nu-Trac Management Consulting Ltd., Calgary, Alberta	
J. Kopec	Husky Energy Inc., Calgary, Alberta	
J. Mackenzie	Keifner and Associates, Inc., Bellingham, Washington, USA	
R.B. Partington	Alberta Agriculture, Food and Rural Development, Edmonton, Alberta	
D. Tchir	ATCO Gas, Edmonton, Alberta	
M. Whitehouse	Union Gas Limited, Chatham, Ontario	
T. Zimmerman	Enbridge Pipelines Incorporated, Edmonton, Alberta	
L. Pelan	Canadian Standards Association, Mississauga, Ontario	<i>Project Manager</i>

Preface

This is the sixth edition of CSA Z662, *Oil and gas pipeline systems*. It supersedes the previous editions published in 2007, 2003, 1999, 1996, and 1994.

The following are the most significant changes, relative to the previous edition:

- (a) [Clause 2](#) now contains reference publications and definitions.
- (b) A new [Clause 3](#) has been added to cover safety and loss management systems, integrity management programs, and engineering assessments.
- (c) [Clause 6.6](#) has been rewritten to focus on prevention and control measures to address the potential for uncontrolled fires, which are a risk during various phases of pipeline installation.
- (d) [Table 7.3](#) has been modified to separate welding procedure specifications for manual or semi-automatic welding for pipe not exceeding 323.9 mm OD and not exceeding Grade 386. Also, items have been added to the welding techniques section of this Table to address newer welding techniques that are being employed with mechanized or automatic welding. In-service welding Clauses have been moved from [Clause 10](#) to [Clause 7](#), and [Table 7.10](#) was developed to address essential changes for qualification of welding procedure specifications intended for welding on in-service piping.
- (e) [Clauses 3, 8, and 10](#) have been significantly restructured.
- (f) In [Clause 9](#), internal corrosion control requirements have been revised to highlight that supporting documentation or tests are necessary to demonstrate that a substance is not corrosive.
- (g) [Clause 12](#) has been revised to incorporate higher performance thermoplastic and reinforced thermoplastic pipe and tubing.
- (h) In [Clause 13](#), numerous new clauses have been added to update the requirements for reinforced composite, thermoplastic-lined, and polyethylene pipelines including expanded requirements for joining personnel, joining inspections, and pressure testing for polyethylene pipelines.
- (i) In [Clause 16](#), changes have been made to clarify the service fluids/pipeline systems to which the sour service clause applies.
- (j) [Annex H](#) has been substantially revised to restrict the scope to incident reporting. As a result, the Annex is now titled “Pipeline failure records” and is a normative part of the Standard.
- (k) [Annex M](#) is a new, informative annex that provides guidance for system control, monitoring, and protection of liquid pipelines.
- (l) The previous [Annex M](#), “Gas distribution system integrity management guidelines”, and the previous [Annex N](#), “Guidelines for pipeline integrity management programs”, have been combined into the current [Annex N](#), which provides guidelines for pipeline system integrity management programs.

The requirements of this Standard are considered to be adequate under conditions normally encountered in the oil and natural gas industry. Specific requirements for abnormal or unusual conditions are not prescribed, nor are all details related to engineering and construction prescribed. It is intended that all work performed within the scope of this Standard meet the standards of safety and integrity expressed or implied herein, and that the requirements of this Standard be applied with due regard to the protection of the environment, which includes land, water, plant life, and animal life. Detailed requirements concerning the protection of the environment are not prescribed.

It is expected that changes will be made from time to time, based on new experience and technology. Where necessary, amendments and supplements will be prepared by the Technical Committee and published in accordance with CSA practices.

This Standard was prepared by the Technical Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials, under the jurisdiction of the Strategic Steering Committee on Petroleum and Natural Gas Industry Systems, and has been formally approved by the Technical Committee.

June 2011

Notes:

- (1) Use of the singular does not exclude the plural (and vice versa) when the sense allows.
- (2) Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.
- (3) This publication was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.
- (4) To submit a request for interpretation of CSA Standards, please send the following information to inquiries@csa.ca and include “Request for interpretation” in the subject line:
 - (a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;
 - (b) provide an explanation of circumstances surrounding the actual field condition; and
 - (c) where possible, phrase the request in such a way that a specific “yes” or “no” answer will address the issue.Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are published in CSA’s periodical Info Update, which is available on the CSA website at <http://standardsactivities.csa.ca>.
- (5) CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee. To submit a proposal for change to CSA Standards, please send the following information to inquiries@csa.ca and include “Proposal for change” in the subject line:
 - (a) Standard designation (number);
 - (b) relevant clause, table, and/or figure number;
 - (c) wording of the proposed change; and
 - (d) rationale for the change.

Z662-11

Oil and gas pipeline systems

1 Scope

1.1

This Standard covers the design, construction, operation, and maintenance of oil and gas industry pipeline systems that convey

- (a) liquid hydrocarbons, including crude oil, multiphase fluids, condensate, liquid petroleum products, natural gas liquids, and liquefied petroleum gas;
- (b) oilfield water;
- (c) oilfield steam;
- (d) carbon dioxide used in oilfield enhanced recovery schemes; or
- (e) gas.

Note: Designers are cautioned that the requirements in this Standard might not be appropriate for gases other than natural gas, manufactured gas, or synthetic natural gas.

1.2

The scope of this Standard, as shown in [Figures 1.1](#) and [1.2](#), includes

- (a) for oil industry fluids, piping and equipment in offshore pipelines, onshore pipelines, tank farms, pump stations, pressure-regulating stations, and measuring stations;
- (b) oil pump stations, pipeline tank farms, and pipeline terminals;
- (c) pipe-type storage vessels;
- (d) for carbon dioxide pipeline systems, piping and equipment in onshore pipelines, pressure-regulating stations, and measuring stations;
- (e) for gas industry fluids, piping and equipment in offshore pipelines, onshore pipelines, compressor stations, measuring stations, and pressure-regulating stations;
- (f) gas compressor stations; and
- (g) gas storage lines and pipe-type and bottle-type gas storage vessels.

