NATIONAL FIRE PROTECTION ASSOCIATION
The leading information and knowledge resource on fire, electrical and related hazards

AGENDA

NFPA Technical Committee on National Fuel Gas Code (NFG-AAA)
NFPA 54 Pre-First Draft Meeting (A2026)

March 12th and March 15th (if needed), 2024
1:00 p.m. – 4:00 p.m. (Eastern)

Web/Teleconference
To join the meeting, please contact Sarah Caldwell (scaldwell@nfpa.org)

1. **Call to order.** Franklin Switzer.
2. **Introductions.** See committee roster attached.
3. **Chair report.** Franklin Switzer.
4. **Staff liaison report.** Alex Ing.
5. **Previous meeting minutes.** October 2022 Pittsburgh Minutes. See attached.
6. **NFPA 54**
   a. **Discussion Items**
      i. **NFPA 54 Manual of Style**
      ii. **Hydrogen Blending**
      iii. **Renewable fuel impact on pipe sizing and equipment operation**
      iv. **Common venting of other then Category 1 Appliances**
      v. **New piping system materials**
      vi. **Pressure limits inside buildings**
      vii. **Fuel gas detection**
      viii. **Leak testing**
      ix. **Underground piping and understructure requirements of piping systems**
      x. **Regulator venting**
7. **Other Business.**
8. **Future meetings.**
9. **Adjournment.**

Address List No Phone

02/27/2024
Alex Ing
NFG-AAA

National Fuel Gas Code

Franklin R. Switzer, Jr. **SE** 8/5/2009
Chair **NFG-AAA**
S-afe, Inc.
P.O. Box 404
Big Flats, NY 14814-0404

Luis Romeo Escobar **IM** 04/02/2020
Recording Secretary (NV) **NFG-AAA**
American Gas Association (AGA)
400 N. Capitol Street NW
#450
Washington, DC 20001

Thomas J. Andrews **SE** 4/3/2019
Principal **NFG-AAA**
TR Energy Consulting
6568 East 100 North
Kokomo, IN 46901

Michael W. Bethany **SE** 04/02/2020
Principal **NFG-AAA**
Gas Piping Safety Services (GPSS)
1088 Brookpoint Drive
Medina, OH 44256

Jonathan Brania **RT** 12/08/2015
Principal **NFG-AAA**
UL LLC
12 Laboratory Drive
Research Triangle Park, NC 27709-3995
Alternate: Travis F. Hardin

James P. Brewer **IM** 01/01/1990
Principal **NFG-AAA**
Rooftop Safety USA LLC
205 Otter Cove
Deltaville, VA 23043
National Chimney Sweep Guild

Charles R. Brown **SE** 08/11/2020
Principal **NFG-AAA**
Advanced Engineering Investigations Corporation (AEI)
8197 W. Brandon Drive
Littleton, CO 80125
Alternate: Zachary John Jason

Ted Bukowski **RT** 04/12/2022
Principal **NFG-AAA**
Gas Technology Institute (GTI)
1700 South Mt. Prospect Road
Des Plaines, IL 60018

James Bunsey **RT** 11/29/2023
Principal **NFG-AAA**
Propane Education and Research Council
1140 Connecticut Avenue NW
Suite 1075
Washington, DC 20036

Chris Dale Byers **U** 12/06/2019
Principal **NFG-AAA**
Duke Energy/Piedmont Natural Gas
1712 Three and Twenty Road
Easley, SC 29642

Jeremy R. Conjura **U** 08/08/2019
Principal **NFG-AAA**
Corning Incorporated
11773 Lower Drive
Corning, NY 14830
Alternate: Joshua P. Askey

Gerald G. Davis **IM** 8/9/2012
Principal **NFG-AAA**
Williams Meter Company
7930 Cryden Way, Suite 100
Forestville, MD 20747

Marvin Evans **RT** 12/07/2021
Principal **NFG-AAA**
CSA Group
178 Rexdale Boulevard
Toronto, ON M9W 1R3 Canada
Alternate: Colin Moorhouse

Pennie L. Feehan **M** 10/20/2010
Principal **NFG-AAA**
Pennie L. Feehan Consulting
611 S. Palm Canyon Drive
#7226
Palm Springs, CA 92264
Copper Development Association Inc.

John P. Foley M 08/23/2023
Principal NFG-AAA
Van-Packer Company
302 Mill Street
Buda, IL 61314

Alberto Jose Fossa SE 10/4/2001
Principal NFG-AAA
NEWEN Creative Engineering
Rua Caropá 72
Vila Madalena, SP 05447-000 Brazil
NFPA Latin American Section

Sean P. George L 08/23/2023
Principal NFG-AAA
Steamfitters LU 449-Pittsburgh
400 Bocktown Cork Road
Aliquippa, PA 15001
United Assn. of Journeymen & Apprentices of the Plumbing & Pipe Fitting Industry

Enrique Trejo Gonzalez E 04/04/2017
Principal NFG-AAA
International Association of Plumbing & Mechanical Officials (IAPMO)
Senior Code Development Administrator
4755 East Philadelphia Street
Ontario, CA 91761
International Association of Plumbing & Mechanical Officials
Alternate: Hugo Aguilar

Mike Gorham IM 1/1/1991
Principal NFG-AAA
Northwest Gas Company
1608 NW 4th Street
Grand Rapids, MN 55744
National Propane Gas Association
Alternate: Bruce J. Swiecicki

Gregg A. Gress E 04/15/2004
Principal NFG-AAA
Retired-International Code Council ICC PEI, LLC
8448 S. 100W
North Judson, IN 46366
Alternate: LaToya Carraway

Roger W. Griffith U 08/03/2016
Principal NFG-AAA
Griffith Engineering
P.O. Box 702
Jefferson City, TN 37760

Paul Gugliotta IM 03/20/2023
Principal NFG-AAA
National Grid
103 Bay Avenue
Building Operations 3, 1st Floor
Hixville, NY 11801

Steen Hagensen M 1/16/1998
Principal NFG-AAA
ENERVEX
1685 Bluegrass Lakes Parkway
Alpharetta, GA 30004
Alternate: Young Han

Peter T. Holmes E 9/30/2004
Principal NFG-AAA
Maine Fuel Board
35 State House Station
Augusta, ME 04333-0035

Nasir Hussain SE 04/02/2020
Principal NFG-AAA
Combustion Science & Engineering, Inc.
8940 Old Annapolis Road
Suite L
Columbia, MD 21045

Zuhair M. Ibrahim SE 04/02/2020
Principal NFG-AAA
Ibrahim & Associates LLC
22647 Ventura Boulevard #432
Woodland Hills, CA 91364

James Kendzel U 08/08/2019
Principal **NFG-AAA**
American Supply Association
1200 N. Arlington Heights Road
#150
Itasca, IL 60143

Jeff Kleiss M 04/03/2019
Principal **NFG-AAA**
Lochinvar
300 Maddox Simpson Parkway
Lebanon, TN 37090
Air-Conditioning, Heating, & Refrigeration Institute (AHRI)
Alternate: Thomas Deary

Marek Kulik E 08/17/2015
Principal **NFG-AAA**
Technical Standards and Safety Authority
Fuels Safety Program
345 Carlingview Drive
Toronto, ON M9W 6N9 Canada

Brian G. Kurtz M 08/23/2023
Principal **NFG-AAA**
Carrier Corporation
7310 W. Morris Street
Indianapolis, IN 46231

Theodore C. Lemoff SE 10/18/2011
Principal **NFG-AAA**
TLemoff Engineering
13821 Callisto Avenue
Naples, FL 34109-0574
Alternate: John R. Puskar

Timothy McNulty M 08/08/2019
Principal **NFG-AAA**
RM Manifold Group Inc., dba US Draft Company
220 South Sylvania Avenue
Suite 207
Fort Worth, TX 76111

William J Murray SE 8/8/2019
Principal **NFG-AAA**
Self
30 Foothill Road
Elmira, NY 14903

Tung Nguyen M 04/11/2018
Principal **NFG-AAA**
Emerson Automation Solution
3200 Emerson Way
McKinney, TX 75071

Andrea Lanier Papageorge IM 7/23/2008
Principal **NFG-AAA**
Southern Company Gas
Manager, Codes and Standards
10 Peachtree Place
Location 1367
Atlanta, GA 30309
American Gas Association
Eastern
Alternate: Ralph Euchner

George Ragula SE 12/07/2021
Principal **NFG-AAA**
RagulaTech
161 Sun Valley Way
Morris Plains, NJ 07950

Brett Readout I 08/23/2023
Principal **NFG-AAA**
EMC Insurance Companies
717 Mulberry Street
Des Moines, IA 50309
Alternate: Kody N. Daniel

Phillip H. Ribbs L 10/23/2003
Principal **NFG-AAA**
PHR Consultants
206 Cypress Park
Santa Cruz, CA 95060
California State Pipe Trades Council

April Dawn Richardson E 12/08/2015
Principal **NFG-AAA**
Railroad Commission of Texas
1701 North Congress Avenue
PO Box 12967
Austin, TX 78711
Alternate: Kent Lowery Thompson

Jon Scott Russell U 12/02/2020
Principal **NFG-AAA**
Clearwater Gas System
777 Maple Street
Clearwater, FL 33755
American Public Gas Association

Brian Ryglewicz M 08/08/2019
Principal **NFG-AAA**
Chimney Design Solutions Inc.
649 Lafayette Avenue, Suite 3
Hawthorne, NJ 07506

Joel E. Sipe SE 08/24/2021
Principal **NFG-AAA**
Exponent, Inc.
3824 Ardley Avenue
Oakland, CA 94602

Jason Stanek IM 04/05/2016
Principal **NFG-AAA**
Metropolitan Utilities District (MUD)
3100 South 61st Avenue
Omaha, NE 68106
American Gas Association
Southwest

Andy John Thielen SE 04/03/2019
Principal **NFG-AAA**
Engineering Systems Incorporated (ESI)/Crane Engineering
2355 Polaris Lane North
Suite 120
Plymouth, MN 55447
Alternate: Matthew W. Wilber

Calvin Timmons M 04/12/2022
Principal **NFG-AAA**
Willbanks & Associates, Inc.
735 Buffalo Run
Missouri City, TX 77489

Christopher Wagner IM 08/10/2022
Principal **NFG-AAA**
AmeriGas Propane
1540 Harvey Lane
Pottstown, PA 19465

Brian K. Williams M 12/07/2021
Principal **NFG-AAA**
Ferguson Enterprises
6603 Fosque Lane
Hayes, VA 23072

Ted A. Williams SE 12/07/2021
Principal **NFG-AAA**
Natural Gas Direct, LLC.
1101 South Forest Drive
Arlington, VA 22204

Jean L. McDowell IM 04/03/2019
Voting Alternate **NFG-AAA**
McDowell Owens Engineering Inc.
740 East 13th Street
Houston, TX 77008
Texas Propane Gas Association

Hugo Aguilar E 04/03/2019
Alternate **NFG-AAA**
International Association of Plumbing & Mechanical Officials (IAPMO)
5001 East Philadelphia Street
Ontario, CA 91761
Principal: Enrique Trejo Gonzalez

Joshua P. Askey U 08/23/2023
Alternate **NFG-AAA**
Corning CET
220 Bridge Street, #101
Corning, NY 14830
Principal: Jeremy R. Conjura

LaToya Carraway E 12/07/2021
Alternate **NFG-AAA**
International Codes Council ICC PEI, LLC
3507 Birchwood Drive
Hazel Crest, IL 60429
Principal: Gregg A. Gress

Kody N. Daniel **I** 04/08/2015
Alternate **NFG-AAA**
American Property Casualty Insurance Association (APCI)
/EMC Insurance Companies
717 Mulberry Street
Des Moines, IA 50309-3810
Principal: Brett Readout

Thomas Deary **M** 11/29/2023
Alternate **NFG-AAA**
Air-Conditioning, Heating, & Refrigeration Institute (AHRI)
2311 Wilson Boulevard
Suite 400
Arlington, VA 22201
Principal: Jeff Kleiss

Ralph Euchner **IM** 12/07/2018
Alternate **NFG-AAA**
PSNC Energy
800 Gaston Road
Gastonia, NC 28506
American Gas Association
Eastern
Principal: Andrea Lanier Papageorge

Young Han **M** 08/23/2023
Alternate **NFG-AAA**
Enervex, Inc.
1685 Bluegrass Lakes Parkway
Alpharetta, GA 30004
Principal: Steen Hagensen

Travis F. Hardin **RT** 04/03/2019
Alternate **NFG-AAA**
UL LLC
12 Laboratory Drive
Research Triangle Park, NC 27709-0163
Principal: Jonathan Brania

Zachary John Jason **SE** 08/24/2021
Alternate **NFG-AAA**
Advanced Engineering Investigations Corporation (AEI Corporation)
8197 West Brandon Drive
Littleton, CO 80125
Principal: Charles R. Brown

Colin Moorhouse **RT** 12/07/2021
Alternate **NFG-AAA**
CSA Group
178 Rexdale Boulevard
Toronto, ON M9W 1R3 Canada
Principal: Marvin Evans

John R. Puskar **SE** 08/17/2017
Alternate **NFG-AAA**
Prescient Technical Services LLC
2078 Ridge Road
Hinckley, OH 44233
Principal: Theodore C. Lemoff

Bruce J. Swiecicki **IM** 1/1/1995
Alternate **NFG-AAA**
National Propane Gas Association
19530 Southfield Lane
Tinley Park, IL 60487
National Propane Gas Association
Principal: Mike Gorham

Kent Lowery Thompson **E** 12/07/2018
Alternate **NFG-AAA**
Railroad Commission Of Texas
Po Box 12967
Austin, TX 78711-2967
Principal: April Dawn Richardson

Matthew W. Wilber **SE** 03/05/2012
Alternate **NFG-AAA**
ESi
2355 Polaris Lane North
Suite 120
Plymouth, MN 55447
Principal: Andy John Thielen

Alex Ing 2/9/2019
Staff Liaison **NFG-AAA**
National Fire Protection Association
One Batterymarch Park
Quincy, MA 02169

Minutes

National Fuel Gas Code (NFGC) Committees
NFPA 54 Second Draft Meeting (Annual 2023)
Kimpton Hotel Monaco
Pittsburgh, Pennsylvania
October 24-25, 2022

1. **Call to Order**: Chair, Frank Mortimer (EMC Insurance), called the meeting to order at 8 am on October 24, 2022.
2. **Introductions**: Attendees introduced themselves and identified their affiliation. See Meeting Attendance Attachment A.
3. **Chair Report**: Mr. Mortimer welcomed attendees and provided an overview of the meeting. The agenda was approved as distributed in the July 28, 2022 email.
4. **Staff Liaison Report**: Alex Ing (NFPA) and Luis Escobar (AGA) provided an overview of the remaining steps in the harmonized development process and the revision cycle schedule.
5. **Approval of Committee Meeting Minutes**: The minutes from September 12-22, 2021 (virtual, MS Teams) were approved with the following revision: John Puskar (Prescient Technical Services) chaired the Combustion Air TG.
6. **NFGC Second Draft**:
   a. **Review of Public Comments and Committee Inputs.** The technical committee reviewed the Public Comments and Committee Inputs and developed Second Revisions as necessary. The committee actions that result in a Second Revisions will be the standing action on the letter ballot. Approved actions from the letter ballot will be incorporated into the Second Draft Report, to be posted on www.nfpa.org/54 and www.aga.org/nfgc along with the Second Draft Report and Report on Public Comments.

   b. **Task Group Reports**:

      i. **Combustion Air and ACH**. The Task Group presented Public Comment 33 (considerations for impact on the accuracy and usefulness of a draft test), Public Comment 34 (method for converting ACH50 to ACHnat), and Public Comment 35 (Annex G.5.2 method of draft testing). to address the issue of how to measure draft and known infiltration rate formula from 9.3.2.2. The task group has been discharged with thanks.

      ii. **Industrial Coverage**. The task group provided a report. The task group was reconstituted to continue work.

      iii. **Multi-Requirements and Exceptions**. The Task Group presented their recommendations for removing exception language and breaking out multi-requirement sections throughout the NFGC. The recommendations were split onto one global revision for split outs and another global revision for exceptions. The task group was reconstituted to continue work. Diane Jakobs steps down as chair; Enrique Gonzalez and Gregg Gress have joined.

c. **Presentations.** The committee heard presentations from the following individuals.

   i. PEX-AL-PEX Piping. Devinder Grewal, Marco Versace. 15 minutes. Presentation attached (Attachment B). See below for additional information

d. **New task groups.** The following task groups were appointed to work subsequent to the meeting:

   i. Flammable Air Gas Mixture Task Group. TG Chair: Franklin Switzer. Members: Ted Lemoff, Bill Murray. The task group will look at the requirements concerning flammable air gas mixtures and updating.

7. **Other Business**:

   a. **PEX-AL-PEX Piping Reports and Presentations**

      i. The following material was made available to committee members in their discussions regarding PEX-AL-PEX piping (PC 40 through PC 45)

         i. PEX-AL-PEX Code Compliance Review ESi Report distributed by Ted Lemoff: https://www.safebuildingmaterials.com/pex-al-pex_report
         ii. Studying the Effect of Lightning Strikes on PEX-AL-PEX Hoses distributed by Andrew Klein: https://www.hpac.com/fire-smoke/article/21252926/studying-the-effect-of-lightning-strikes-on-pexalpex-hoses
         iii. Fire Performance Evaluation of PEX-AL-PEX Specimens Installed in Gypsum Stud Cavity Tested in General Accordance with ASTM E119-20, *Standard Test Methods for Fire Tests of Building Construction and Materials* distributed by Andrew Klein (See Attachment C)
         iv. ISO 17484-1: 2014 *Plastics piping systems — Multilayer pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar (500 kPa) — Part 1: Specifications for systems* (Available for purchase at https://www.iso.org/standard/57597.html)
         v. ISO 17484-2: 2009 *Plastics piping systems — Multilayer pipe systems for indoor gas installations — Part 2: Code of pratice* (Available for purchase at https://www.iso.org/standard/46115.html)

   b. **New Technology for Leaking Gas Piping**: George Ragula (RagulaTech) brought up the topic of new technology that repairs leaking fuel gas piping in situ (intended for leaking joints). The Committee tasked Mr. Ragula with developing material for review in the next development cycle.

   c. **Hydrogen Fuel Gas Mixtures**: The committee discussed upcoming research and work being done to add some quantity of hydrogen to fuel gas mixtures and the potential changes

8. **Future Meetings**: There is no plan to meet again in person for the 2024 NFGC development cycle. AGA and NFPA staff will contact the committee if this changes. This was the final meeting of this committee for the revision cycle. Public Inputs for the next edition are expected to close June 2024. A meeting notification will be posted at www.nfpa.org/54next when the next meeting is scheduled.
9. **Adjournment**: The meeting was adjourned at 3:30 pm on October 25, 2022.