1.3

This Standard does not apply to

- (a) piping with metal temperatures below $-70\text{ }^{\circ}\text{C}$;
- (b) piping (except oilfield steam distribution piping) with metal temperatures above $230\text{ }^{\circ}\text{C}$;
- (c) gas piping beyond the outlet of the customer's meter set assembly (covered by CAN/CSA-B149.1);
- (d) piping in natural gas liquids extraction plants, gas processing plants (except main gas stream piping in dehydration and all other processing plants installed as part of gas pipeline systems), gas manufacturing plants, industrial plants, and mines;
- (e) oil refineries, terminals other than pipeline terminals, and marketing bulk plants;
- (f) abandoned piping;
- (g) in-plant piping for drinking, make-up, or boiler feed water;
- (h) casing, tubing, or pipe in oil or gas wells, wellheads, separators, production tanks, and other production facilities;
- (i) vent piping for waste gases of any kind operating at or near atmospheric pressure;
- (j) heat exchangers;
- (k) liquefied natural gas systems (covered by CSA Z276);
- (l) liquid fuel distribution systems;
- (m) loading/unloading facilities for tankers or barges;
- (n) refuelling facilities; and

- (o) hydrocarbon storage in underground formations and associated equipment (covered by CSA Z341 Series).

1.4

This Standard is intended to establish essential requirements and minimum standards for the design, construction, operation, and maintenance of oil and gas industry pipeline systems. This Standard is not a design handbook, and competent engineering judgment should be employed with its use.

Note: For steel pipe of grade higher than Grade 555, requirements in addition to those specified in this Standard might be needed. Matters that should be considered include joining, thermal aging effects during coating application, strain capacity (including cold bending), pressure testing, assessment of imperfections, and repair.

1.5

The requirements of this Standard are applicable to the operation, maintenance, and upgrading of existing installations; however, it is not intended that such requirements be applied retroactively to existing installations insofar as design, materials, construction, and established operating pressures are concerned.

1.6

Unless otherwise stated, to determine conformance with the specified requirements, it is intended that observed or calculated values be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding method of ASTM E29.

1.7

Where any requirements of this Standard are at variance with the requirements of other publications referenced in this Standard, it is intended that the requirements of this Standard govern.

1.8

It is not the intent of this Standard to prevent the development of new equipment or practices, or to prescribe how such innovations are to be handled.

1.9

In CSA standards, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; and “may” is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (nonmandatory) to define their application.

Commentary on CSA Z662-11, *Oil and gas pipeline systems*



Legal Notice

This document is provided by the Canadian Standards Association (CSA) as a convenience only.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

Intellectual property rights and ownership

As between CSA and the users of this document (whether it be in printed or electronic form), CSA is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA's and/or others' intellectual property and may give rise to a right in CSA and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CSA shall not be held responsible for identifying any or all such patent rights. Users of this document are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Use of this document

This document is being provided by CSA for informational and non-commercial use only. If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not use this document. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.

CSA Standards Update Service

Z662.1-11

June 2011

Title: *Commentary on CSA Z662-11, Oil and gas pipeline systems*

Pagination: **161 pages** (xii preliminary and 149 text), each dated **June 2011**

To register for e-mail notification about any updates to this publication

- go to **www.ShopCSA.ca**
- click on **E-mail Services** under **MY ACCOUNT**
- click on **CSA Standards Update Service**

The **List ID** that you will need to register for updates to this publication is **2421301**.

If you require assistance, please e-mail techsupport@csa.ca or call 416-747-2233.

Visit CSA's policy on privacy at www.csagroup.org/legal to find out how we protect your personal information.

CSA Special Publication

Z662.1-11
**Commentary on CSA Z662-11, Oil and
gas pipeline systems**



*Published in June 2011 by Canadian Standards Association
A not-for-profit private sector organization
5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6
1-800-463-6727 • 416-747-4044*

Visit our Online Store at www.ShopCSA.ca



The Canadian Standards Association (CSA) prints its publications on Rolland Enviro100, which contains 100% recycled post-consumer fibre, is EcoLogo and Processed Chlorine Free certified, and was manufactured using biogas energy.

*To purchase CSA Standards and related publications, visit CSA's Online Store at **www.ShopCSA.ca** or call toll-free 1-800-463-6727 or 416-747-4044.*

ISBN 978-1-55491-651-1

© Canadian Standards Association — 2011

All rights reserved. No part of this publication may be reproduced in any form whatsoever without the prior permission of the publisher.

Contents

Preface *xii*

0 Introduction 1

1 Scope 2

2 Reference publications and definitions 3

2.1 Reference publications 3

2.2 Definitions 9

3 Safety and loss management systems, integrity management programs, and engineering assessments for oil and gas industry pipeline systems 11

3.1 Safety and loss management system 11

3.3 Engineering assessments 11

3.3.4 Documentation 11

4 Design 11

4.1 General 11

4.2.1 General 11

4.2.2 Temperature 12

4.3 Design criteria 12

4.3.1 General 12

4.3.2 Class location assessment areas 12

4.3.3 Class location designations 14

4.3.4 Class location end boundaries 14

4.3.5 Pressure design for steel pipe — General 22

4.3.6 Pressure design for steel pipe — Design factor (F) 24

4.3.7 Pressure design for steel pipe — Location factor (L) and Table 4.2 Location factor for steel pipe 24

4.3.8 Pressure design for steel pipe — Joint factor (J); and Table 4.3 Joint factor for steel pipe 25

4.3.11 Pressure design for steel pipe — Wall thickness 25

4.3.12 Pressure design for components — General 26

4.3.13 Pressure design for components — Closures 26

4.3.18 Pressure design for components — Welded branch connections 27

4.3.19 Pressure design for components — Reinforcement of single openings 27

4.4 Valve location and spacing 27

4.5.2 Threaded joints 27

4.11 Cover and clearance 28

4.12 Crossings 28

4.12.1 General 28

4.12.2 Crossings of utilities 28

4.12.3 Crossings of roads and railways 28

4.13 Requirements for pipelines in proximity to electrical transmission lines and associated facilities 29

4.13.1 General 29

4.13.2 Effects on pipelines in proximity to high-voltage DC lines 29

4.14 Design of compressor stations over 750 kW and pump stations over 375 kW 29

4.14.3 Design of pump stations over 375 kW 29

4.15 Liquid storage in oil pipeline pump stations, tank farms, and terminals 30

4.15.1 Aboveground tanks over 4000 L 30

4.18 Pressure control and overpressure protection of piping 30

4.18.1 General 30

4.18.2 General design requirements for systems for pressure control and overpressure protection 31

- 4.18.3 Additional design requirements for pressure-relieving installations 31
- 4.20 Leak detection capability 31
- 4.22 Requirements for pipelines installed by horizontal directional drilling 31

5 Materials 31

- 5.1 Qualification of materials 31
- 5.2 Steel materials and gaskets 32
 - 5.2.1 Design temperatures — Steel materials 32
 - 5.2.2 Notch toughness requirements — Steel pipe 32
 - 5.2.3 Notch toughness requirements — Steel components 37
 - 5.2.6 Steel components — Flanges 38
 - 5.2.8 Steel components — Gaskets 38
 - 5.2.9 Steel components — Fittings 38
- 5.3 Other materials 39
 - 5.3.2 Polyethylene pipe and fittings 39
 - 5.3.3 Cast iron components 39
 - 5.3.5 Stainless steels 39
- 5.6 Reuse of materials 39
- 5.7 Records of materials 39

6 Installation 40

- 6.1 General 40
- 6.2 Activities on pipeline rights-of-way 40
 - 6.2.2 Pipe and components handling 40
 - 6.2.3 Bends and elbows in steel piping 40
 - 6.2.7 Backfilling 41
 - 6.2.11 Horizontal directional drilling (HDD) 41
- 6.3 Pipe surface requirements applicable to steel piping 41
 - 6.3.2 Field repair of gouges and grooves 41
 - 6.3.3 Dents 41
- 6.4 Electrical test leads on pipeline systems 42
- 6.5 Inspection 42
- 6.6 Precautions to avoid uncontrolled fires 42

7 Joining 43

- 7.2 Arc and gas welding — General 43
- 7.3 Arc and gas welding — Joint configurations 44
 - 7.3.1 Butt welds 44
 - 7.3.2 Fillet welds 44
- 7.5 Arc and gas welding — Materials 45
 - 7.5.2 Filler metals and fluxes 45
 - 7.5.3 Shielding gases 45
- 7.6 Arc and gas welding — Qualification of welding procedure specifications 45
 - 7.6.1 General 45
 - 7.6.2 Company approval 46
 - 7.6.3 Records 46
 - 7.6.4 Welding procedure specifications 46
 - 7.6.5 Essential changes for qualification of welding procedure specifications 48
- 7.7 Arc and gas welding — Testing for qualification of welding procedure specifications and qualification of welders 51
 - 7.7.1 Welding of test joints 51
 - 7.7.2 Testing of butt welds — General 51
 - 7.7.5 Testing of butt welds — Root-bend and face-bend tests 52
 - 7.7.7 Testing of fillet welds and branch connection welds — Root-break test 52

- 7.7.8 Testing of fillet welds and branch connection welds — Macrosection test 52
- 7.7.9 Tensile strength requirements for fillet welds and branch connection welds 52
- 7.7.10 Additional testing of partial-penetration butt welds 52
- 7.8 Arc and gas welding — Qualification of welders 52
 - 7.8.1 General 52
 - 7.8.2 Qualification range 53
 - 7.8.7 Records of qualified welders 54
- 7.9 Arc and gas welding — Production welding 54
 - 7.9.2 Alignment and root gap 54
 - 7.9.4 Use of line-up clamps — Butt welds 54
 - 7.9.13 Seal welding 54
 - 7.9.15 Preheating, interpass temperature control, controlled cooling, and stress relieving 55
- 7.10 Arc and gas welding — Inspection and testing of production welds 55
 - 7.10.1 General 55
 - 7.10.2 Visual inspection 55
 - 7.10.3 Mandatory nondestructive inspection 56
 - 7.10.4 Nondestructive inspection 56
 - 7.10.5 Destructive testing 56
- 7.11 Arc and gas welding — Standards of acceptability for nondestructive inspection 57
 - 7.11.1 General 57
 - 7.11.2 Weld crown 57
 - 7.11.3 Incomplete penetration of the root bead 58
 - 7.11.4 Incomplete fusion 58
 - 7.11.5 Internal concavity 58
 - 7.11.6 Undercut 58
 - 7.11.13 Spherical porosity 58
 - 7.11.14 Wormhole porosity 59
 - 7.11.17 Accumulation of imperfections 59
- 7.12 Arc and gas welding — Repair of welds containing repairable defects 59
 - 7.12.1 Partial-penetration butt welds 59
 - 7.12.3 Repair procedures 59
 - 7.12.4 Removal of arc burns in weld areas 59
 - 7.12.5 Removal of cracks in circumferential butt welds and in fillet welds 59
 - 7.12.6 Inspection of repairs 60
- 7.13 Arc and gas welding — Materials and equipment for radiographic inspection 60
 - 7.13.1 General 60
 - 7.13.2 Radiographic procedure 60
 - 7.13.4 Imaging media 60
 - 7.13.5 Screens 60
 - 7.13.6 Image quality indicators 60
 - 7.13.7 Comparator shims 61
- 7.14 Arc and gas welding — Production of radiographs 62
 - 7.14.1 Radiation source location 62
 - 7.14.3 Size of radiation field 62
 - 7.14.4 Location of image quality indicators 62
 - 7.14.5 Radiographic image identification markers 62
 - 7.14.6 Processing of radiographic images 63
 - 7.14.8 Radiographers 63
 - 7.14.9 Retention of radiographic records 63
- 7.15 Arc and gas welding — Ultrasonic inspection of circumferential butt welds in piping 63
 - 7.15.1 Methods 63
 - 7.15.2 Terminology 63
 - 7.15.3 General 63
 - 7.15.4 Equipment and supplies — General 64