Attachment A – Combined Daily Attendance

#	FIRST	LAST	COMPANY	24-Oct	25-Oct
1	Eric	Adair	Hearth, Patio & Barbecue Association	x	
2	Hugo	Aguilar	International Assoc. of Plumbing & Mech. Officials		
3	Thomas	Andrews	Michigan Technical Education Center	x	x
4	Michael	Bethany	Gas Piping Safety Service		x
5	Jonathan	Brania	Underwriters Laboratories:	x	x
6	James P.	Brewer	National Chimney Sweep Guild	x	x
7	Daniel	Buuck	National Assoc. of Home Builders	x	x
8	Charles	Brown	Advanced Engineering Investigations		x
9	Ted	Bukowski	Gas Technology Institute	x	x
10	Christopher	Byers	American Gas Association	x	x
11	Bob	Carpenter	Viega	x	
12	LaToya	Carraway	International Code Council		x
13	William	Chapin	Professional Code Consulting		
14	Jeremy	Conjura	Corning Incorporated	x	x
15	Shannon	Corcoran	Staff - AGA	x	x
16	Kody	Daniel	EMC Insurance Companies	x	x
17	John	Doucette	State of CT - Office of State Fire Marshal		
18	Gerald	Davis	Williams Metering Company	x	x
19	Luis	Escobar	Staff - AGA	x	x
20	Ralph	Euchner	American Gas Association	x	
21	Marvin	Evans	CSA Group	x	x
22	Pennie	Feehan	Copper Development Association	x	x
23	Alberto	Fossa	NEWEN Creative Engineering		
24	Richard	Gilbert	Texas Propane Gas Association	x	x
25	Edward	Glende	Gastite	x	
26	Enrique	Gonzalez	International Assoc. of Plumbing & Mech. Officials	x	x
27	Michael R.	Gorham	The National Propane Gas Association	x	x
28	Gregg	Gress	International Code Council	x	x
29	Devinder	Grewal	Fathom Engineering - Consultant - Ferguson	x	
30	Paul	Gugliotta	American Gas Association	x	x
31	Roger	Griffith	Griffith Engineering	x	x
32	Steen	Hagensen	ENERVEX, Inc.		
33	Travis	Hardin	Underwriters Laboratories:		
34	Peter	Holmes	Maine Fuel Board	x	x
35	Nasir	Hussain	Combustion Science & Engineering	x	x
36	Zuhair	Ibrahim	Ibrahim & Associates	x	

#	FIRST	LAST	COMPANY	24-Oct	25-Oct
37	Alex	Ing	Staff - NFPA	x	x
38	Diane	Jakobs	Air Conditioning, Heating, and Refrigeration Institute	x	x
39	Zachary	Jason	Advanced Engineering Investigations		
40	Andy	Kireta	Copper Development Association		
41	James	Kendzel	American Supply Association	x	x
42	Andrew	Klein	Consultant - Ferguson	x	
43	Jeff	Kleiss	Air Conditioning, Heating, and Refrigeration Institute	x	x
44	Vladimir	Kochkin	National Assoc. of Home Builders		
45	Marek	Kulik	Technical Standards and Safety Authority		
46	Theodore	Lemoff	Self - T Lemoff Engineering - OmegaFlex on some issues	x	x
47	Joshua	Makatura	Corning Incorporated		
48	Jean	McDowell	Texas Propane Gas Association		
49	Timothy	McNulty	US Draft Company (RM Manifold Group)	x	x
50	Colin	Moorhouse	CSA Group		
51	Frank	Mortimer	EMC Insurance Companies	x	x
52	William	Murray	Self	x	x
53	Tung	Nguyen	Emerson Automation Solutions	x	
54	Andrea	Papageorge	American Gas Association	x	x
55	John	Puskar	Technical Services LLC	x	x
56	George	Ragula	RagulaTech	x	x
57	Brett	Readout	EMC Insurance Companies	x	x
58	Phillip	Ribbs	PHR Consultants	x	x
59	April Dawn	Richardson	Railroad Commission of Texas		
60	Jon	Russell	American Public Gas Association	x	x
61	Brian	Ryglewicz	Chimney Design Solutions		x
62	Jonathan	Sargeant	Self - OmegaFlex	x	x
63	Joel	Sipe	Exponent		
64	Eric C.	Smith	International Fire Marshals Association	x	x
65	Stan	Smith	American Gas Association	x	x
66	Jason	Stanek	American Gas Association	x	x
67	Phillip	Stephens	Air Conditioning, Heating, and Refrigeration Institute	x	x
68	Bruce	Swiecicki	The National Propane Gas Association	x	x
69	Franklin	Switzer	S-afe, Inc.	x	x
70	Andy	Thielen	Crane Engineering	x	x
71	Kent	Thompson	Railroad Commission of Texas	x	x
72	Calvin	Timmons	Willbanks & Associates		
73	Robert	Torbin	Air Conditioning, Heating, and Refrigeration Institute	x	x

#	FIRST	LAST	COMPANY	24-Oct	25-Oct
74	Marco	Versace	Ferguson Enterprises	x	
75	Christopher	Wagner	AmeriGas Propane	x	x
76	Cory	Weiss	Field Controls	x	x
77	Matt	Wilber	Crane Engineering		
78	Matthew	Williams	Association of Home Appliance Manufacturers		
79	Brian	Williams	Ferguson Enterprises	x	x
80	Ted	Williams	Natural Gas Direct	x	
81	Chris	Wolfe	Ray Murray Inc.	x	x
				59	53

NFPA Attendance (Technical Committee Members Only)

✓	**Mortimer, Frank**	Chair	American Property Casualty Insurance
✓	**Escobar, Luis**	Recording Secretary	American Gas Association
✓	**Andrews, Thomas**	Principal	Michigan Training & Education Center
✓	**Bethany, Michael**	Principal	Gas Piping Safety Services (GPSS)
✓	**Brania, Jonathan**	Principal	UL LLC
✓	**Brewer, James**	Principal	National Chimney Sweep Guild
✓	**Brown, Charles**	Principal	Advanced Engineering Investigations
✓	**Bukowski, Ted**	Principal	Gas Technology Institute (GTI)
✓	**Byers, Chris**	Principal	Duke Energy/Piedmont Natural Gas
✓	**Conjura, Jeremy**	Principal	Corning Incorporated
✓	**Davis, Gerald**	Principal	Williams Meter Company
✓	**Evans, Marvin**	Principal	CSA Group
✓	**Feehan, Pennie**	Principal	Copper Development Association Inc.
	Fossa, Alberto	Principal	NFPA Latin American Section
✓	**Gilbert, Richard**	Principal	Texas Propane Gas Association
✓	**Gonzalez, Enrique**	Principal	International Association of Plumbing &
✓	**Gorham, Mike**	Principal	National Propane Gas Association
✓	**Gress, Gregg**	Principal	International Code Council
✓	**Griffith, Roger**	Principal	Griffith Engineering
	Hagensen, Steen	Principal	ENERVEX
✓	**Holmes, Peter**	Principal	Maine Fuel Board

COMMITTEE ON NATIONAL FUEL GAS CODE

✓	**Hussain, Nasir**	Principal	Combustion Science & Engineering, Inc.
✓	**Ibrahim, Zuhair**	Principal	Ibrahim & Associates LLC
✓	**Jakobs, Diane**	Principal	Air-Conditioning, Heating, & Refrigeration
✓	**Kendzel, James**	Principal	American Supply Association
✓	**Kleiss, Jeff**	Principal	Air-Conditioning, Heating, & Refrigeration
	Kulik, Marek	Principal	Technical Standards and Safety Authority
✓	**Lemoff, Theodore**	Principal	TLemoff Engineering
✓	**McNulty, Timothy**	Principal	RM Manifold Group Inc., dba US Draft
	Murray, William	Principal	Self
✓	**Nguyen, Tung**	Principal	Emerson Automation Solution
✓	**Papageorge, Andrea**	Principal	American Gas Association
✓	**Ragula, George**	Principal	RagulaTech
✓	**Ribbs, Phillip**	Principal	California State Pipe Trades Council
	Richardson, April	Principal	Railroad Commission of Texas
✓	**Russell, Jon**	Principal	American Public Gas Association
✓	**Ryglewicz, Brian**	Principal	Chimney Design Solutions Inc.
	Sipe, Joel	Principal	Exponent, Inc.
✓	**Smith, Eric**	Principal	International Fire Marshals Association
✓	**Stanek, Jason**	Principal	American Gas Association
✓	**Switzer, Franklin**	Principal	S-afe, Inc.
✓	**Thielen, Andy**	Principal	Engineering Systems Incorporated (ESI)
	Timmons, Calvin	Principal	Willbanks & Associates, Inc.
✓	**Wagner, Christopher**	Principal	AmeriGas Propane
✓	**Williams, Brian**	Principal	Ferguson Enterprises
✓	**Williams, Ted**	Principal	Natural Gas Direct, LLC.
✓	**Carpenter, Bob**	Voting Alternate	Viega, LLC.
	Aguilar, Hugo	Alternate	International Association of Plumbing &
✓	**Carraway, LaToya**	Alternate	International Code Council
✓	**Daniel, Kody**	Alternate	American Property Casualty Insurance
✓	**Euchner, Ralph**	Alternate	American Gas Association

ASC Z223 NFPA 54

COMMITTEE ON NATIONAL FUEL GAS CODE

	Hardin, Travis	Alternate	UL LLC
	Jason, Zachary	Alternate	Advanced Engineering Investigations
	Makatura, Joshua	Alternate	Corning Incorporated
	McDowell, Jean	Alternate	Texas Propane Gas Association
	Moorhouse, Colin	Alternate	CSA Group
✓	**Puskar, John**	Alternate	Prescient Technical Services LLC
✓	**Stephens, Phillip**	Alternate	Air-Conditioning, Heating, & Refrigeration
✓	**Swiecicki, Bruce**	Alternate	National Propane Gas Association
✓	**Thompson, Kent**	Alternate	Railroad Commission Of Texas
✓	**Torbin, Robert**	Alternate	Air-Conditioning, Heating, & Refrigeration
	Wilber, Matthew	Alternate	ESi
✓	**Ing, Alex**	Staff Liaison	National Fire Protection Association

HPAC Engineering®

FIRE / SMOKE

Studying the Effect of Lightning Strikes on PEX-AL-PEX Hoses

LAB TESTS: Researchers compared the effects with those from similar strikes on common CSST hoses and black iron pipes.

By **ZUHAIR IBRAHIM**, Ph.D., P.E., and **ASIF SHAKEEL**, Ph.D., Ibrahim & Associates

Lightning strikes occur during extreme weather conditions and can be the cause of severe damage. In 2021, lightning strikes caused $1.3 billion In U.S. homeowners claim payouts[1]. In the past two decades, lightning strike research has progressed in both experimental and simulation fields. This has been driven by increased awareness of the risks associated with climate uncertainty and the frequency of extreme events.

This study looked at the effect of direct lightning strikes on pipes and flexible hoses, typically used in building gas plumbing, with special focus on cross-lined polyethylene (PEX) hoses. PEX, a type of flexible plastic, is increasingly being used in construction as a conduit for gas and water transport. It is a material derived from polyethylene (common plastic) through a process involving radiation treatment. PEX tubing made its way into the U.S. market in the 1980s, beginning with its use in radiant floor heating systems, and finding numerous applications thereon.

PEX-AL-PEX tubing goes further and sandwiches a layer or aluminum between two layers of PEX (Fig. 1), increasing the sturdiness and resilience of the tube. Among the PEX tubing, PEX-AL-PEX has the highest-pressure rating, and through a memory feature, the ability to retain its shape.

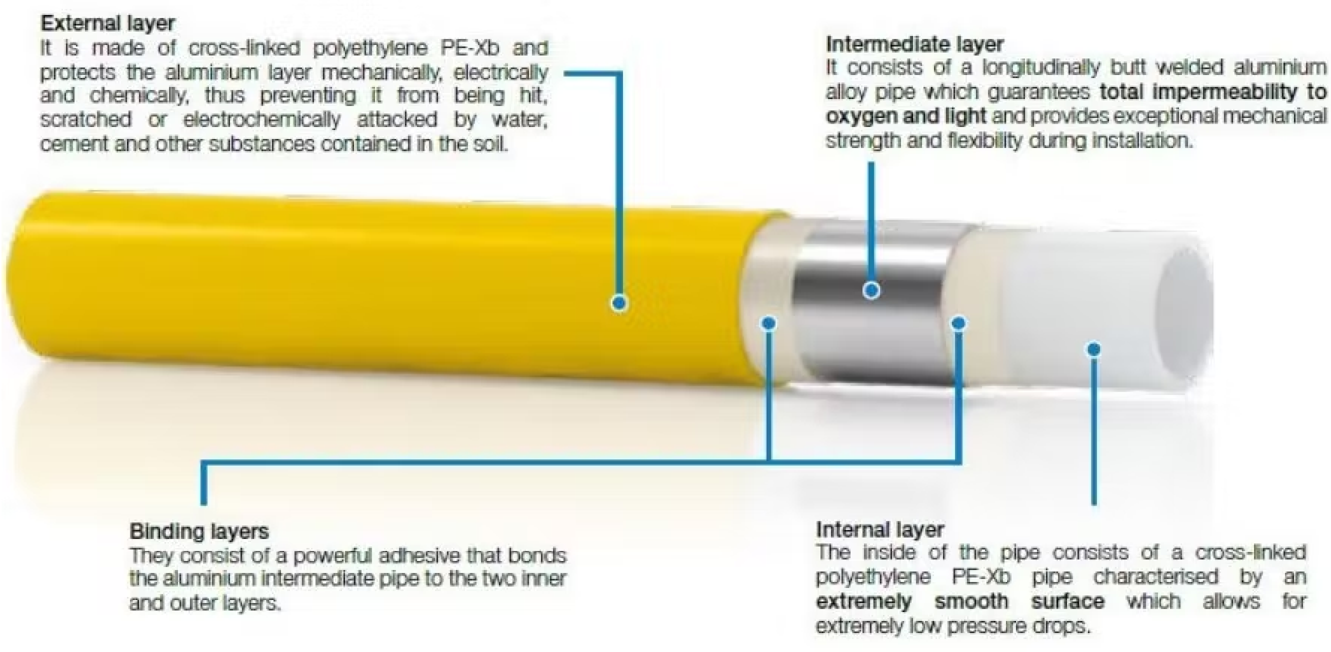
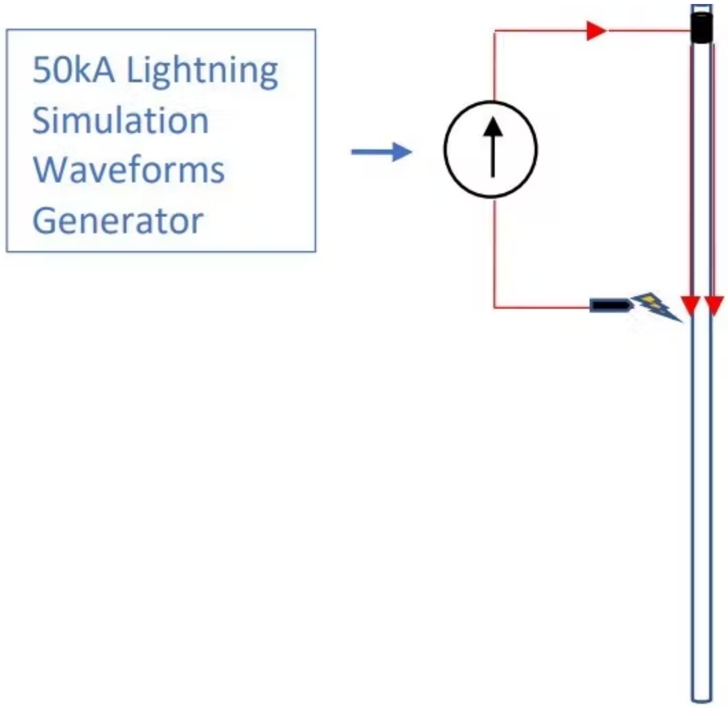
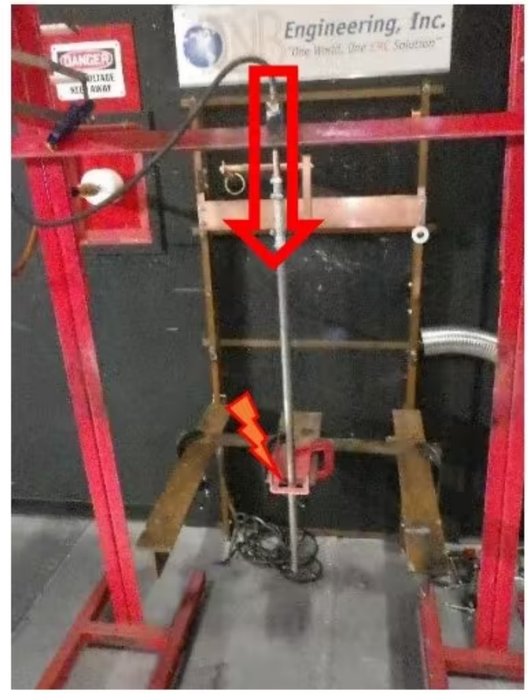


Fig. 1: Jones Stephens Brand Pex-Al-Pex (Construction).

Our study used a random, 45 to 50 samples from two types of corrugated stainless steel tubing (CSST) pipes -- regular CSST (non-arc resistant jacket) and Arc-resistant jacket CSST; black iron pipes, and Pex-Al-Pex pipes. Each sample was tested using the setup shown using the below schematic for the test setup. These tests were conducted at the DNB Laboratories, Fullerton, CA. The current enters the sample at one end and exits to a ground point located 1/8-inch from the sample. The simulated lightning occurs near the ground metal bar, with the potential damage accompanying it.