- 7.15.5 Equipment and supplies — Additional requirements for mechanized inspection systems 64
- 7.15.6 Qualification of ultrasonic inspectors 64
- 7.15.7 Calibration 64
- 7.15.8 Inspection procedure for production welds 65
- 7.15.10 Standards of acceptability for ultrasonic inspection 65
- 7.15.11 Ultrasonic inspection reports and records 65
- 7.16 Mechanical interference fit joints 65
- 7.17 Welding on in-service piping 66
- 7.17.2 Fillet welds and branch connection welds on liquid-filled piping or flowing-gas piping and direct deposition welds on flowing-gas piping 66
- 7.17.3 Essential changes for qualification of welding procedure specifications intended for welding on in-service piping 66
- 7.17.5 Fillet welds and branch connection welds — Macroexamination and hardness tests 66
- 7.17.6 Qualification of welding procedure specifications and welders for direct deposition welds 67
- 7.17.7 Nondestructive inspection of welds made on in-service piping 67

8 Pressure testing 68

- 8.1 General 68
- 8.2 Safety during pressure tests 68
- 8.5 Test-head assemblies 68
- 8.6 Testing procedures and techniques 69
- 8.7 Piping to be operated at pressure greater than 700 kPa 70
- 8.7.1 Strength and leak tests 70
- 8.7.2 Pressure-test mediums 71
- 8.7.3 Minimum strength and leak test pressures 71
- 8.7.4 Maximum strength and leak test pressures 72
- 8.7.5 Duration of tests 73
- 8.7.6 Maximum operating pressures 73
- 8.7.7 Pressure-test measurements and records 74
- 8.8 Piping intended to be operated at pressures of 700 kPa or less 74
- 8.8.2 Pressure-test mediums 74
- 8.8.3 Minimum leak test pressures 74
- 8.8.5 Duration of tests 74
- 8.8.7 Pressure-test measurements and records 75
- 8.9 Leaks and ruptures during pressure tests 75
- 8.11 Cleaning and drying 75
- 8.12 Tie-ins of tested sections 76

9 Corrosion control 76

- 9.1 General 76
- 9.2 Selection of external protective coatings for buried or submerged piping 76
- 9.3 Application and inspection of external protective coatings for buried or submerged piping 76
- 9.8 Corrosion control test stations 77
- 9.9 Operation and maintenance of impressed current and sacrificial cathodic protection systems 77
- 9.10 Internal corrosion control 77
- 9.10.1 General 77
- 9.10.2 Mitigation 77
- 9.10.3 Monitoring 78

10 Operating, maintenance, and upgrading 78

- 10.1 General 78
- 10.2 Safety 78
- 10.2.8 In-service pipelines 78
- 10.2.10 Fluids containing H₂S 78

10.2.11	Carbon dioxide pipelines	78
10.3	Integrity of pipeline systems	78
10.3.1	Integrity of existing pipeline systems	78
10.3.3	Leak detection for liquid hydrocarbon pipeline systems	78
10.3.4	Leak detection for gas pipeline systems	79
10.3.5	Leak detection for oilfield water pipeline systems	79
10.3.8	Upgrading to a higher maximum operating pressure	79
10.3.9	Pressure testing existing piping	79
10.4	Records	79
10.4.1	General	80
10.4.2	Pipeline systems	80
10.5	Operating and maintenance procedures	80
10.5.3	Pipeline identification	80
10.5.4	Signs at stations and other facilities	81
10.5.5	Ground disturbance	81
10.5.6	Odorization	81
10.8	Crossings of existing pipelines	82
10.9	Operation and maintenance of facilities and equipment	82
10.9.2	Aboveground tanks and pressure vessels	82
10.9.5	Pressure-control, pressure-limiting, and pressure-relieving systems	82
10.10	Evaluation of imperfections	83
10.10.2	Corrosion imperfections in pipe	83
10.10.3	Gouges, grooves, and arc burns in pipe	84
10.10.4	Dents in pipe	84
10.10.7	Weld imperfections in mill seam welds and mill circumferential welds	84
10.11	Permanent repair methods	85
10.11.2	Grinding repairs	85
10.11.3	Piping replacements	85
10.11.4	Repair sleeves	85
10.11.5	Defect removal by hot tapping	86
10.11.6	Direct deposition welding	86
10.12	Temporary repair methods	87
10.13	Maintenance welding	89
10.13.2	In-service piping	89
10.14	Pipeline hot taps	89
10.16	Abandonment of piping	90

11 Offshore steel pipelines 90

11.2	Design — General	90
11.3	Design information	90
11.4	Design and load conditions	90
11.6	Environmental loads	91
11.6.5	Loads due to ice conditions and regional ice features	91
11.7	Design analysis	91
11.8	Design for mechanical strength	92
11.8.1	Design criteria for installation	92
11.8.2	Design criteria for pressure testing	92
11.8.3	Design criteria for operation	92
11.8.4	Determination of stresses	92
11.8.6	Strain-based design	93
11.19	Emergency shutdown valve	93
11.20	Materials	93
11.21	Installation	93
11.22	Welding	93

- 11.24 Pressure testing 93
- 11.24.1 General 93
- 11.24.3 Test pressure 93
- 11.24.4 Pressure-test medium 94
- 11.25 Corrosion control 94
- 11.25.2 External corrosion control — Protective coatings 94
- 11.26 Operating and maintenance 94

12 Gas distribution systems 94

- 12.1 General 94
- 12.2 Applicability 94
- 12.3 Gas containing hydrogen sulphide 95
- 12.4 Design 95
- 12.4.3 Polyethylene piping — Design limitations 96
- 12.4.7 Cover 96
- 12.4.9 Limitations on operating pressure — General 96
- 12.4.13 Distribution system valves — Valve location and spacing 96
- 12.4.15 Customers' meters and service regulators 96
- 12.4.17 Liquefied petroleum gas (LPG) pipeline systems 97
- 12.5 Materials 97
- 12.5.2 Polyethylene pipe, tubing, and components 97
- 12.6 Installation 98
- 12.6.2 Steel piping 98
- 12.6.3 Polyethylene piping — General 98
- 12.6.5 Polyethylene piping — Direct burial 98
- 12.6.12 Installation of service lines — Additional installation requirements for polyethylene service lines 98
- 12.6.13 Trenchless installations 98
- 12.7 Joining 99
- 12.7.2 Steel pipe joints and connections — Essential changes for qualification of welding procedure specification 99
- 12.7.12 Joints in copper pipe and tubing 99
- 12.7.13 Service line connections 99
- 12.8 Pressure testing 99
- 12.8.2 Piping within customers' buildings 99
- 12.8.3 Polyethylene piping 99
- 12.10 Operating, maintenance, and upgrading 99
- 12.10.5 Pressure-control, pressure-limiting, and pressure-relieving devices 99
- 12.10.6 Repair procedures for steel distribution pipeline systems 99
- 12.10.7 Maintenance welding 100
- 12.10.8 Squeezing of polyethylene and polyamide pipe for pressure-control purposes 100