All the pipes and hose assemblies were subjected to high-current tests of the type described in Clifford, et al, *Lightning Simulation and Testing,*[2] most relevant to lightning strike testing. Tests were consistent with the guidelines of LC1027, and MIL-STD- 1757A, and were designed to examine damage from high currents on the hose and pipe assemblies. The high current testing included Component A at 50 KA, which is greater than 83.67%[3,4] (Fig. 2), of the lightning strike intensities in the distribution of the naturally occurring lightning strikes. Component A has action integral greater than 55000 A2-S, Component B with an average current of 2000 amps and 10 coulombs of charge transfer, and Component C with a minimum charge transfer of 27 coulomb. The shape of the test waveforms, adapted from Sun, et al.,[5] are shown here.

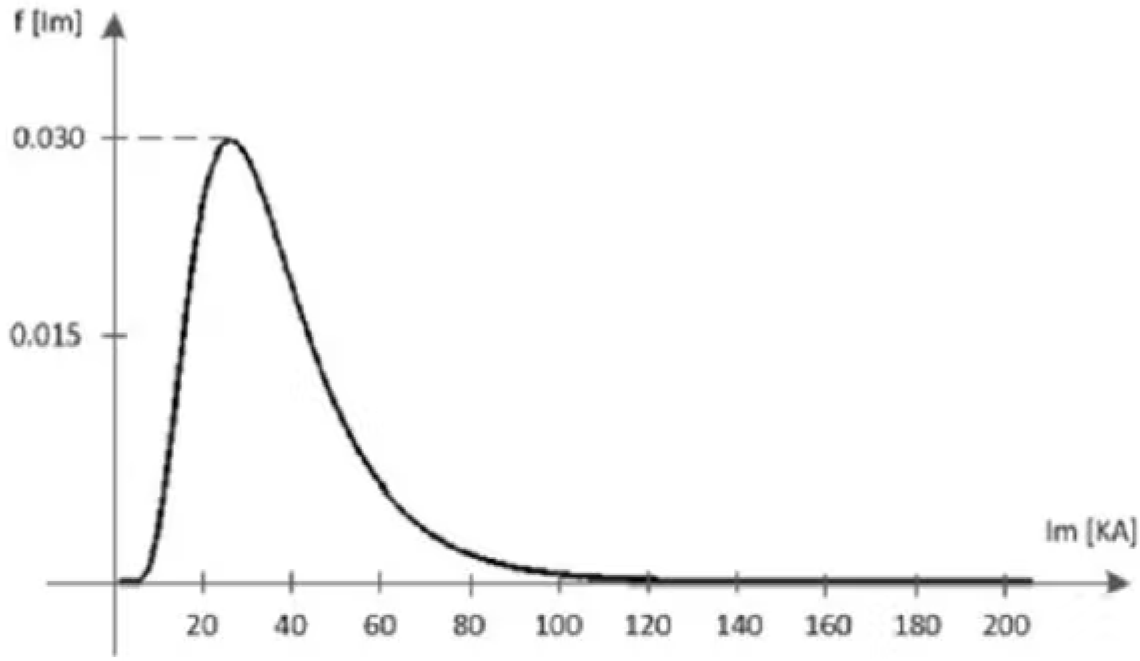


Fig. 2: Probability density function for maximum current.

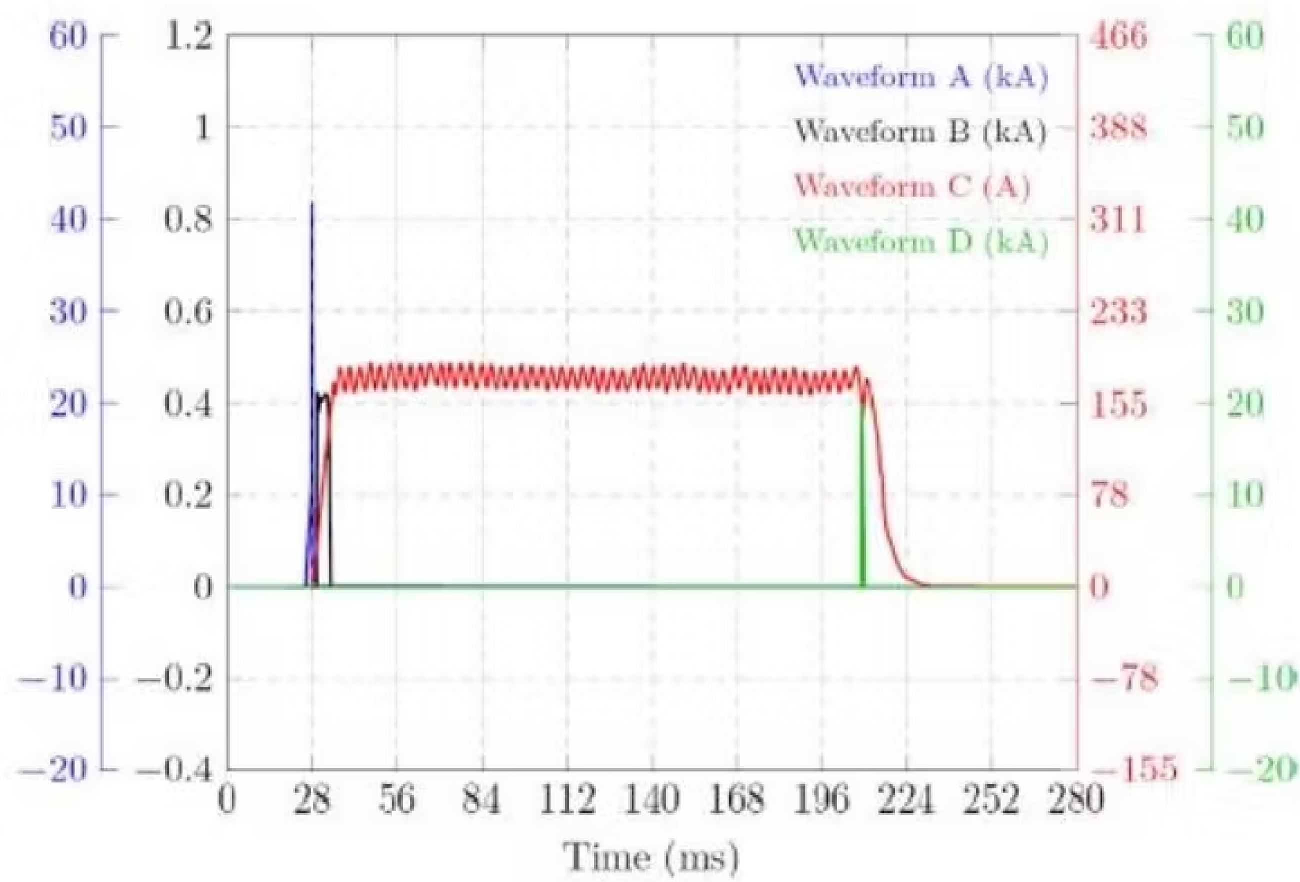


Fig. 3: Continuous test waveforms A, B, C, and D redrawn from Sun, et al.

Following the lightning test, each sample which did not exhibit a clear failure (hole), was subjected to a pressurized leak test using compressed air. Black iron pipes, and Pex-Al-Pex hoses were tested at 60 psi. The CSST hoses (regular and arc resistant jacket) were tested to 25 psi which was their maximum rating. The test duration was 10 minutes in accordance with the guidelines of NFPA 546 . At the conclusion of the tests, the following results were recorded:

Item	Number Tested	Number Failed
Pex-Al-Pex	45	0
Black Iron	45	0
Regular CSST (non-arc resistant jacket)	45	45
Arc resistant jacket CSST	45	45

Figure *4* Post Test Visual Assessment – JS Pex-Al-Pex

Conclusion

Figure 5 Post Test Visual Assessment – Regular CSST

The report presents the results and findings from an extensive experimental lightning strike study of common piping and CSST used by the gas industry. The high current value chosen as 50kA, which is 60% higher than the mean value of a direct lightning strike. The study examined the response and damage to two common CSST types, and black iron pipe. The results were analyzed using pairwise using hypothesis test of two sample proportions at a significance of 0.05. The statical tests confirm that Pex-Al-Pex hoses have a failure rate which is significantly lower than comparable CSSTs. Pex-Al-Pex hoses had a pass rate similar to those of black iron pipes. Pex-Al-Pex hoses were found to withstand up to 50 kA without exhibiting noticeable damage and were capable of holding pressure at 60 psi.

The hypothesis *Test for Two-Sample Proportions* was conducted pairwise among the listed pipes, to statistically compare the above test results (Appendix A), at the standard significance level of 0.05 (95% confidence level). It shows that the Pex-Al-Pex and Black Iron pipe are not distinguishable, while, with at least 95% confidence, both Pex-Al-Pex and Black Iron pipe in general would have failure rates significantly lower than the CSST pipes, hence a higher resilience to direct lightning strikes, as far as the test conditions and samples are representative of the true conditions and populations, respectively.

Figure 6 Post Test Visual Assessment – Arc Resistant Jacket CSST

#####

Figure 7 Post Test Visual Assessment – Black Iron Pipe

[1] Insurance Information Institute - https://www.iii.org/press-release/triple-i-lightning-caused-13-billion-in-ushomeowners-claim-payouts-in-2021-supply-chain-issues-exacerbate-losses-062122 ;

[2] D.W. Clifford, K. E. Crouch and E. H. Schulte, "Lightning Simulation and Testing," in IEEE Transactions on Electromagnetic Compatibility, vol. EMC-24, no. 2, pp. 209-224, May 1982, doi: 10.1109/TEMC.1982.304032;

[3] K. Berger, R.B. Anderson, H. Kröninger, Parameters of Lightning Flashes," Electra, No. 41, 1975 23–37;

[4] P. Venturino et al. "Pipeline failures due to lightning", Engineering Failure Analysis 64 (2016) 1–12;

[5] Sun J, Yao X, Tian X, Chen J, Wu Y. Damage characteristics of CFRP Laminates subjected to multiple lightning current strike. Appl Compos Mater 2018;26:745–62;

[6] NFPA 54-2021 8.1.4 and 8.1.4.3.

Acknowledgment

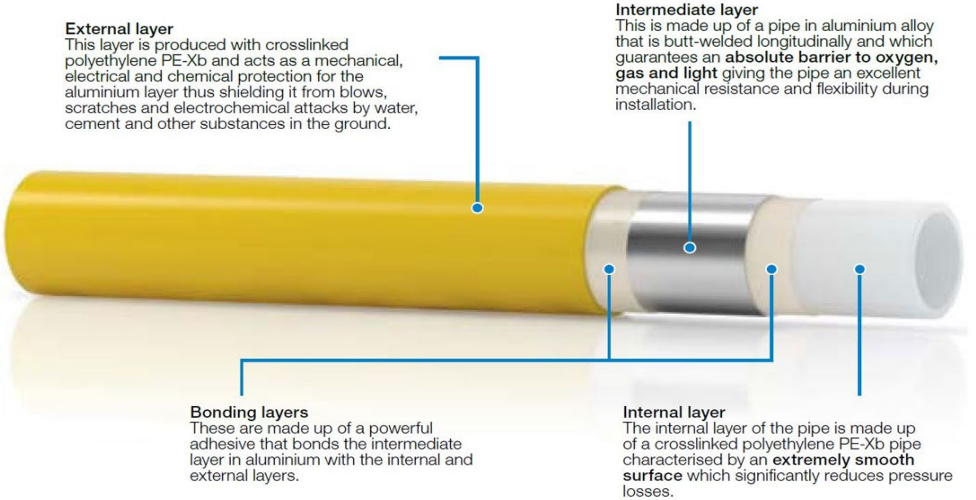
This research was supported by Ferguson Enterprises, LLC. The experiments and the analysis were independently conducted, and the authors have no financial interest in any commercial tubing used in the study.

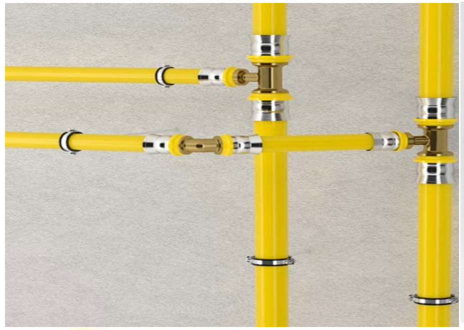
NFPA-54 MEETING
PEX-AL-PEX GAS PIPING SYSTEM

Date: October 24-25, 2022

Product Overview

- Standard Product in Europe, Australia, and South America for the past 15 years – 300 Mio feet installed yearly *
- ICC ES Report certifies compliance with IFGC, IRC, UPC
- Certified to ISO 17484 and ASTM F1281 standards
- Manufacturer audited twice annually by ICC
- Simplified installation process reduces risks of human error
- Flexible piping system reduces the number of joints required
- Improved lightning performance designed into system (bonding not required)
- Edges not sharp after cutting, potential reduction of injuries from skin lacerations and reduction of bloodborne pathogen





Brass fitting, 2 o-rings, stainless steel sleeve

* Report from KWD-Globalpipe Research Institute , April 2020

TESTING AS PER ICC-ES PMG-1588 CERTIFICATE

Passed all tests for ASTM F1281 (PEX-Aluminum-PEX Standard Specification for pressure pipe water and gas applications) and ISO 17484 (Metal-Plastic Multilayer pipes and brass fittings for conveying combustible gases):

- Adhesion Test (no delamination)
- Tensile Strength
- Burst Pressure
- Sustained Pressure
- Thermocycling
- Gas compatibility
- Tensile load on joint
- Joint resistance to crushing and impact resistance of the joint
- Repeating bending resistance

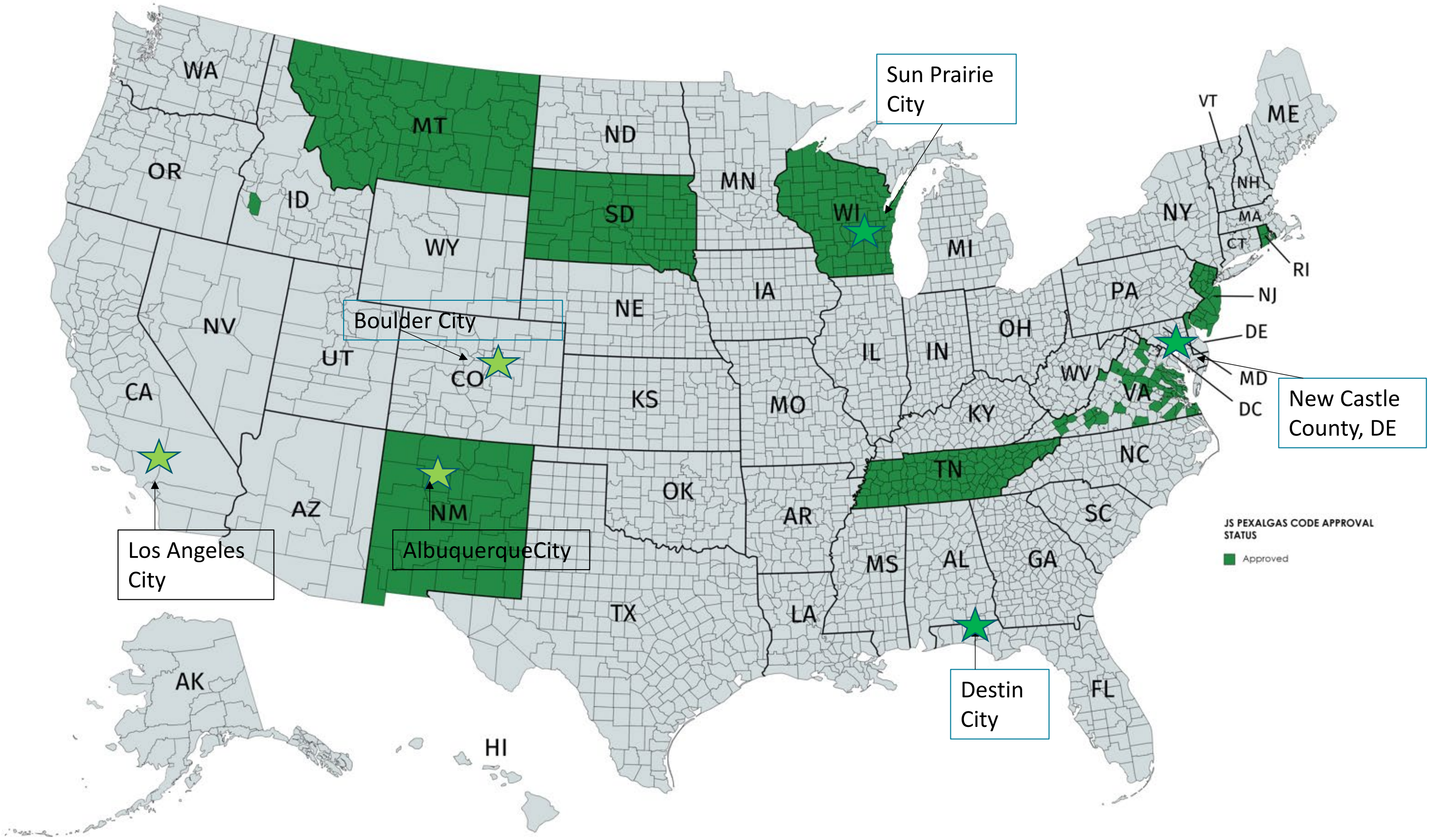
-Statistical study on Lightning strike simulation performed at 3rd party consultant showed that:

PEX-AL-PEX in general would have failure rates significantly lower than the CSST and Copper pipes, hence less damage to piping system and leakage of gas due to lightning strikes**

** Report from Ibrahim & Associates, September 2022

APPROVALS AS ALTERNATIVE MATERIAL

- Already approved as alternative material in the following states:
  Montana, New Mexico, South Dakota, Wisconsin, New Jersey, Tennessee, and Rhode Island
- Approved in several municipalities, including Cities of Los Angeles, CA, Albuquerque, NM, Destin, FL



FIRE RESISTANCE TESTED AS PER ASTM E119 AT SWRI

The system was tested at Southwest Research Institute according to the ASTM E119 standard for fire resistance test

ASTM E119: Standard test method for fire tests of building constructions and materials

<u>Test 1</u>

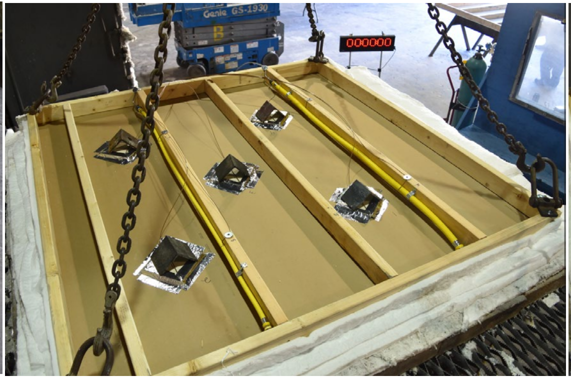
- System held pressure for approximately 31 minutes when installed behind a 5/8-inch gypsum wall.

At 30 minutes the temperature was ~1,550°F according to the temperature curve of the E119 standard

<u>Test 2</u>

- System held pressure for approximately 17 minutes when installed behind a ½-inch gypsum wall

At 17 minutes the temperature was ~1,400°F according to the temperature curve of the E119 standard ***



7. Control

7.1 *Fire-Resistance Test:*

7.1.1 *Time-Temperature Curve:*

7.1.1.1 The furnace temperatures shall be controlled to follow the standard time-temperature curve shown in Fig. 1. The points on the curve that determine its character are:

1000°F (538°C)	at 5 min
1300°F (704°C)	at 10 min
1550°F (843°C)	at 30 min
1700°F (927°C)	at 1 h
1850°F (1010°C)	at 2 h
2000°F (1093°C)	at 4 h
2300°F (1260°C)	at 8 h or over

*** Report from Southwest Research Institute , October 2020

ESi

PEX-AL-PEX
Code Compliance Review

ESi Project No: 89455

2355 Polaris Lane North, Suite 120
Plymouth, MN 55447-4777

PEX-AL-PEX Review

ESi Project No: 89455

Report Prepared for:

Mr. Luke Marchant
Safe Building Materials Association of America
1717 North Akard Street
Suite 170
Dallas, TX 75201

Submitted by:

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

May 13, 2022

Andrew J. Thielen, P.E.
Senior Managing Consultant
Texas P.E. | No. 109571 | Expires: September 30, 2022

Date

Technical Review by:

May 13, 2022

Matthew W. Wilber, CGE, CFEI
Senior Staff Consultant

Date

Phone: 763-557-9090 | Fax: 763-557-0710 | Toll Free: 866-596-3994
www.engsys.com

CONTENTS

SUMMARY

This report involves the evaluation of a product known as PEX-AL-PEX with respect to its proposed use as an interior fuel gas piping system. Engineering Systems, Inc. (ESi) was engaged on March 22, 2022 by Mr. Luke Marchant to investigate and evaluate applicable existing standards, codes and product test results to assess compliance and potential safety concerns regarding the use of PEX-AL-PEX for fuel gas. This report, prepared at the request of Mr. Luke Marchant, represents the results of our analysis performed to date.

I am a Mechanical Engineer with ESi. My area of expertise is Mechanical systems used in buildings including fuel gas systems and Liquefied Petroleum Systems. I received a Bachelor of Science degree in Mechanical Engineering from the University of North Dakota (1985). I am a licensed Professional Engineer (PE) in the State of Minnesota, Texas, and several other states. I have over 37 years of experience in the following areas: building construction, primarily in terms of HVAC, piping, and plumbing systems – which includes humidity control, district heating and cooling systems, and humidifier installations in residential, commercial, and industrial settings. ESi currently charges $335 per hour for my services.

BASIS FOR THIS REPORT

This report, and the findings, opinions and conclusions stated throughout, are based on the education, training, and experience of the author, as well as on the analysis and review of materials that have been conducted in this matter to date. The opinions and conclusions are stated to a reasonable degree of engineering and scientific certainty.

BACKGROUND

Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX), in the United States, *is typically* expected to meet the requirements of the ASTM F1281-17 Standard Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe. This is recognized as an international standard that covers pipe intended primarily for use in water distribution systems. PEX-AL-PEX has been in use for more than twenty years in hydronic heating and other water distribution systems, including potable water systems. More recently, certain manufacturers of this product are promoting its use as an interior fuel gas piping system. At least one manufacturer has received a product certification from the International Code Council Evaluation Service (ICC-ES) for the use of their PEX-AL-PEX product as an interior gas pipe and fitting system.

ANALYSIS

Fuel gas piping in the US, in most jurisdictions, is required to comply with existing related code requirements. The most widely adopted codes related to the use of fuel gas in buildings are the National Fuel Gas Code (NFPA 54/ANSI Z223.1) and the International Fuel Gas Code (IFGC). These codes were reviewed as a part of this evaluation. Interior fuel gas piping has, historically, been primarily comprised of steel, copper, or a combination thereof. The PEX-AL-PEX product is not identified in the fuel gas codes as an acceptable alternative for piping material or fittings.

NFPA 54 contains the following statements regarding materials:

Equivalency. The provisions of this code are not intended to prevent the use of any material, method of construction, or installation procedure not specifically prescribed by this code[1]…

and in the section covering acceptable piping materials and joining methods:

Other Materials. Material not covered by the standards specifications listed herein shall meet the following criteria:

1. Be investigated and tested to determine that it is safe and suitable for the proposed service
2. Be recommended for that service by the manufacturer
3. Be acceptable to the authority having jurisdiction[2].

The **IFGC** contains the following statements and requirements regarding materials and methods:

Other materials. Material not covered by the standards specifications listed herein shall be investigated and tested to determine that it is safe and suitable for the proposed service, and, in addition, shall be recommended for that service by the manufacturer and shall be *approved* by the code official.[3]

Alternative materials, methods, appliances, and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. An alternative material or method of construction shall be *approved* where the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety[4].

Since the mid 1990's, corrugated stainless steel (CSST) gas piping systems have become increasingly popular. When CSST was first introduced in the US, although it had been in use elsewhere, there was some reluctance by code authorities to accept a system not covered by a nationally recognized safety standard.

A project had been initiated to develop a suitable standard and after extensive research, testing, development, and public comment, the first edition of the standard was approved by ANSI in 1991 and harmonized with safety standards in Canada in 1994. CSST products acceptable for use in the US and Canada are certified to ANSI/CSA LC-1, CSA 6.26 Standard for Fuel gas piping systems using corrugated stainless-steel tubing, which addresses the materials, fittings, components, compatibility with other materials, safety issues, and installation requirements.

Another, more recently introduced, type of product used in fuel gas piping systems is known as press-connect fittings and valves. The products accepted for use in this category are certified to the

---

[1] NFPA 54, ANSI Z223.1, National Fuel Gas Code – 2018 Clause 1.4
[2] NFPA 54, ANSI Z223.1, National Fuel Gas Code – 2018 Clause 5.6.1.3
[3] IFGC, International Fuel Gas Code – 2015 Clause 403.3
[4] IFGC, International Fuel Gas Code – 2015 Clause 105.2

requirements in CSA/ANSI LC-4, CSA 6.32 Standard for Press-connect fittings and valves for use in fuel gas distribution systems.

As mentioned previously, at least one PEX-AL-PEX product has received product certification by ICC-ES for use as an interior fuel gas piping system. Specifically, the ICC-ES product certification identifies compliance with ASTM F1281-2017, Standard Specification for Cross-linked Polyethylene/Aluminum/ Cross-linked Polyethylene (PEX-AL-PEX) Pressure Pipe and AS 4176.8-2010, Metal-Plastic Multilayer Pipes and Brass Fittings for Conveying Combustible Gases for System in Pressure Up to 5 bar. The same product certification indicates compliance with several editions of the International Fuel Gas Code (IFGC), International Residential Code (IRC) and the Uniform Plumbing Code (UPC). Neither the ASTM F1281 nor AS 4176.8 are referenced in the fuel gas codes.

Standards

While certain PEX-AL-PEX products may have been determined by the ICC-ES to be in compliance with the ASTM F1281 Standard, the scope of this standard states "The pipe covered by this specification is intended for use in potable water distribution systems for residential and commercial applications, water service, underground irrigation systems, and radient (sic) panel heating systems, baseboard, snow- and ice-melt systems, and gases that are compatible with the composite pipe and fittings." No other mention of the word gas or gases exists in this standard and there is no content that would address the safety issues related to fuel gas systems. This standard is not referenced by NFPA 54 or the IFGC and appears to be irrelevant in the evaluation of this product as a fuel gas piping system.

The ICC-ES product certification also indicates compliance with AS 4176.8. This is a standard in Australia and is not referenced by, or considered to be harmonized with, the fuel gas codes or gas equipment standards in the US. We have not reviewed the content of this standard, as it would not be recognized by jurisdictions in the US.

No nationally recognized US standard has been identified which would comprehensively address the evaluation, certification, and use of PEX-AL-PEX as a fuel gas piping system. Additionally, in the US, this product is clearly unique in terms of its potential use as a fuel gas piping system and it seems appropriate that it be subject to scrutiny, rigorous testing, and safety standard development similar to that which occurred during introduction of CSST gas piping systems and press-connect fittings and valves.

Codes

The ICC-ES product certification indicates compliance with the IFGC, IRC and UPC. Sections in 403 of the IFGC state "Aluminum-alloy tubing shall comply with ASTM B 210 or ASTM B 241" and "the use of alloy 5456 is prohibited". Based on available information, it is unclear what alloys are used in the PEX-AL-PEX products or whether they comply with that section. Section 404.17.1 Limitations, requires "Plastic pipe shall be installed outdoors underground only. Plastic pipe shall not be used within or under any building or slab…". These products are made with two layers of plastic pipe and no testing or evaluation has been identified that would allow the existence of the plastic layers relative to this requirement.

NFPA 54 has substantially similar requirements regarding aluminum alloys and the use of plastic pipe and further requires that plastic pipe used for gas systems must comply with ASTM D2513[5].

The fuel gas requirements in the IRC are extracted from the IFGC and identical[6].

The fuel gas requirements in the UPC reference NFPA 54 and are substantially similar relative to materials and aluminum and plastic piping[7].

NFPA 54 and the IFGC require gas pipe and tubing to be electrically continuous and bonded to a ground-fault current path[8]. The tested PEX-AL-PEX fittings were found to be dielectrically isolated from the aluminum portion of the composite tubing. Installation of this product would interrupt the continuity of other portions of a gas piping system. This aspect of the product would require further study to evaluate the impact and potential for unintended consequences.

Manufacturer's Literature

The online information provided by the website of a manufacturer of a PEX-AL-PEX product which has received an ICC-ES product certification was reviewed[9]. The website indicates the product has been "certified to" several codes which were described above. Generally, products are certified to a standard(s) by a qualified testing agency. The codes listed are not standards and the products identified within those codes are required to be investigated and tested, listed or certified to an appropriate standard for their safety and suitability for the intended purpose.

This manufacturer's installation instructions state that the installer should follow the requirements of the appropriate fuel gas code. PEX-AL-PEX is not included in any fuel gas code.

The manufacturer's installation instructions do not address the installation of fittings in concealed spaces. Unless they have been tested to a recognized safety standard for this purpose, compression fittings in fuel gas piping are not allowed in concealed spaces by the aforementioned fuel gas codes.

The instructions indicate that protective devices (such as "nail plates") should be installed where the tubing may be susceptible to damage, such as in studs or joists. The instructions do not offer guidance or provide information about materials to accomplish this protection. To be equivalent, instruction on proper strike protection should be included in the manufacturer's instructions,

TESTING

The Safe Building Material Association engaged the CSA Group to conduct testing on one of the PEX-AL-PEX products. Because no recognized standard exists for the use of PEX-AL-PEX as a fuel gas piping system, certain test procedures were selected from the CSA/ANSI LC-1 Standard to evaluate the performance of the product. The LC-1 standard appears to contain the closet set of requirements however, while some of the tests and requirements might apply, it could not be used for certification of the PEX-AL-PEX product as a gas piping system. In addition, flame spread and smoke density testing

[5] NFPA 54, ANSI Z223.1, National Fuel Gas Code – 2018 Clause 5.6.4.1.1
[6] IRC, International Residential Code – 2015 Chapter 24
[7] UPC, Uniform Plumbing Code – 2012 Sections 301.2, 1208.5.2.4, 1208.5.4
[8] NFPA 54, ANSI Z223.1, National Fuel Gas Code – 2018 Clause 7.12.1
[9] jonesstephens.com/pexalgas/

was conducted by Intertek following the test procedures in CAN/ULC S102-18, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

Test Results, CSA (Appendices A and B)

The following tests from CSA/ANSI LC-1 were conducted and the results are summarized below. All tests were reported to be conducted following the requirements in the standard and incorporating the product manufacturers instructions.

- Exposure to elevated temperatures – Clause 5.9
  - The product did not meet the requirements of these tests. The specified test duration is one hour at 1000° F, and any leak should not exceed 6 ft^3 of air per hour. Two tests were conducted. The fittings pushed off, leaking all of the test pressure in 10 and 24 seconds. The test samples then ignited, caught fire and burned for 5 and 8 minutes.
  - Note: both NFPA 54 and the IFGC require tubing joints to be capable of withstanding exposure to at least 1000° F[10].
- Impact Strength – Clause 5.7
  - No damage or leaks occurred during these tests.
- Crushing Strength – Clause 5.6
  - No damage occurred during these tests and the leakage results were characterized as “satisfactory”.
- Axial Strength – Clause 5.5
  - No leakage occurred during these tests.
- Flexibility of tubing in bending – Clause 5.4.1 & 5.4.2
  - No drop in pressure or leaks occurred during these tests.
- Electrical Resistance & conductivity – Clause 5.15
  - The product exceeded the maximum electrical resistance values in Table 8 of the standard.
  - The fuel gas codes require a gas piping system to be electrically continuous and bonded[8].

Test Results, Intertek (Appendix C)

The following tests from CAN/ULC S102-18 were conducted and the results are summarized. All tests were conducted following the requirements in the standard.

[10] NFPA 54, ANSI Z223.1, National Fuel Gas Code – 2018 Clause 5.6.7.2, 5.6.7.3

- Flame spread
  - The two tests of the product resulted in flame spread ratings of 1 and 3.
- Smoke density
  - The two tests of the product resulted in smoked developed numbers of 10 and 74. Note that most applicable building code requirements are for smoke developed ratings of 50 or less.

CONCLUSIONS AND OPINIONS

Based on my education, training, and experience as well as the investigation and analysis outlined herein, I hold the following conclusions and opinions to a reasonable degree of engineering certainty.

1. The PEX-AL-PEX product appears to be widely accepted for use in hydronic systems. Testing for use in a hydronic system are different than testing for use as a fuel gas system inside a building.
2. Alternative materials for use as interior fuel gas piping should be investigated and tested to determine that they are safe and suitable for use as interior fuel gas piping system. An appropriate safety standard should be identified or developed for the PEX-AL-PEX product as a fuel gas piping system. That standard should be recognized by all model code agencies. Then the product should be tested to that standard.
3. No recognized industry standard is referenced in the fuel gas codes that would effectively evaluate the safety and suitability of the PEX-AL-PEX products as a fuel gas piping system.
4. The PEX-AL-PEX product tested failed the test for “Exposure to elevated temperatures” described in clause 5.9 of the CSA/ANSI LC-1 standard by leaking all the test pressure within seconds of starting a planned one-hour test. The PEX-AL-PEX pipe product then ignited and burned for an extended period following the test.
5. The PEX-AL-PEX product exceeded the normally accepted threshold value in one of the smoke development tests.
6. The PEX-AL-PEX product is not electrically continuous as required by the fuel gas codes.
7. The PEX-AL-PEX product has not been demonstrated to be an equivalent alternative for use as a fuel gas piping system and does not meet the intent of the requirements in the fuel gas codes.

The preliminary conclusions and opinions formulated during this investigation and presented herein are based on information available to date. ESi reserves the right to supplement or otherwise amend this report should other information become available.

AJT/saa

Appendix A

CSA-80102353 PEXALGAS Report

Project: 80102353
Project: 80102354
Revision: 0

February 28, 2022

PEXALGAS Testing
(Non-Certification)

Prepared for:
Luke Marchant
Executive Director
Safe Building Material Association
1717 North Akard Street
Dallas, Texas 75201
(972) 822-9439
Luke.marchant@safebuildingmaterials.com

Project Report Numbers
80102353 & 80102354

Test Protocol
ANSI LC 1:19 • CSA 6.26:19

Prepared By:
John Kristoff-Kichka

John Kristoff-Kichka
Project Engineer/Certifier III
CSA Group
8501 E. Pleasant Valley Road
Cleveland, Ohio 44131-5516 U.S.A.
Phone: 216.524.4990 Ext: 8822
E-mail: john.kristoff-kichka@csagroup.org
Website: www.CSAgroup.org

February 28, 2022

Program Description:
Testing shall be performed on the PEX-AL-PEX piping supplied by the Client. Two sizes of tubing and fittings shall be supplied including 20-mm (1/2") and 32-mm (1"). The tubing and fittings shall be assembled by the testing lab in accordance with the manufacturer's instructions and assembly tools. For each test method, the test lab shall perform the test twice for each size tubing using a new test specimen for each test. Using the CSA LC-1 Standard for Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing as the basis, the test lab shall complete the following test methods:

- Exposure to Elevated Temperatures: LC-1 Performance Test 5.9
- Impact Strength: LC-1 Performance Test 5.7
- Crushing Strength: LC-1 Performance Test 5.6
- Axial Strength: LC-1 Performance Test 5.5
- Flexibility of Tubing in Bending: LC-1 Performance Tests 5.4.1 and 5.4.2
- Electrical Resistance and Conductivity: LC-1 Performance Test 5.15
- Flame Spread and Smoke Density: LC-1 Requirement 4.1.7 performed by a third-party testing agency

Product Description:
The Jones Stephens PEXALGAS is a multilayer system composed of crosslinked polyethylene internal layer PEX-b, internal bonding layer, intermediate aluminum layer, external bonding layer crosslinked polyethylene PEX-b. The color is a Yellow RAL 1023. The Client has provided for test approximately 266 feet of 20-mm (1/2") and 114 feet of 32-mm (1") of tubing. Also supplied were the brass press fittings for the PEXALGAS tubing. 20-mm x 2-mm (1/2") and 32-mm x 3-mm (1"). The PEXALGAS Pressing Tools were provided for making up various length test samples, PCJ20 and PCJ32. The brass press fittings terminated in 1/2" NPT(M) and 1" NPT(M) threads for connection to standard iron type pipe fittings. To aid in cutting the tubing and assuring a round inner circumference, the Manufacturer provided a VIRAX cutting tool and reamer. Also provided were the PEXALGAS technical specifications and installation instructions.