13 Reinforced composite, thermoplastic-lined, and polyethylene pipelines 100

- 13.1 Reinforced composite pipelines 100
- 13.1.1 General 100
- 13.1.2 Design 101
- 13.1.4 Installation 102
- 13.1.5 Joining 103
- 13.1.6 Pressure testing 104
- 13.1.7 Operation 105
- 13.1.8 Pipeline repairs 105
- 13.2 Thermoplastic-lined pipelines 105
- 13.2.1 General 105
- 13.2.2 Design 105

- 13.2.3 Materials 106
- 13.2.4 Installation 106
- 13.2.5 Joining liners 107
- 13.2.6 Flange connections 107
- 13.2.7 Pressure testing 107
- 13.2.8 Operation and maintenance 108
- 13.3 Polyethylene pipelines 108
- 13.3.2 Design 108
- 13.3.4 Installation 109
- 13.3.5 Joining procedure and qualification 110
- 13.3.6 Joining personnel — Competency requirements 110
- 13.3.7 Joining inspection 111
- 13.3.8 Pressure testing 111
- 13.3.9 Operation and maintenance 111

14 Oilfield steam distribution pipelines 112

- 14.1 General 112
- 14.2 Design 112
- 14.2.1 General 113
- 14.2.2 Straight pipe under internal pressure 113
- 14.2.3 Pipe bends 114
- 14.2.5 Expansion, flexibility, and support 114
- 14.2.6 Corrosion and erosion allowances 114
- 14.3 Materials 114
- 14.3.1 General 114
- 14.3.2 Material testing 115
- 14.3.3 Pipe 115
- 14.3.4 Fittings other than bends; 14.3.5 Flanges; and 14.3.6 Valves 116
- 14.3.4 Fittings other than bends 116
- 14.3.5 Flanges 117
- 14.3.6 Valves 117
- 14.3.7 Transition pieces 117
- 14.3.8 Pipe bends — General 117
- 14.3.9 Pipe bends — Qualification and production 118
- 14.3.10 Piping supports 118
- 14.4 Joining 118
- 14.5 Pressure testing 119
- 14.5.1 General 119
- 14.5.2 Aboveground pipelines 119
- 14.5.3 Underground pipelines 120
- 14.6 Corrosion control 120
- 14.7 Commissioning and operation 120

15 Aluminum piping 120

- 15.2 Applicability 120
- 15.3 Design 121
- 15.3.1 Pressure design for aluminum pipe 121
- 15.3.2 Pressure design for components 121
- 15.3.4 Aluminum properties 121
- 15.4 Materials 121
- 15.4.1 Design temperatures 121
- 15.4.2 Notch toughness 121
- 15.5 Installation of aluminum piping 121
- 15.5.1 Bends and elbows 121
- 15.6 Joining 121

- 15.6.6 High-energy joining — Inspection and testing of high-energy joints for qualification of joining procedure specifications and personnel 121
- 15.6.8 High-energy joining — Inspection and testing of high-energy joints 122
- 15.8 Corrosion control 122
 - 15.8.1 Test lead attachment 122
 - 15.8.3 Corrosive medium 122
- 15.9 Operating, maintenance, and upgrading 122
 - 15.9.1 Evaluation of imperfections and repair of piping containing defects 122
 - 15.9.3 Pipeline hot taps 123
- 15.10 Sour service 123
 - 15.10.3 Exposure to iron sulphides 123

16 Sour service pipelines 123

- 16.1 General 123
- 16.2 Sour service — Specific definition 124
- 16.3 Design 126
 - 16.3.1 Design parameters 126
 - 16.3.2 Design information 126
 - 16.3.3 Stress design; 16.3.4 Anchors and restraints 126
- 16.4 Materials 126
 - 16.4.2 Material provisions; 16.4.3 Marking 126
 - 16.4.4 Nonferrous metals 126
- 16.5 Construction 127
 - 16.5.1 Deviations 127
 - 16.5.2 Records 127
 - 16.5.3 Inspection plan 127
- 16.6 Joining 127
 - 16.6.1 Carbon equivalent 127
 - 16.6.2 Change in carbon equivalent 127
 - 16.6.3 Butt welds of unequal thickness 127
 - 16.6.4 Weld hardness requirements 127
 - 16.6.5 Deposited weld metal composition limitations 128
 - 16.6.6 Alignment 128
 - 16.6.7 Preheat 128
 - 16.6.8 Backwelding 128
- 16.7 Corrosion and corrosion control 128
 - 16.7.1 Supplemental mitigation requirements 128
 - 16.7.2 Mitigation and monitoring program; 16.7.3 Design and sizing of pigs 128
- 16.8 Operation and maintenance 128
 - 16.8.1 Procedures 128
 - 16.8.3 Repair methods 129
 - 16.8.4 Hydrogen charging 129
 - 16.8.6 Change management process 129
 - 16.8.7 Changes in service conditions 129
- 16.9 Gas and multiphase pipelines 129
 - 16.9.2 Design 129
 - 16.9.3 Joining 130
- 16.10 Additional requirements for gas pipelines only 130
 - 16.10.2 Mechanical interference joints 130
 - 16.10.3 Start-up corrosion mitigation 130