End Fitting Characteristics:
Before commencing with making up the test samples as per the manufacturer's instructions, the 1/2" NPT(M) and 1" NPT(M) end fittings were tested using a calibrated L1 ring gauge. The 1/2" NPT(M) end fittings were found to be within the allowable +/- 1 turn. The 1" NPT(M) end fittings were all found to be minus 4 to 5 turns. Due to these findings, additional tightening torque was applied to the 1" NPT(M) end fitting to obtain a leakage free connection between the end fitting and the black iron pipe fittings used for testing.

Applicable Standard:
CSA/ANSI LC 1:19 • CSA 6.26:19 Fuel gas piping systems using corrugated stainless-steel tubing

CSA GROUP™

February 28, 2022

Required Testing:
The following testing was requested and conducted using the above Standard:

1. Exposure to elevated temperatures – Clause 5.9
2. Impact Strength – Clause 5.7
3. Crushing Strength – Clause 5.6
4. Axial Strength – Clause 5.5
5. Flexibility of tubing in bending – Clause 5.4.1 & 5.4.2
6. Electrical Resistance & conductivity – Clause 5.15
7. Flame Spread & Smoke Density – Clause 4.1.7

SCOPE – The tubing and fittings shall be assembled by the testing lab in accordance with the manufacturer's instructions and assembly tools. For each test method, the test lab shall perform the test twice for each size tubing using a new test specimen for each test.

Flame Spread & Smoke Density:
Note: For above item 7, a quote to perform the testing was requested from four (4) independent testing labs, Applied Labs (partner lab Commercial Testing Company), Element Lab, Govmark Lab and Intertek Testing Services. Intertek was selected with Kevin Reese Senior Sales Representative Intertek as the point of contact. The quote received from Kevin (Qu-01238199-0, January 17, 2022) was for an evaluation test and not for certification testing. All quotes considered were based on the CAN/ULC S-102 Standard. To initiate the project test samples were sent to Intertek Testing Lab, 1500 Brigantine Drive, Coquitlam, BC V3K 7C1, Canada, Attention: Gregory Philip. FedEx Tracking #775872429362. The test samples were comprised of 54 feet of 20-mm (1/2") and 54 feet of 32-mm (1") of tubing only, no end fittings provided. According to the FedEx tracking number, the test samples were received and signed for on Wednesday, February 2, 2022, at 3:51PM. Following the testing, Gregory Philip provided a descriptive report explaining the results from their testing and review.

<u>Performance Testing:</u>
Exposure to elevated (1000°F) temperatures – Clause 5.9

a. Test sample #1 - **20-mm (1/2")** x 2 feet in length
b. End fittings installed on both ends per the Installation Instruction Manual
c. The test sample was installed into the pre-heated oven chamber and 72 PSI (5 bar) was applied to the test sample.
d. After approximately 10 seconds the end fittings pushed away from the tubing releasing the 72 PSI test pressure. The test sample caught fire and burned for approximately 5 minutes.
e. After the test sample flame extinguished, the sample was removed from the oven chamber and allowed to cool to room temperature. Pictures were taken of the test sample showing the destructive results.

February 28, 2022

Exposure to elevated (1000°F) temperatures – Clause 5.9

f. Test sample #1- **32-mm (1")** x 2 feet in length
g. End fittings installed on both ends per the Installation Instruction Manual
h. The test sample was installed into the pre-heated oven chamber and 72 PSI (5 bar) was applied to the test sample.
i. After approximately 24 seconds the end fittings pushed away from the tubing releasing the 72 PSI test pressure. The test sample caught fire and burned for approximately 8 minutes.
j. After the test sample flame extinguished, the sample was removed from the oven chamber and allowed to cool to room temperature. Pictures were taken of the test sample showing the destructive results.

Note: Due to the test results as witnessed above, a second test sample was not evaluated.

Axial Strength Test – Clause 5.5

a. Test sample #1 - **20-mm (1/2")** x 1 foot in length
b. End fittings installed on both ends per the Installation Instruction Manual
c. The test sample was installed into Instron test fixture.
d. The air supply system and test gauge were connected to the test sample.
e. The air supply to the test sample was increased to 72 PSI (5 bar)
f. A pulling force of 400 lb. was applied for 5 minutes. (Based on 800 lb./in of diameter)

Results: No leakage (Clause 5.2) recorded during and/or after the test. The end fittings were still intact on the tubing.

Axial Strength Test – Clause 5.5

g. Test sample #2 - **20-mm (1/2")** x 1 foot in length
h. End fittings installed on both ends per the Installation Instruction Manual
i. The test sample was installed into Instron test fixture.
j. The air supply system and test gauge were connected to the test sample.
k. The air supply to the test sample was increased to 72 PSI (5 bar)
l. A pulling force of 400 lb. was applied for 5 minutes. (Based on 800 lb./in of diameter)

Results: No leakage (Clause 5.2) recorded during and/or after the test. The end fittings were still intact on the tubing.

Axial Strength Test – Clause 5.5

m. Test sample #1 - **32-mm (1")** x 1 foot in length
n. End fittings installed on both ends per the Installation Instruction Manual
o. The test sample was installed into Instron test fixture.
p. The air supply system and test gauge were connected to the test sample.
q. The air supply to the test sample was increased to 72 PSI (5 bar)
r. A pulling force of 800 lb. was applied for 5 minutes. (Based on 800 lb./in of diameter)

Results: No leakage (Clause 5.2) recorded during and/or after the test. The end fittings were still intact on the tubing.

Axial Strength Test – Clause 5.5

s. Test sample #2 - **32-mm (1")** x 1 foot in length
t. End fittings installed on both ends per the Installation Instruction Manual
u. The test sample was installed into Instron test fixture.
v. The air supply system and test gauge were connected to the test sample.
w. The air supply to the test sample was increased to 72 PSI (5 bar)
x. A pulling force of 800 lb. was applied for 5 minutes. (Based on 800 lb./in of diameter)

Results: No leakage (Clause 5.2) recorded during and/or after the test. The end fittings were still intact on the tubing.

Impact Strength Test – Clause 5.7

a. Test sample #1 - **20-mm (1/2")** x 2 feet in length
b. End fittings installed on both ends per the Installation Instruction Manual
c. The test sample was installed into the test fixture V-block steel holder.
d. The tubing was struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact.
e. The end fittings were struck twice on each end turning the fitting 180° between strikes.
f. The impact was positioned over the wrench flats of each fitting.

Results: No leakage (Clause 5.2) recorded after the test. The end fittings were still intact and did not exhibit any damage.

Impact Strength Test – Clause 5.7

g. Test sample #2 - **20-mm (1/2")** x 2 feet in length
h. End fittings installed on both ends per the Installation Instruction Manual
i. The test sample was installed into the test fixture V-block steel holder.
j. The tubing was struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact.
k. The end fittings were struck twice on each end turning the fitting 180° between strikes.
l. The impact was positioned over the wrench flats of each fitting.

Results: No leakage (Clause 5.2) recorded after the test. The end fittings were still intact and did not exhibit any damage.

Impact Strength Test – Clause 5.7

m. Test sample #1 - **32-mm (1")** x 2 feet in length
n. End fittings installed on both ends per the Installation Instruction Manual
o. The test sample was installed into the test fixture V-block steel holder.
p. The tubing was struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact.
q. The end fittings were struck twice on each end turning the fitting 180° between strikes.
r. The impact was positioned over the wrench flats of each fitting.

Results: No leakage (Clause 5.2) recorded after the test. The end fittings were still intact and did not exhibit any damage.

Impact Strength Test – Clause 5.7

s. Test sample #2 - **32-mm (1")** x 2 feet in length
t. End fittings installed on both ends per the Installation Instruction Manual
u. The test sample was installed into the test fixture V-block steel holder.
v. The tubing was struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact.
w. The end fittings were struck twice on each end turning the fitting 180° between strikes.
x. The impact was positioned over the wrench flats of each fitting.

Results: No leakage (Clause 5.2) recorded after the test. The end fittings were still intact and did not exhibit any damage.

Flexibility of Tubing Test – Clause 5.4.1 & 5.4.2

a. Test sample #1 - **20-mm (1/2")** x 2 feet in length
b. End fittings installed on both ends per the Installation Instruction Manual
c. Minimum Bend Radius: 3 inches
d. Test Pressure: 1.5 times the rated pressure = 108 PSI
e. Cycles Required: 6 (5 cycles per minute)

Results: No sudden drop-in pressure was recorded during the 6 cycles. Both tubing and fittings complied with Clause 5.2 leakage after the test.

Flexibility of Tubing Test – Clause 5.4.1 & 5.4.2

f. Test sample #2 - **20-mm (1/2")** x 2 feet in length
g. End fittings installed on both ends per the Installation Instruction Manual
h. Minimum Bend Radius: 3 inches
i. Test Pressure: 1.5 times the rated pressure = 108 PSI
j. Cycles Required: 6 (5 cycles per minute)

Results: No sudden drop-in pressure was recorded during the 6 cycles. Both tubing and fittings complied with Clause 5.2 leakage after the test.

Flexibility of Tubing Test – Clause 5.4.1 & 5.4.2

k. Test sample #1 - **32-mm (1")** x 2 feet in length
l. End fittings installed on both ends per the Installation Instruction Manual
m. Minimum Bend Radius: 5 inches
n. Test Pressure: 1.5 times the rated pressure = 108 PSI
o. Cycles Required: 6 (5 cycles per minute)

Results: No sudden drop-in pressure was recorded during the 6 cycles. Both tubing and fittings complied with Clause 5.2 leakage after the test.

Flexibility of Tubing Test – Clause 5.4.1 & 5.4.2

p. Test sample #2 - **32-mm (1")** x 2 feet in length
q. End fittings installed on both ends per the Installation Instruction Manual

r. Minimum Bend Radius: 5 inches
s. Test Pressure: 1.5 times the rated pressure = 108 PSI
t. Cycles Required: 6 (5 cycles per minute)

Results: No sudden drop-in pressure was recorded during the 6 cycles. Both tubing and fittings complied with Clause 5.2 leakage after the test.

Electrical Resistance & Conductivity Test – Clause 5.15

a. Test sample #1 - **20-mm (1/2")** x 6 feet in length
b. End fittings installed on both ends per the Installation Instruction Manual
c. Requirement: An assembly of tubing and fittings shall not have an electrical resistance that exceeds the values given in Table 8. For 1/2" nominal size of pipe the maximum electrical resistance is 0.150 ohms/foot. (0.150 ohms x 6 feet = 0.9 ohms)

Results: > 300 M ohms Resistance. The Gas Piping System press fittings are dielectrically isolated from the internal aluminum pipe layer. The tests performed confirms the isolation across the length of the test sample.

Note: The NFPA 54 Code requires a low impedance pathway to ground for metallic piping systems to ensure electrical safety in the event of a ground fault. That is why the allowable resistance value is at a minimum as shown in Table 8 of the Standard.

Electrical Resistance & Conductivity Test – Clause 5.15

d. Test sample #2 - **20-mm (1/2")** x 6 feet in length
e. End fittings installed on both ends per the Installation Instruction Manual
f. Requirement: An assembly of tubing and fittings shall not have an electrical resistance that exceeds the values given in Table 8. For 1/2" nominal size of pipe the maximum electrical resistance is 0.150 ohms/foot. (0.150 ohms x 6 feet = 0.9 ohms)

Results: > 300 M ohms Resistance. The Gas Piping System press fittings are dielectrically isolated from the internal aluminum pipe layer. The tests performed confirms the isolation across the length of the test sample.

Note: The NFPA 54 Code requires a low impedance pathway to ground for metallic piping systems to ensure electrical safety in the event of a ground fault. That is why the allowable resistance value is at a minimum as shown in Table 8 of the Standard.

Electrical Resistance & Conductivity Test – Clause 5.15

g. Test sample #1 - **32-mm (1")** x 6 feet in length
h. End fittings installed on both ends per the Installation Instruction Manual
i. Requirement: An assembly of tubing and fittings shall not have an electrical resistance that exceeds the values given in Table 8. For 1" nominal size of pipe the maximum electrical resistance is 0.120 ohms/foot. (0.120 ohms x 6 feet = 0.72 ohms)

Results: > 300 M ohms Resistance. The Gas Piping System press fittings are dielectrically isolated from the internal aluminum pipe layer. The tests performed confirms the isolation across the length of the test sample.

February 28, 2022

Note: The NFPA 54 Code requires a low impedance pathway to ground for metallic piping systems to ensure electrical safety in the event of a ground fault. That is why the allowable resistance value is at a minimum as shown in Table 8 of the Standard.

Electrical Resistance & Conductivity Test – Clause 5.15

j. Test sample #2 - **32-mm (1")** x 6 feet in length
k. End fittings installed on both ends per the Installation Instruction Manual
l. Requirement: An assembly of tubing and fittings shall not have an electrical resistance that exceeds the values given in Table 8. For 1" nominal size of pipe the maximum electrical resistance is 0.120 ohms/foot. (0.120 ohms x 6 feet = 0.72 ohms)

Results: > 300 M ohms Resistance. The Gas Piping System press fittings are dielectrically isolated from the internal aluminum pipe layer. The tests performed confirms the isolation across the length of the test sample.

Note: The NFPA 54 Code requires a low impedance pathway to ground for metallic piping systems to ensure electrical safety in the event of a ground fault. That is why the allowable resistance value is at a minimum as shown in Table 8 of the Standard.

Crushing Strength Test – Clause 5.6

a. Test sample #1 - **20-mm (1/2")** x 2 feet in length
b. End fittings installed on both ends per the Installation Instruction Manual
c. Requirement: Tubing and fittings shall withstand, without a decrease in flow capacity of more than 50%, a crushing force of 1000 lb. (4.45 kN) when tested in accordance with Clause 5.6.2. Uniformly applied to the tubing for 15 minutes.

Results: Pressure drop (1" w.c.) capacity before the crushing force was 225,573 Btu/hr.
Pressure drop (1" w.c.) capacity after the crushing force was 211,808 Btu/hr.
Percentage of reduction in capacity was: -6.1% "Satisfactory"

d. End fittings exposed (15 minutes) to the crushing force of 1000 lb. (4.45 kN)

Results: No damage to the end fittings. Leakage 5.2 was "Satisfactory"

Crushing Strength Test – Clause 5.6

e. Test sample #2 - **20-mm (1/2")** x 2 feet in length
f. End fittings installed on both ends per the Installation Instruction Manual
g. Requirement: Tubing and fittings shall withstand, without a decrease in flow capacity of more than 50%, a crushing force of 1000 lb. (4.45 kN) when tested in accordance with Clause 5.6.2. Uniformly applied to the tubing for 15 minutes.

Results: Pressure drop (1" w.c.) capacity before the crushing force was 222,277 Btu/hr.
Pressure drop (1" w.c.) capacity after the crushing force was 195,064 Btu/hr.
Percentage of reduction in capacity was: -12.2% "Satisfactory"

h. End fittings exposed (15 minutes) to the crushing force of 1000 lb. (4.45 kN)

Results: No damage to the end fittings. Leakage 5.2 was "Satisfactory"

February 28, 2022

Crushing Strength Test – Clause 5.6

i. Test sample #1 - **32-mm (1")** x 2 feet in length
j. End fittings installed on both ends per the Installation Instruction Manual
k. Requirement: Tubing and fittings shall withstand, without a decrease in flow capacity of more than 50%, a crushing force of 1000 lb. (4.45 kN) when tested in accordance with Clause 5.6.2. Uniformly applied to the tubing for 15 minutes.

Results: Pressure drop (1" w.c.) capacity before the crushing force was 969,845 Btu/hr.
Pressure drop (1" w.c.) capacity after the crushing force was 932,264 Btu/hr.
Percentage of reduction in capacity was: -3.9% "Satisfactory"

l. End fittings exposed (15 minutes) to the crushing force of 1000 lb. (4.45 kN)

Results: No damage to the end fittings. Leakage 5.2 was "Satisfactory"

Crushing Strength Test – Clause 5.6

m. Test sample #2 - **32-mm (1")** x 2 feet in length
n. End fittings installed on both ends per the Installation Instruction Manual
o. Requirement: Tubing and fittings shall withstand, without a decrease in flow capacity of more than 50%, a crushing force of 1000 lb. (4.45 kN) when tested in accordance with Clause 5.6.2. Uniformly applied to the tubing for 15 minutes.

Results: Pressure drop (1" w.c.) capacity before the crushing force was 969,682 Btu/hr.
Pressure drop (1" w.c.) capacity after the crushing force was 941,191 Btu/hr.
Percentage of reduction in capacity was: -2.9% "Satisfactory"

p. End fittings exposed (15 minutes) to the crushing force of 1000 lb. (4.45 kN)

Results: No damage to the end fittings. Leakage 5.2 was "Satisfactory"

Closing Summary:

All required testing has been completed on the PEX-AL-PEX piping supplied by the Client. Two (2) sizes of tubing and fittings were tested including the 20-mm (1/2") and 32-mm (1"). The test results were reported accordingly under each test section.

All actual test samples will be forwarded to ESi for their post test analysis.