17 Composite-reinforced steel pipelines 130

- 17.1 General 130
- 17.2 Applicability 131

- 17.4.3 Design pressure 131
- 17.4.6 Design temperature 131
- 17.5 Materials and manufacture 131
 - 17.5.1 Steel pipe 131
 - 17.5.2 Fibre-reinforced composite 131
 - 17.5.3 Composite-reinforced steel pipe manufacture 131
- 17.6 Installation 131
 - 17.6.1 Field bending; 17.6.2 Damage; and 17.6.3 Crossings 131
- 17.7 Joining 131
- 17.9 Corrosion control 132

Annexes

- B** — Guidelines for risk assessment of pipelines 133
- C** — Limit states design 134
- D** — Guidelines for in-line inspection of piping for corrosion imperfections 135
- E** — Recommended practice for liquid hydrocarbon pipeline system leak detection 136
- F** — Slurry pipeline systems 139
- H** — Pipeline failure records 140
- I** — Oilfield steam distribution pipelines — Alternate provisions 141
- J** — Recommended practice for determining the acceptability of imperfections in fusion welds using engineering critical assessment 142
- K** — Standards of acceptability for circumferential pipe butt welds based on fracture mechanics principles 144
- L** — Alternate or supplementary test methods for coating property and characteristics evaluation 148
- O** — Reliability-based design and assessment of onshore non-sour natural gas transmission pipelines 149

Figures

- 1** — Class location assessment area 13
- 2** — Critical dwelling unit for Class 2 location 15
- 3** — End boundary for Class 2 location 16
- 4** — End boundary for Class 3 location based on dwelling unit density 17
- 5** — End boundaries for Class 2 location based on dwelling unit density 18
- 6** — End boundaries for Class 2 location based upon a special feature 19
- 7** — Effect of special feature on end boundary for Class 2 location 20
- 8** — End boundaries for Class 4 location 22
- 9** — Flow chart for Table 10.1 88
- 10** — Sour service requirements clause applicability 125

Preface

This is the fourth edition of CSA Z662.1, *Commentary on CSA Z662-11*, Oil and gas pipeline systems. It supersedes the previous editions published in 2007, 2003, and 2001.

This Commentary is not part of the Standard and it has not been formally reviewed or approved by the Technical Committee responsible for CSA Z662. It does not provide formal interpretations of the Standard and should be viewed as an informal annotation of portions of the Standard, as compiled by those individuals involved in its development.

The purpose of the Commentary is to provide background information concerning certain clauses and requirements in the Standard, to provide information that can be of assistance to the reader in the understanding and implementation of such requirements, and to refer to research materials that were used during the formulation of some of the requirements in the Standard. The clause headings and numbers used in this Commentary correspond to those in the Standard; however, it should be noted that comments have not been provided for all the clauses of the Standard.

The Preface in the 2011 edition of the Standard highlights the most significant changes to the Standard, relative to the previous edition. All commentaries are the opinions of the respective authors and are not necessarily the opinions of CSA or its Technical Committee. The commentaries reflect the authors' selection of relevant material and do not include every change made throughout the history of the Standard.

It is expected that revisions to this Commentary will be made from time to time in order to incorporate information associated with new editions of the Standard.

June 2011

Notes:

- (1) Use of the singular does not exclude the plural (and vice versa) when the sense allows.
- (2) Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.
- (3) This publication was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.
- (4) To submit a request for interpretation of CSA Standards, please send the following information to inquiries@csa.ca and include “Request for interpretation” in the subject line:
 - (a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;
 - (b) provide an explanation of circumstances surrounding the actual field condition; and
 - (c) where possible, phrase the request in such a way that a specific “yes” or “no” answer will address the issue.Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are published in CSA’s periodical Info Update, which is available on the CSA website at <http://standardsactivities.csa.ca>.
- (5) CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee. To submit a proposal for change to CSA Standards, please send the following information to inquiries@csa.ca and include “Proposal for change” in the subject line:
 - (a) Standard designation (number);
 - (b) relevant clause, table, and/or figure number;
 - (c) wording of the proposed change; and
 - (d) rationale for the change.

Z662.1-11

Commentary on CSA Z662-11, Oil and gas pipeline systems

0 Introduction

0.1

CSA Z662 (hereafter in this Commentary also referred to as “the Standard” or “Z662”) presents a collection of requirements for oil and gas pipeline systems to describe what has been accepted as good practice from the standpoint of safety. The requirements have been developed over time, based upon industry experience and knowledge of the scientific principles involved. The first edition of the Standard was published in 1994 and it was developed by the amalgamation of the requirements that were previously contained in three CSA Standards: CAN/CSA-Z183-M90, *Oil pipeline systems*; CAN/CSA-Z184-M92, *Gas pipeline systems*; and CAN/CSA-Z187-M87 (R1992), *Offshore pipeline systems*.

0.2

Prior to 1967 for oil pipeline systems and 1968 for gas pipeline systems, the standards used for such systems in Canada were codes that were developed in the U.S. and published by the American Society of Mechanical Engineers as part of the ASME B31 series (i.e., ASME B31.4 for liquid hydrocarbons and ASME B31.8 for gas). The first editions of the CSA oil and gas pipeline standards were based extensively on the U.S. codes and, appropriately, many of their requirements were adopted by the Canadian publications without modification.

0.3

The requirements for aluminum pipe and aluminum piping systems were originally contained in CSA Z169-1964, *Code for Aluminum Pressure Piping*, which was later revised and published as CSA Z169-M1978, *Aluminum pipe and pressure piping systems*, with requirements more in harmony with the CSA Standards for oil and gas pipeline systems that were current at that time. The 1978 edition was reaffirmed in 1992 and again in 1998. CAN/CSA-Z245.6-M92, *Coiled aluminum line pipe and accessories*, was developed to incorporate and update the requirements for the manufacture of coiled aluminum line pipe that were contained in CSA Z169-M1978, and this coiled line pipe standard was later revised and published as CSA Z245.6-98, *Coiled aluminum line pipe and accessories*. Clause 15 of Z662 was developed to incorporate and update the requirements for the design, construction, operation, and maintenance of aluminum piping that were contained in CSA Z169-M1978 and to reference CSA Z245.6-98 for the material requirements for aluminum piping. Upon the completion of these two standardization activities, CSA Z169-M1978 (R1998) was withdrawn.