ESi Address

ESi
2355 Polaris Lane North
Suite 120
Plymouth, MN 55447-4447
Attention: Andy Thielen
763-557-9090

February 28, 2022

Test Equipment				
Description	**Model Number**	**Asset Number**	**Cal. Date**	**Cal. Due Date**
Test Gauge (600 PSI)	3D Instruments	PG-139	9/27/2021	9/27/2022
Associated Research	3160 Ground Bond	EA-166	5/27/2021	5/27/2022
Test Gauge (60 PSI)	3D Instruments	PG-145	9/27/2021	9/27/2022
Validyne Gauge	PS309	PM-30	6/16/2021	6/16/2022
Validyne Gauge	PS309	PM-31	7/26/2021	7/26/2022
Validyne Gauge	PS309	PM-44	7/7/2021	7/7/2022
Flow Element	Meter 4	9279	6/29/2021	6/29/2022
Yokogawa Recorder	MV 2000	TR-95	5/18/2021	5/18/2022
Control Company	Stopwatch	Z00009524	8/12/2021	8/12/2022
Flow Element	Meter 3	9277	6/29/2021	6/29/2022
INSTRON	20K Load Cell	FG-35	10/23/2021	10/23/2022
RIGID Press Tool	RP350	n/a	n/a	n/a
Alicat Flow Meter	Mass Flow	92140	11/4/2021	11/4/2022
High Temperature	Electric Oven	CH-40	n/a	n/a
Yokogawa Recorder	MV 1000	Z00000039	4/1/2021	4/1/2022
Fluke Thermometer	51 II Series	TPI-90	3/12/2021	3/12/2022

Appendix B

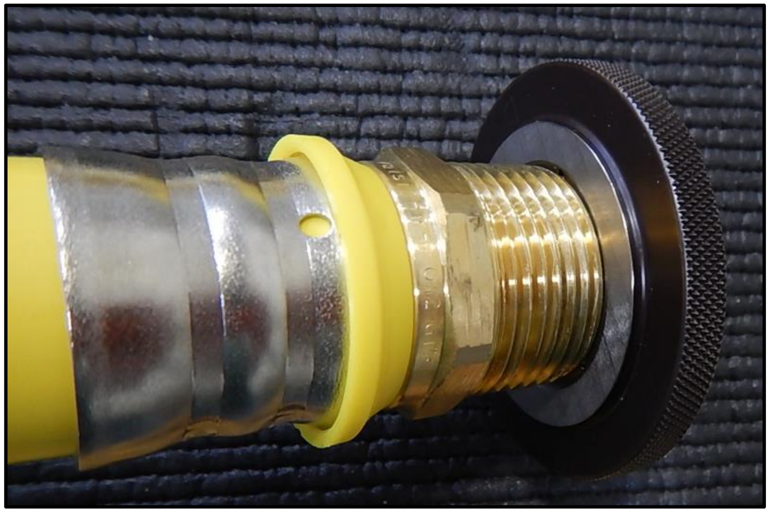
CSA-80102353 PEXALGAS Report Pictures

PEX-AL-PEX piping as received from the Manufacturer Omega Flex. Two sizes of tubing and fittings supplied including 20-mm (1/2") and 32-mm (1"). Approximately 266 feet of 1/2" and 114 feet of 1”

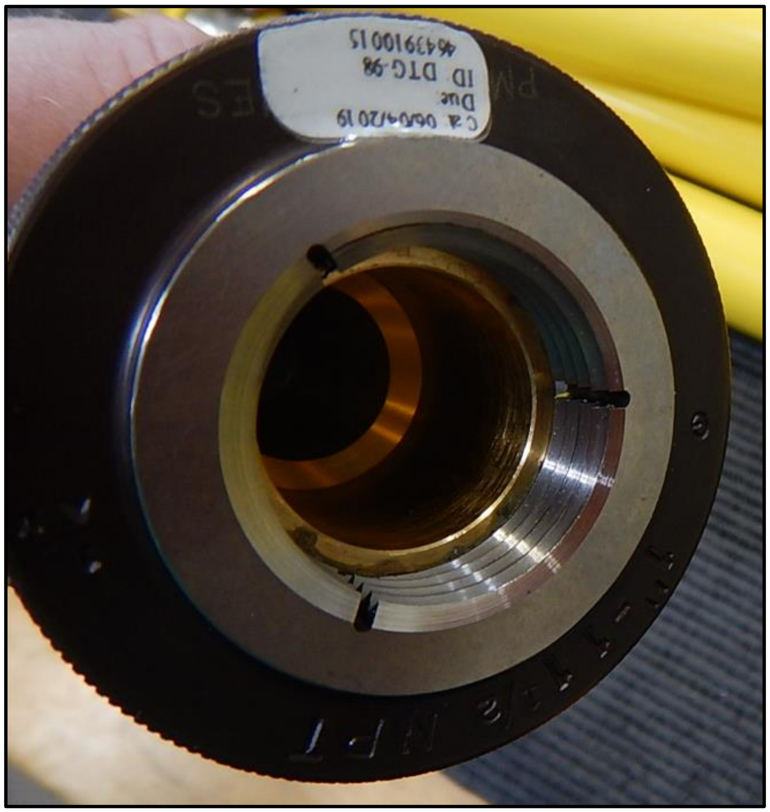
PEX-AL-PEX piping as received from the Manufacturer Omega Flex. Two sizes of tubing and fittings supplied including 20-mm (1/2") and 32-mm (1"). Approximately 266 feet of 1/2" and 114 feet of 1” Close up View.

PEX-AL-PEX piping test samples as required by the ANSI LC 1:19 • CSA 6.26:19 Standard. Clauses 5.4.1/5.4.2, 5.5, 5.6, 5.7, 5.9, and 5.15.

PEX-AL-PEX piping test samples as required by the ANSI LC 1:19 • CSA 6.26:19 Standard. Clauses 5.4.1/5.4.2, 5.5, 5.6, 5.7, 5.9, and 5.15. Alternate view.



PEX-AL-PEX piping 1” NPT(M) end fitting being validated by a calibrated L1 ring gauge.



PEX-AL-PEX piping 1” NPT(M) end fitting being validated by a calibrated L1 ring gauge. This view shows that the end fitting threads were incorrectly cut not allowing the calibrated ring gauge to fit properly. This problem was found to be on all 1” NPT(M) fittings supplied by the Manufacturer. Allowable: +/- 1 turn.

Exposure to elevated (1000 F) temperatures – Clause 5.9   20-mm (1/2”)

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 feet long in length. Sample #1, Test pressure applied equal to 72 PSI (5 bar). Pre-heated oven chamber to 1000°F

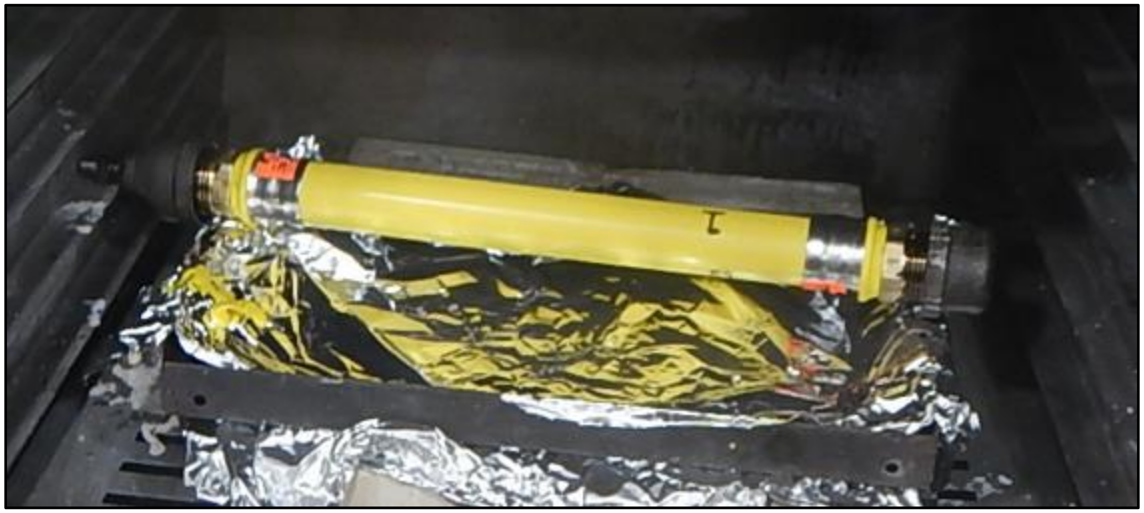
PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 feet long in length. Test pressure applied equal to 72 PSI (5 bar). Sample #1, after 10 seconds the end fittings released from the tubing. The cover caught fire and burned.

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 feet long in length. Test sample after cooling to room temperature.

PEX-AL-PEX piping 20-mm (1/2") NPT(M) with end fittings by 2 feet long in length. Test sample after cooling to room temperature.

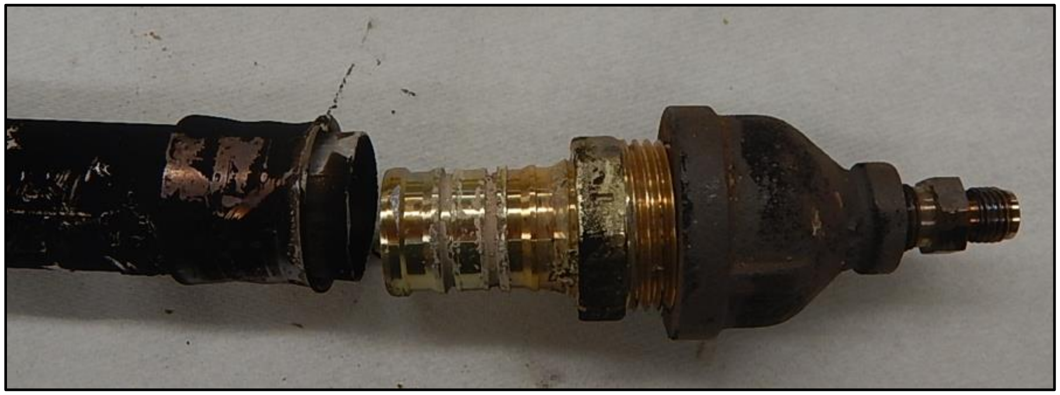
PEX-AL-PEX piping 20-mm (1/2") NPT(M) with end fittings by 2 feet long in length. Test sample after cooling to room temperature.

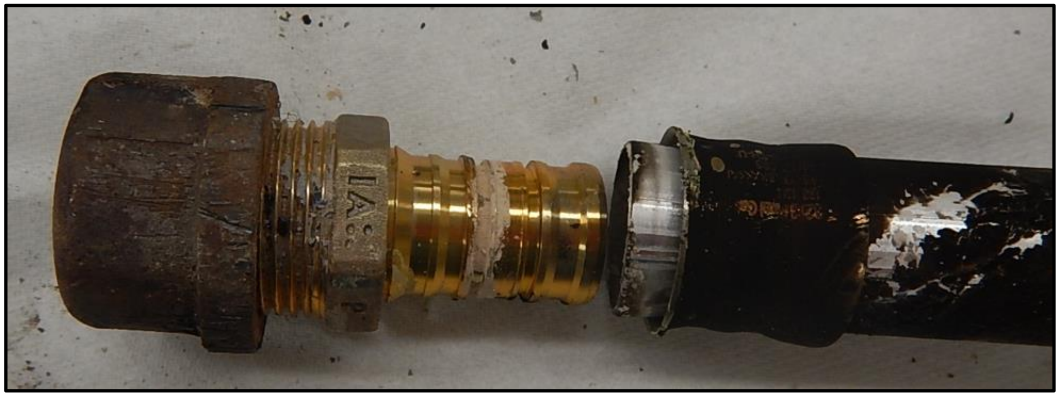
Exposure to elevated (1000 F) temperatures – Clause 5.9 32-mm (1")



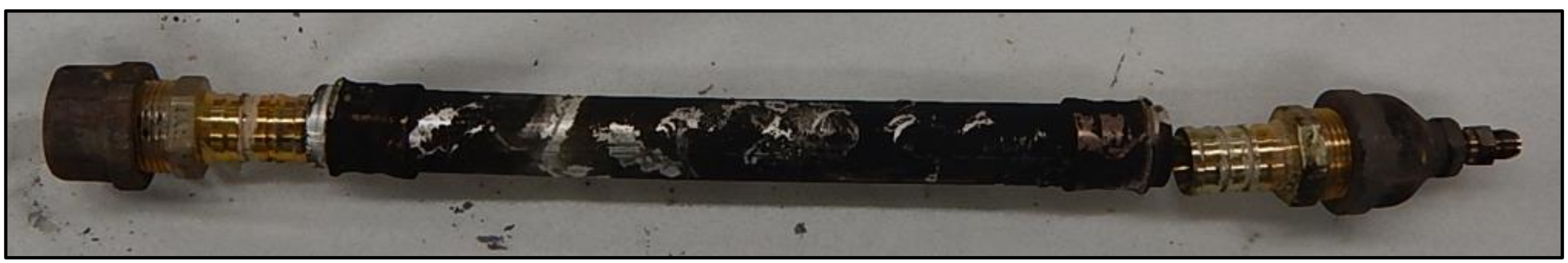
PEX-AL-PEX piping 32-mm (1") NPT(M) with end fittings by 2 feet long in length. Sample #1, Test pressure applied equal to 72 PSI (5 bar). Pre-heated oven chamber to 1000°F

PEX-AL-PEX piping 32-mm (1") NPT(M) with end fittings by 2 feet long in length. Sample #1, Test pressure applied equal to 72 PSI (5 bar). Pre-heated oven chamber to 1000°F. After 24 seconds the end fittings released from the tubing. The cover caught fire and burned.

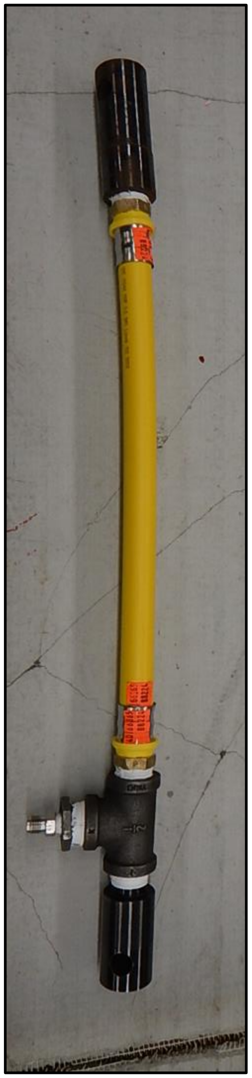


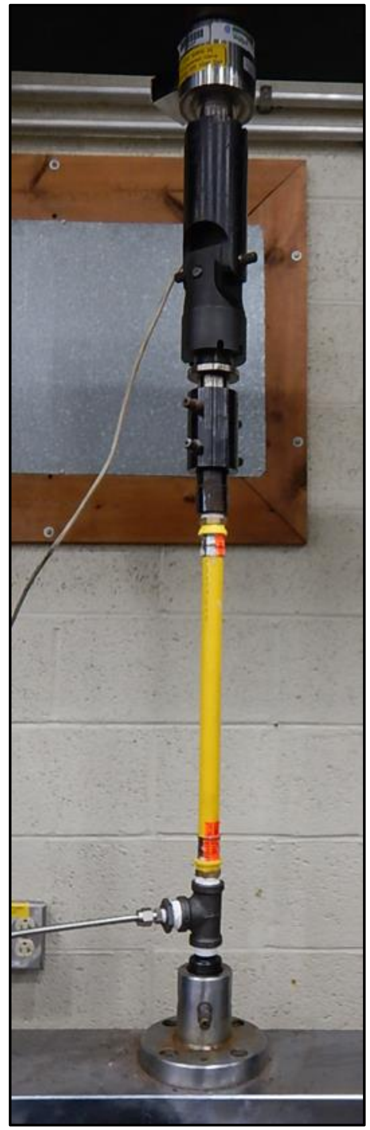


PEX-AL-PEX piping 32-mm (1") NPT(M) with end fittings by 2 feet long in length. Test sample after cooling to room temperature.



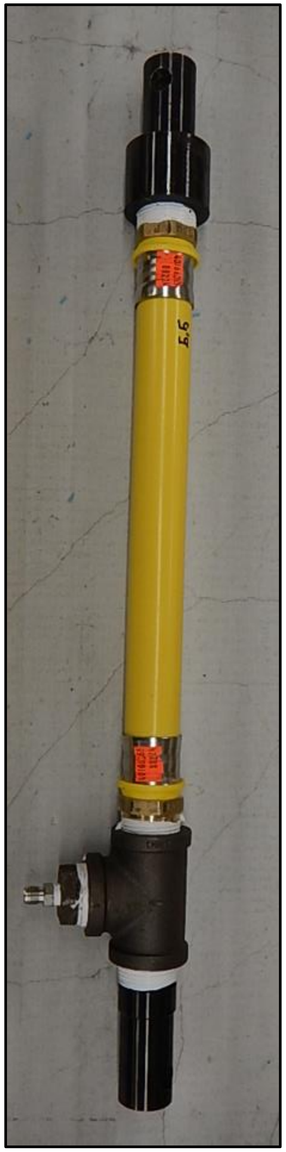
Axial Strength Test – Clause 5.5 20-mm (1/2”)





PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 1 foot long in length. Test sample #1 & #2. Test pressure applied equal to 72 PSI (5 bar). A pulling force of 400 lb./in^2 was applied for 5 minutes.

Axial Strength Test – Clause 5.5 32-mm (1”)



PEX-AL-PEX piping 32-mm (1”) NPT(M) with end fittings by 1 foot long in length. Test sample #1 & #2. Test pressure applied equal to 72 PSI (5 bar). A pulling force of 800 lb./in^2 was applied for 5 minutes.

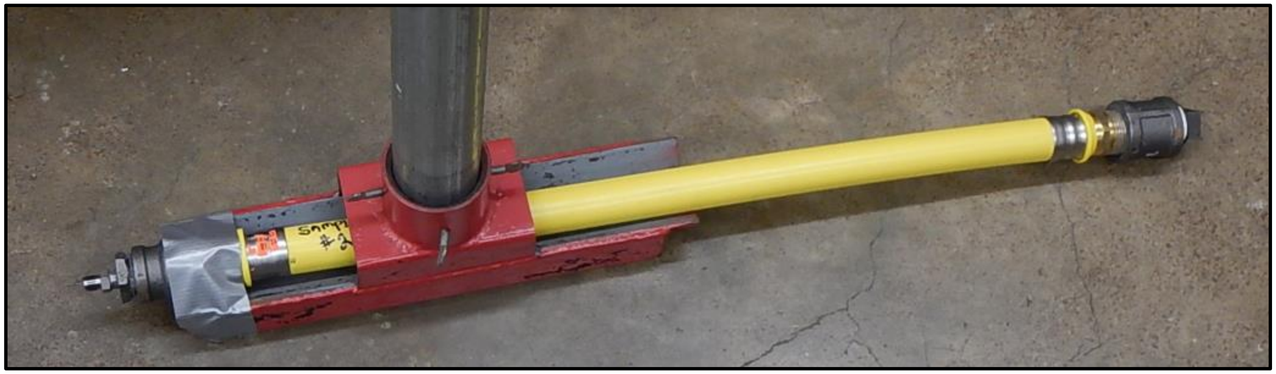
Impact Strength Test – Clause 5.7 20-mm (1/2”)

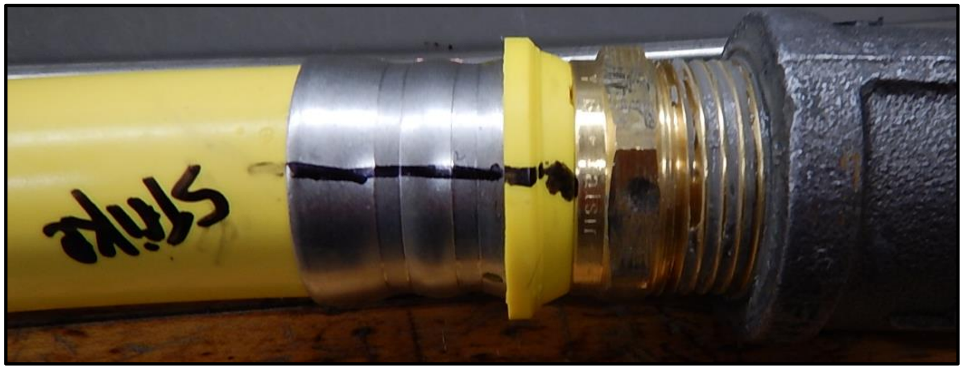
PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 foot long in length. Test sample #1 & #2. Test pressure applied equal to 72 PSI (5 bar for leakage). Tubing struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact. The end fittings were struck twice on each end turning the fitting 180° between strikes.

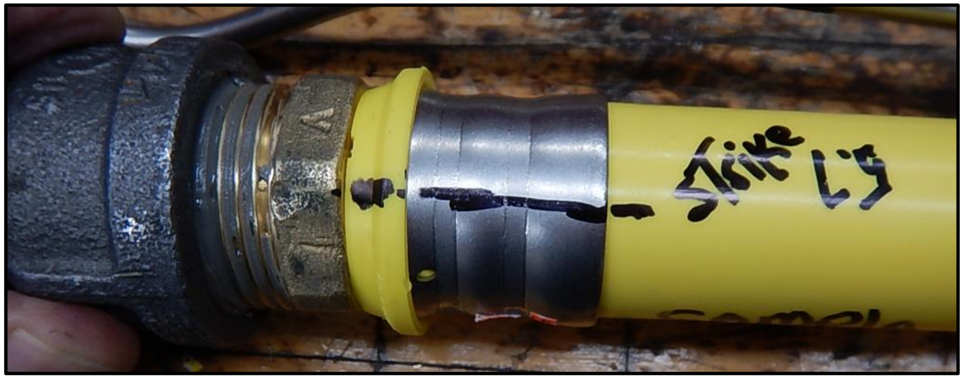
Impact Strength Test – Clause 5.7   32-mm (1")

PEX-AL-PEX piping 20-mm (1/2") NPT(M) with end fittings by 2 foot long in length. Test sample #1 & #2. Test pressure applied equal to 72 PSI (5 bar for leakage). Tubing struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact. The end fittings were struck twice on each end turning the fitting 180° between strikes.

Impact Strength Test – Clause 5.7 32-mm (1”)







PEX-AL-PEX piping 32-mm (1”) NPT(M) with end fittings by 2 foot long in length. Test sample #1 & #2. Test pressure applied equal to 72 PSI (5 bar for leakage). Tubing struck four (4) times (30 ft.•lb.) across its length. The tubing was turned ¼ turn after each impact. The end fittings were struck twice on each end turning the fitting 180° between strikes.

Flexibility of Tubing Test – Clause 5.4.1 & 5.4.2 20-mm (1/2”)

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 3” diameter pipe fittings. Minimum specified bend radius per manufacture’s installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

Shown in the starting position

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 3” diameter pipe fittings. Minimum specified bend radius per manufacture’s installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

Shown tubing condition after two (2) cycles of operation.

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 3” diameter pipe fittings. Minimum specified bend radius per manufacture’s installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

Shown tubing condition after four (4) cycles of operation.

Shown tubing condition after six (6) cycles of operation.

PEX-AL-PEX piping 20-mm (1/2") NPT(M) with end fittings by 2 feet long in length.

Tubing being checked for leaks after the six (6) bending cycles. Test pressure was adjusted to 72 PSI (5 bar).

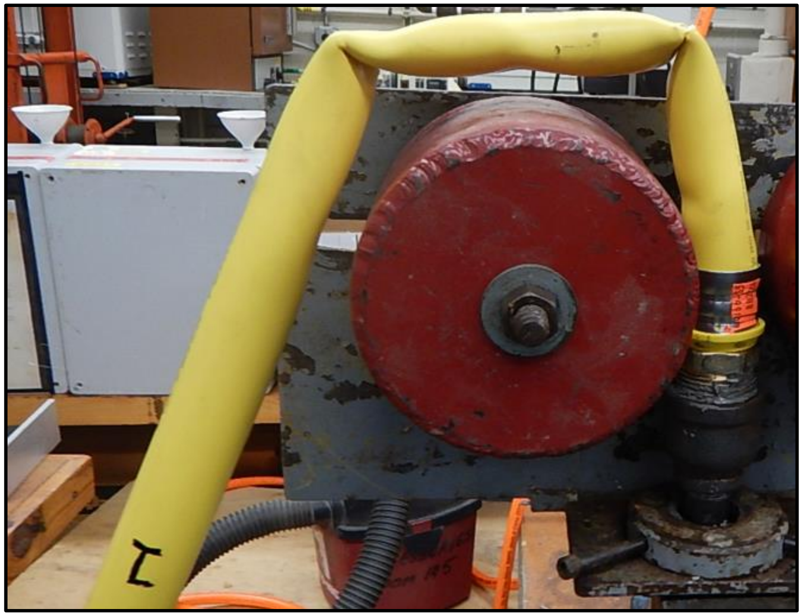
Flexibility of Tubing Test – Clause 5.4.1 & 5.4.2   32-mm (1”)

PEX-AL-PEX piping 32-mm (1”) NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 5” diameter mandrels. Minimum specified bend radius per manufacture’s installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

Shown mounted.

PEX-AL-PEX piping 32-mm (1”) NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 5” diameter mandrels. Minimum specified bend radius per manufacture’s installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

Shown in starting position.



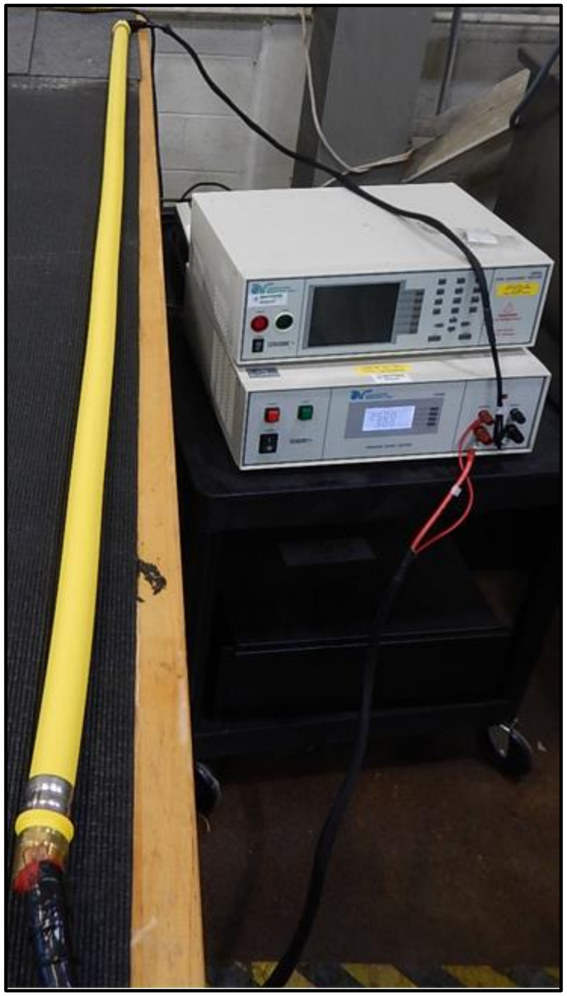
PEX-AL-PEX piping 32-mm (1") NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 5" diameter mandrels. Minimum specified bend radius per manufacture's installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

Shown after six (6) cycles of operation.

PEX-AL-PEX piping 32-mm (1") NPT(M) with end fittings by 2 feet long in length. Test sample mounted between two (2) 5" diameter mandrels. Minimum specified bend radius per manufacture's installation instructions. Test pressure is 1.5 times the rated which equals 108 PSI. Six (6) cycles required.

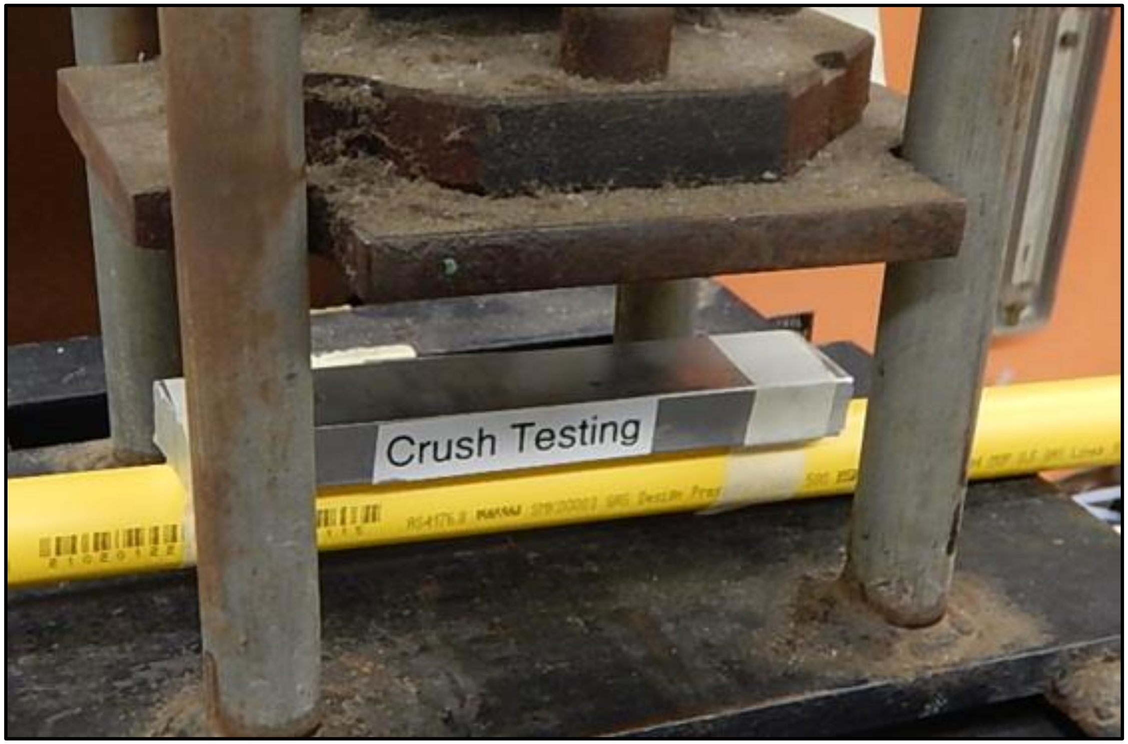
Shown be checked for leakage following the six (6) cycles of operation. Test pressure was equal to 72 PSI (5bar).

Electrical Resistance & Conductivity Test – Clause 5.15 20-mm (1/2”) & 32-mm (1”)

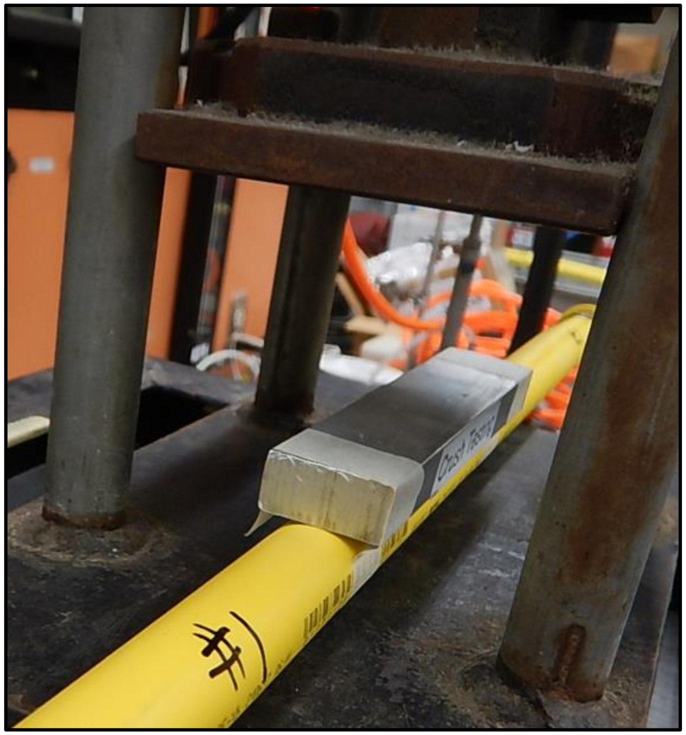


PEX-AL-PEX piping 20-mm (1/2”) NPT(M) and 32-mm (1”) NPT(M) by 6 feet long in length. End fittings applied. The Gas Piping System press fittings are dielectrically isolated from the internal aluminum pipe layer. Resistance readings were recorded to be > 300 M ohms from end fitting to end fitting.

Crushing Strength Test – Clause 5.6 20-mm (1/2")

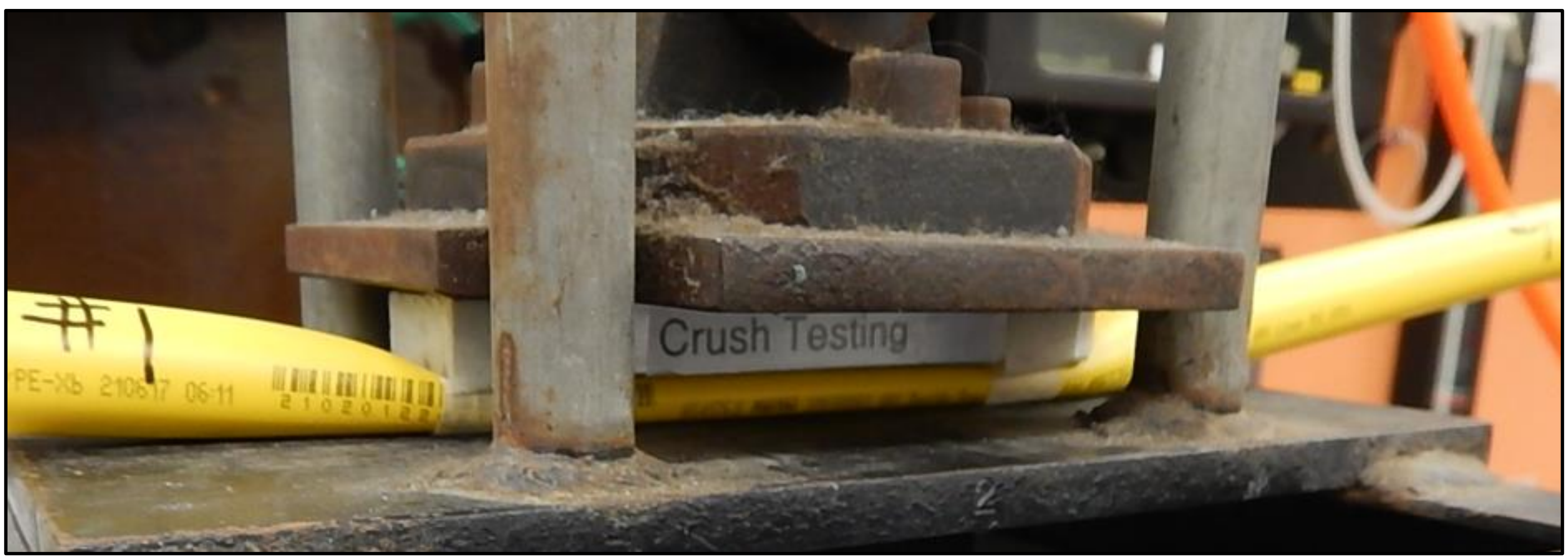


PEX-AL-PEX piping 20-mm (1/2") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN).

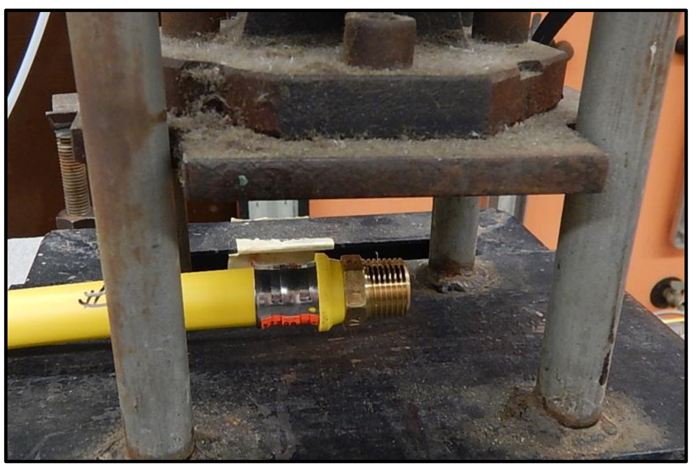


PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Ready to apply the 1000 lb. crushing force as required by Clause 5.6.

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the tubing as required by Clause 5.6.

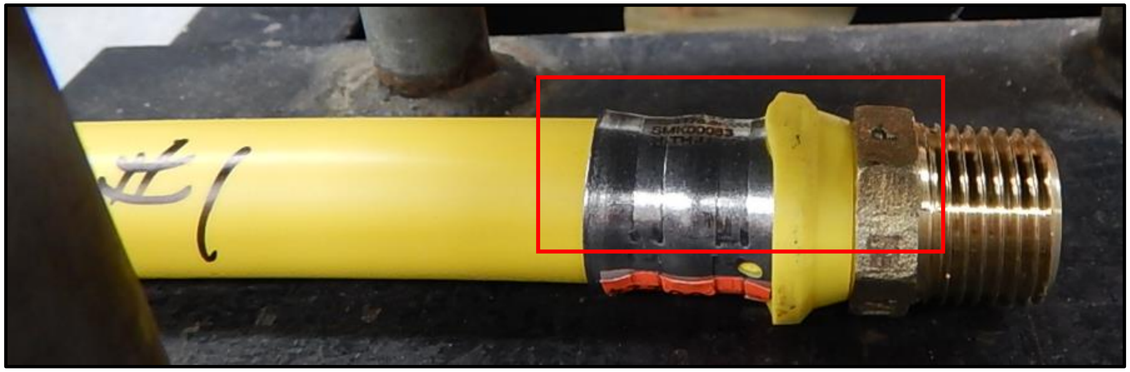


PEX-AL-PEX piping 20-mm (1/2") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the tubing as required by Clause 5.6.

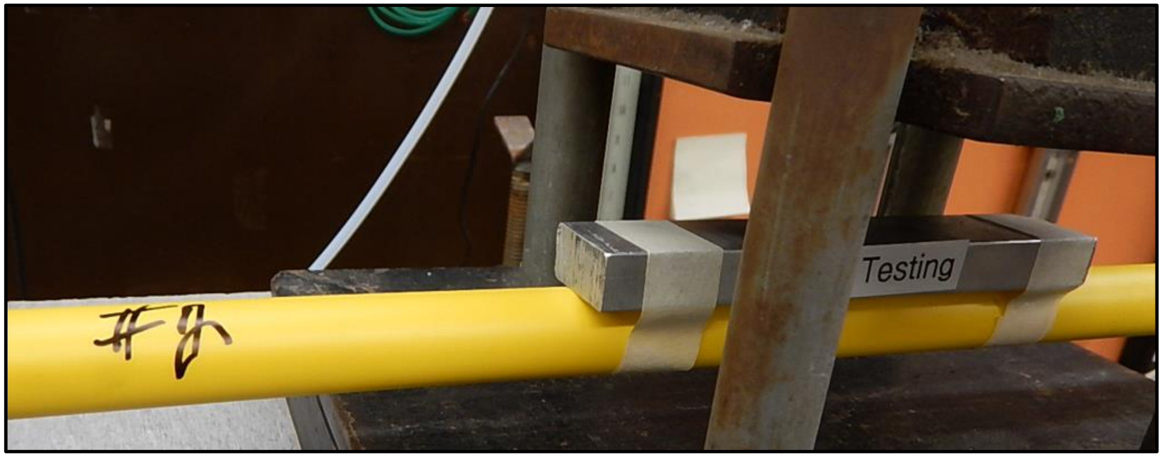


PEX-AL-PEX piping 20-mm (1/2") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6.

PEX-AL-PEX piping 20-mm (1/2") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6.



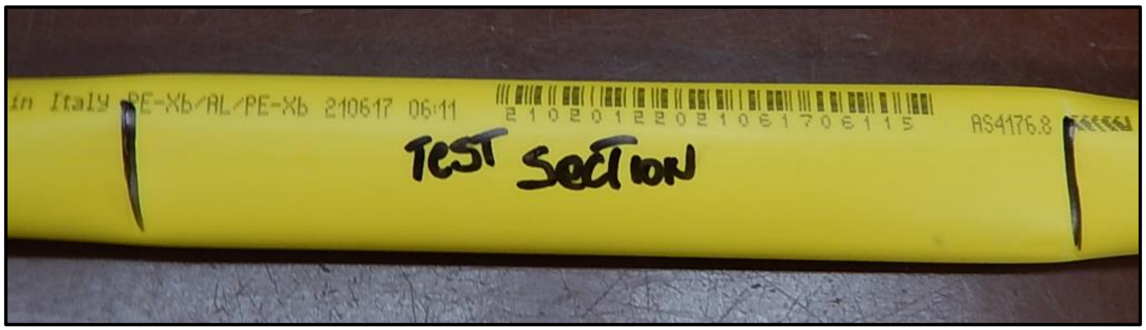
PEX-AL-PEX piping 20-mm (1/2") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The condition of the end fitting after applying the 1000 lb. crushing force as required by Clause 5.6.



PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Test sample #2

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Test sample #2

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the tubing as required by Clause 5.6. Test sample #2



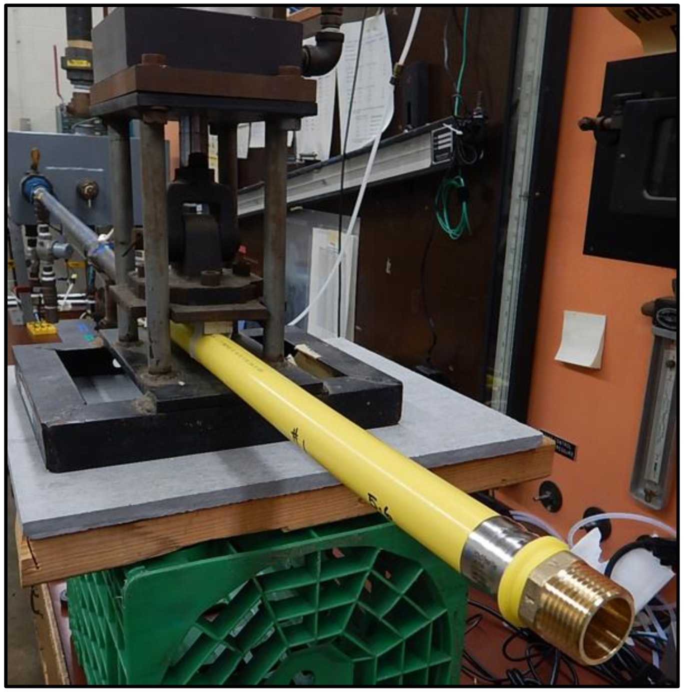
PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the tubing as required by Clause 5.6. Test sample #2

PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6. Test sample #2

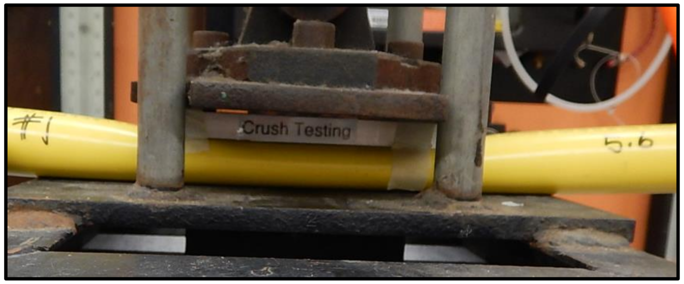
PEX-AL-PEX piping 20-mm (1/2”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6. Test sample #2

Crushing Strength Test – Clause 5.6 32-mm (1”)

PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Test sample #1

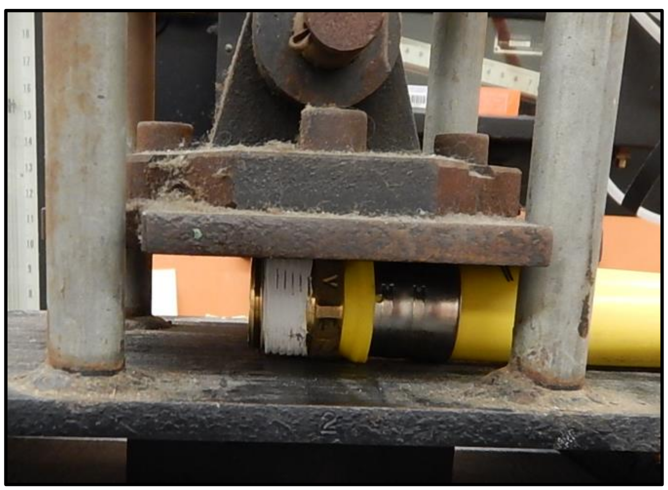


PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Test sample #1



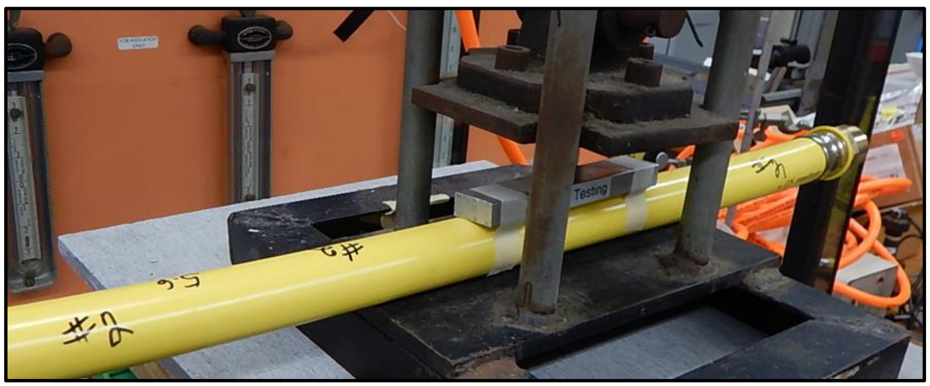
PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Crushing force applied. Test sample #1

PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Crushing force released. Test sample #1



PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6. Test sample #1

PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6. Test sample #1



PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Sample #2

PEX-AL-PEX piping 32-mm (1”) NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). Crushing force applied to the tubing. Sample #2

PEX-AL-PEX piping 32-mm (1") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the tubing as required by Clause 5.6. Test sample #2

PEX-AL-PEX piping 32-mm (1") NPT(M) by 2 feet long in length. End fittings applied. Crushing Force equals 1000 lb. (4.45kN). The 1000 lb. crushing force applied to the end fitting as required by Clause 5.6. Test sample #2

Appendix C

80102353 Intertek Test Results Report

1500 Brigantine Drive
Coquitlam, BC, V3K 7C1

Telephone: 604-520-3321
Facsimile: 604-524-9186
www.intertek.com

February 22, 2022

Letter Report No. 104948454COQ-001
Project No. G104948454

Mr. John Kristoff-Kichka
CSA America Testing & Certification
178 Rexdale Blvd
Toronto, ON M9W 1R3

Subject: CAN/ULC S102-18 Flame Spread Test Results for Jacketed PEXALGAS Metal Tubing.

Dear Mr, Kristoff-Kichka,

This letter concludes and represents the results of the evaluation and tests of the above referenced material to the requirements contained in the following standards:

CAN/ULC S102-18, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.

On February 17, 2022 Intertek Testing Services NA Ltd. conducted a R&D flame spread test program to determine the surface burning characteristics on jacketed PEXALGAS Metal Tubing.

Upon receipt of the samples at the Intertek Coquitlam laboratory, they were placed in a conditioning room where they remained in an atmosphere of 23 ± 3ºC (73.4 ± 5ºF) and 50 ± 5% relative humidity.

For each trial run, two 8 ft. long by sections of tubing were fastened to 24 in. wide by 8 ft. reinforced cement board substrate panels using metal tie wire. The pipe was orientated so they would be in line with each burner port. Three 8 ft. panels were butted together and placed on the upper ledge of the flame spread tunnel to form the required 24 ft. sample length. A layer of 6 mm reinforced cement board was placed over top of the samples, the tunnel lid was lowered into place, and the samples were then tested in accordance with CAN/ULC S102-18.

Flame Spread

The resultant flame spread ratings are as follows:

Sample Material	Flame Spread	Flame Spread Rating
PEXALGAS Metal Tubing 20 x 2	1	N/A
PEXALGAS Metal Tubing 32 x 3	3	N/A

Smoke Developed

The resultant smoke developed ratings are as follows:

Sample Material	Smoke Developed	Smoked Developed Classification
PEXALGAS Metal Tubing 20 x 2	10	N/A
PEXALGAS Metal Tubing 32 x 3	74	N/A

This letter report completes our evaluation covered by Intertek Project No. G104948454.

A series of three test runs of material must be conducted to conform to the requirements of the National Building Code of Canada.

If there are any questions regarding the results contained in this report, or any of the other services offered by Intertek, please do not hesitate to contact the undersigned.

Please note that this Letter Report does not represent authorization for the use of any Intertek certification marks.

Tested and Reported by:	Sean Brewer	Reviewed by:	Greg Philp
Title:	Technician, Building Products Testing	Title:	Reviewer, Building Products Canada
Signature:		Signature	
Date	February 22, 2022	Date:	February 22, 2022

CAN/ULC S102-18 DATA SHEETS

Page **1** of **2**

Standard: ULC S102

Lab ID: Intertek Coquitlam Fire Laboratory
Client: CSA
Date: 17 Feb 2022
Project Number: 104948454
Test Number: 1
Operator: Sean Fewer

Specimen ID and Description:

1/2 inch pex al pex tubing

TEST RESULTS

FLAMESPREAD INDEX: 1.000
SMOKE DEVELOPED INDEX: 10.000

SPECIMEN DATA

Time to Ignition (sec): 120.144
Time to Max Flame Spread (min): 7.586
Maximum Flame Spread (mm): 0.170
Time to 527 C / 980 F (sec): 0.000
Max Temperature (deg F or C as per test standard): 235.020
Time to Max Temperature (sec): 599.145
Total Fuel Burned (cubic feet): 49.383

Flame Spread*Time Area (M*min): 0.409
Smoke Area (%A*min): 15.434
Unrounded FSI: 0.757
Unrounded SDI: 9.930

CALIBRATION DATA

Time to Ignition of Last Red Oak (sec): 47

Calibrated Smoke Area (%A*min): 155.423

15 point Heptane average for E84-19b
5 point Red Oak average for S102

Tested by: SF

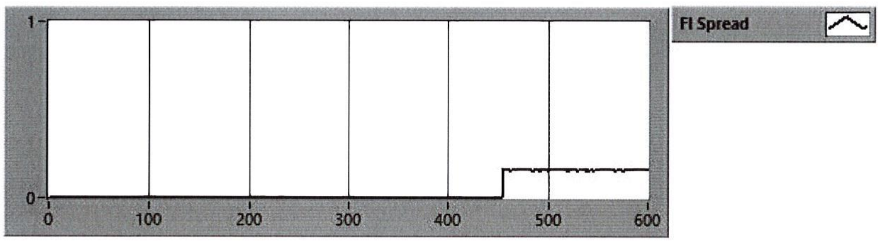
Reviewed by: [signature]

CAN/ULC S102-18 DATA SHEETS

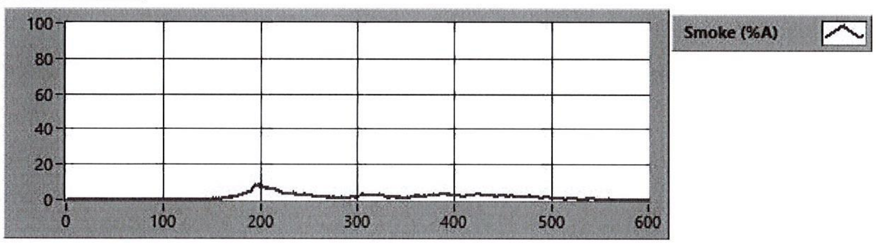
Client: CSA Project Number:

Test Number: 1 Test Standard: ULC S102

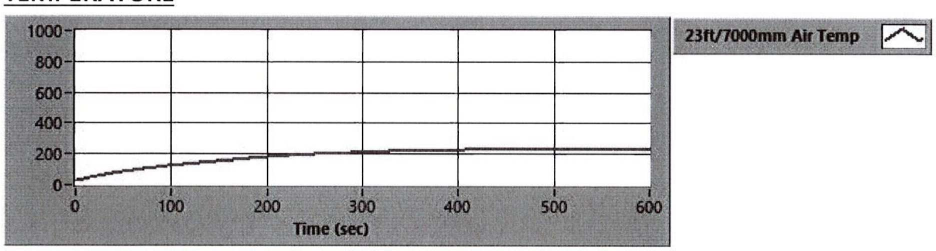
FLAME SPREAD



SMOKE (%A)



TEMPERATURE



Tested by: SF

Reviewed by:

CAN/ULC S102-18 DATA SHEETS

Standard: ULC S102

Lab ID: Intertek Coquitlam Fire Laboratory
Client: CSA America
Date: 17 Feb 2022
Project Number: 104948454
Test Number: 1
Operator: Sean Fewer

Specimen ID and Description:

1 inch pex al pex tubing

TEST RESULTS

FLAMESPREAD INDEX: 3.000
SMOKE DEVELOPED INDEX: 74.000

SPECIMEN DATA

Time to Ignition (sec): 172.917
Time to Max Flame Spread (min): 9.315
Maximum Flame Spread (mm): 0.650
Time to 527 C / 980 F (sec): 0.000
Max Temperature (deg F or C as per test standard): 249.630
Time to Max Temperature (sec): 598.917
Total Fuel Burned (cubic feet): 49.325

Flame Spread*Time Area (M*min): 1.811
Smoke Area (%A*min): 114.409
Unrounded FSI: 3.350
Unrounded SDI: 73.611

CALIBRATION DATA

Time to Ignition of Last Red Oak (sec): 47

Calibrated Smoke Area (%A*min): 155.423

15 point Heptane average for E84-19b
5 point Red Oak average for S102

Tested by: SF

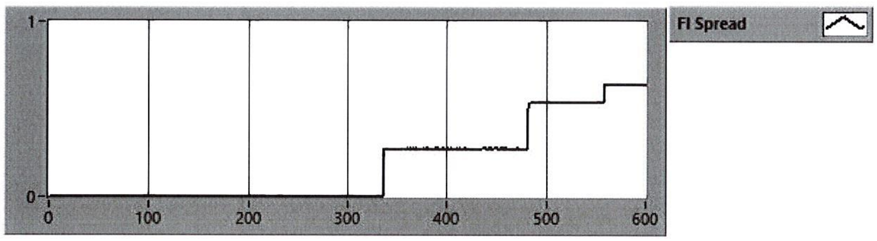
Reviewed by: [signature]

CAN/ULC S102-18 DATA SHEETS

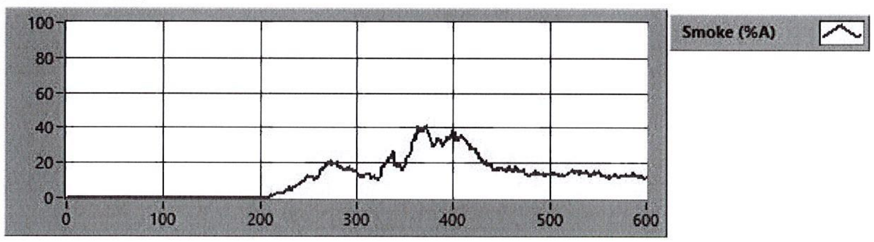
Client: CSA America
Project Number: 104948454

Test Number: 1
Test Standard: ULC S102