0.4

The clause headings and clause numbers used in this Commentary, except for those of this introductory clause, correspond to those used in the current Standard. Due to clause numbering changes in the current edition of CSA Z662, the referenced clause numbers in this Commentary do not necessarily correspond to the clause numbers in the previous editions of the Standard. Comments concerning specific clauses are sometimes presented under the heading of the broader clause number, rather than under the heading of the applicable subordinate clause number. Comments concerning figures and tables are sometimes presented under the heading of one of the clauses that refer to the figure or table, rather than under the heading of the applicable figure or table.

Notes:

- (1) In this Commentary, references to clauses, figures, tables, and annexes in the Standard will be in the format "Clause X.X, Figure X.X, Annex X, and Table X.X", generally without the phrase "of CSA Z662".
- (2) Figures in this Commentary are identified in the format "Figure X" in order to distinguish them from figure numbers in the Standard.

0.5

This Commentary is not part of the Standard and has not been formally reviewed or approved by the Technical Committee responsible for CSA Z662. Accordingly, this Commentary does not provide formal interpretations of the Standard. For formal interpretations of the Standard, see Note (5) in the Preface to the Standard.

1 Scope**1.1**

- The scope statement indicates which aspects and parts of pipeline systems and which service fluids are covered by the Standard.
- Carbon dioxide was added as a new service fluid in 1996. The definition of "gas" was changed in 1983 to accommodate the coverage of gaseous service fluids other than fuel gas and sour gas; however, until 1996, none had been added.
- The carbon dioxide pipelines that are covered are those onshore pipelines that are for use in enhanced oil recovery operations, involving the transportation of high-purity carbon dioxide from a suitable source to the injection site at an oil well. These pipelines were added to the Standard because it was considered that there had been sufficient experience with such an application to warrant their inclusion. Pure carbon dioxide is non-toxic and non-flammable; however, it has some specific characteristics that necessitated the addition of requirements specific to carbon dioxide pipeline systems. It should be noted that the definition of a carbon dioxide pipeline system permits the service fluid in such a pipeline to be other than pure carbon dioxide, so additional special requirements are in some cases appropriate.
- It should be noted that carbon dioxide might additionally be present in conventional pipelines as a component of a multiphase fluid or as a component of a fluid in a gas pipeline system. For such fluids, the conventional requirements applicable to the multiphase liquid or gas pipeline system continue to be appropriate.

1.2

The parts of pipeline systems that are included in the scope are listed here, and the pictorial representations in Figures 1.1, 1.2, 11.1 to 11.5, and 12.1 are intended to augment the information provided in Clauses 1.2 and 1.3. The figures are schematic and are intended to convey broad functions rather than specific details.

1.3

The parts of pipeline systems that are not included in the scope are listed here, along with a list of some related items that are beyond the defined limits of pipeline systems. Items that are within the defined limits of pipeline systems but are currently outside the scope of the Standard could be included in the scope in some future edition of the Standard, should the CSA Technical Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials and the Strategic Steering Committee on Petroleum and Natural Gas Industry Systems deem that such additions to the scope are appropriate.

1.4

The requirements in the Standard are considered adequate under conditions normally encountered, and requirements for abnormal or unusual conditions are not necessarily specifically addressed. Although in some instances in the Standard the requirements are necessarily quite prescriptive, the Standard is not a

design handbook and the exercise of competent engineering judgment is necessary when using the Standard. The exercise of competent engineering judgment is intended to recognize circumstances in which the essential requirements and minimum standards contained in the Standard may be insufficient. The note provides a specific instance of such circumstances, pertaining to the use of high-strength materials.

1.5

The design and construction requirements have been primarily developed with new pipelines and facilities in mind. Some practices that are reasonable and practicable during design and construction are in some cases not practical for an existing pipeline (e.g., the requirement to use piping that has proven notch toughness properties). The requirements in the Standard have been modified and generally made more stringent through the years, primarily to provide improved safety, but also to reflect technological improvements that have been made in the manufacturing processes used for pipe and components. Design requirements can be readily changed; however, the mechanical properties of in-service piping cannot. Where upgrading involves the replacement of existing piping with new piping, what was not practical for the old piping is practicable for the new piping.

Note: The terms “practicable”, “practical”, and “impractical” are not defined in the Standard because the ordinary dictionary meanings are intended, whereby “practicable” means capable of being effected or accomplished; “practical” means adapted to actual conditions; and “impractical” is the negative form of “practical”. The term “not practicable” is used in the Standard rather than the dictionary term “impracticable” to indicate the negative form of “practicable”. The similarity of the terms can lead to confusion for the reader unless the specific meanings are understood.

1.6

Clause 1.6 defines the basis for the numerical rounding practices used throughout the Standard. It is important to understand its effect when applied in conjunction with the number of digits indicated in the specific requirements of the standard.

1.7

A requirement in the Standard cannot be superseded by a less restrictive requirement in a referenced publication.

1.8

Practices are not included in the Standard until sufficient experience has been accumulated for them to become generally accepted as being good practices. Even new practices that are superior to established practices are not included in the Standard until the Technical Committee deems such new practices to be acceptable. It is not the intent of the Standard to prevent the development of new practices, and generally such practices would need to be approved for use by the regulatory authority having jurisdiction.

2 Reference publications and definitions

2.1 Reference publications

- Various documents published by a variety of organizations are included by reference and the specific publication dates and titles for the referenced publications are listed. Normally, the editions listed are the editions that were current at the time that the Standard was being edited prior to publication.
- The context of the reference being made should be known because typically only limited parts of the referenced publications are intended to apply.
- The Commentary on the Standard refers to the publications listed below. The list includes a number of withdrawn standards and other published industry documents, as well as superseded editions that are cited in describing the development of requirements and standards. The list also reflects the editions available during the development and production of CSA Z662-11; more recent editions could have been published since its publication date.

CSA (Canadian Standards Association)

B51-09

Boiler, pressure vessel, and pressure piping code

B137 Series-09

Thermoplastic pressure piping compendium

B149.1-10

Natural gas and propane installation code

CAN/CSA-C22.3 No. 6-M91 (R2009)

Principles and practices of electrical coordination between pipelines and electric supply lines

CAN/CSA-C22.3 No. 7-10

Underground systems

CAN/CSA-S471-04 (R2008)

General requirements, design criteria, the environment, and loads

W48-06

Filler metals and allied materials for metal arc welding

W59-03 (R2008)

Welded steel construction (metal arc welding)

W178.2-08

Certification of welding inspectors

Z169-M1978 (withdrawn)

Aluminum pipe and pressure piping systems

CAN/CSA-Z183-M90 (withdrawn)

Oil pipeline systems

CAN/CSA-Z184-M92 (withdrawn)

Gas pipeline systems

CAN/CSA-Z187-M87 (withdrawn)

Offshore pipeline systems

Z245.1-07

Steel pipe

Z245.6-06 (R2011)

Coiled aluminum pipe and accessories

Z245.11-09

Steel fittings

Z245.12-09

Steel flanges

Z245.15-09

Steel valves

Z245.20 Series-10
Plant-applied external coatings for steel pipe

Z662-11
Oil and gas pipeline systems

API (American Petroleum Institute)

5L-2007 (SPEC)
Line Pipe

15LE-2008 (SPEC)
Polyethylene (PE) Line Pipe

15S-2006 (RP)
Qualification of Spoolable Reinforced Plastic Line Pipe

17J-2008 (SPEC)
Unbonded Flexible Pipe

576-2009 (RP)
Inspection of Pressure-relieving Devices

620-2009 (STD)
Design and Construction of Large, Welded, Low-Pressure Storage Tanks

650-2005 (STD)
Welded Steel Tanks for Oil Storage

653-2009 (STD)
Tank Inspection, Repair, Alteration, and Reconstruction

1104-2005
Welding of Pipelines and Related Facilities

1156-1999 (PUBL)
Effects of Smooth & Rock Dents on Liquid Petroleum Pipelines

2610-2005 (STD)
Design, Construction, Operation, Maintenance & Inspection of Terminal and Tank Facilities

ASME (The American Society of Mechanical Engineers)

B16.5-2009
Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

B16.9-2007
Factory-Made Wrought Steel Buttwelding Fittings

B16.11-2009
Forged Fittings, Socket-Welding and Threaded

B16.20-2007
Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral-Wound, and Jacketed

B16.21-2005
Nonmetallic Flat Gaskets for Pipe Flanges

B16.34-2009

Valves Flanged Threaded and Welding End

B16.49-2007

Factory-Made, Wrought Steel, Buttwelding Induction Bends For Transportation and Distribution Systems

B31G-1991 (R2004)

Manual: Determining the Remaining Strength of Corroded Pipelines: Supplement to B31 — Pressure Piping

B31.1-2010

Power Piping

B31.3-2008

Process Piping

B31.4-2009

Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

B31.8-2010

Gas Transmission and Distribution Piping Systems

ASME Boiler and Pressure Vessel Code, 2009

ASTM International (American Society for Testing and Materials)

A53/A53M-07

Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106-07

Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A234/A234M-07

Standard Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A268/A268M-05a

Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service

A269-08

Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A312/A312M-09

Standard Specification for Seamless, Welded and Heavily Cold Worked Austenitic Stainless Steel Pipes

A333/A333M-05

Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service

A370-06

Standard Test Methods and Definitions for Mechanical Testing of Steel Products

D2290-04

Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method

D2837-08

Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D2992-06

Standard Practice for Obtaining Hydrostatic or Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3350-10

Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

E21-09

Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials

E747-04

Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E1025-05

Standard Practice for Design, Manufacture, and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E1290-08

Standard Test Method for Crack-Tip Opening Displacement (CTOD) Fracture Toughness Measurement

E1316-10c

Standard Terminology for Nondestructive Examinations

AWS (American Welding Society)

A5.1-2004

Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

BSI (British Standards Institution)

BS 7448-1:1991

Fracture mechanics toughness tests. Method for determination of K_{Ic} , critical CTOD and critical J values of metallic materials

BS 7448-2:1997

Fracture mechanics toughness tests. Method for determination of K_{Ic} , critical CTOD and critical J values of welds in metallic materials

BS 7910:2005

Guide on methods for assessing the acceptability of flaws in metallic structures

PD 6493:1991

Guidance on methods for assessing the acceptability of flaws in fusion welded structures

(previous edition published in 1980 as *Guidance on Some Methods for the Derivation of Acceptance Levels for Defects in Fusion Welded Joints*)

CAPP (Canadian Association of Petroleum Producers)

2009-0014

Mitigation of Internal Corrosion in Sweet Gas Gathering Systems

CCME (Canadian Council of Ministers of the Environment)

CCME-EPC-LST-71E (1994)

*Environmental Code of Practice for Aboveground Storage Tank Systems Containing Petroleum Products***CGA (Canadian Gas Association)**

OCC-1-2005

*Recommended Practice for the Control of External Corrosion on Buried or Submerged Metallic Piping Systems***DNV (Det Norske Veritas)**

DNV-OS-F101-2010

*Submarine Pipeline Systems***ESI (Electricity Supply Industry)**

98-2-1979

*Ultrasonic Probes: Medium Frequency, Miniature Shear Wave, Angle Probes***Government of USA**US Code of Federal Regulations, Title 49, Part 192, *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards* (referenced as 49 CFR 192)**ISO (International Organization for Standardization)**

5579:1998

*Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules***MSS (Manufacturers Standardization Society)**

SP-25-2008

*Standard Marking System for Valves, Fittings, Flanges and Unions***NACE International (National Association of Corrosion Engineers)**

ANSI/MR0175/ISO 15156-2009

Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production

RP0175-95

Control of Internal Corrosion in Steel Pipelines and Piping Systems

RP0675-88 (withdrawn)

Control of External Corrosion on Offshore Steel Pipelines

TM0177-2005

*Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in the H₂S-Environments***NFPA (National Fire Protection Association)**

30-2003

*Flammable and Combustible Liquids Code***NRCC (National Research Council Canada)***National Fire Code of Canada, 2005***PPI (Plastic Pipe Institute)**

TR-3/2010

Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe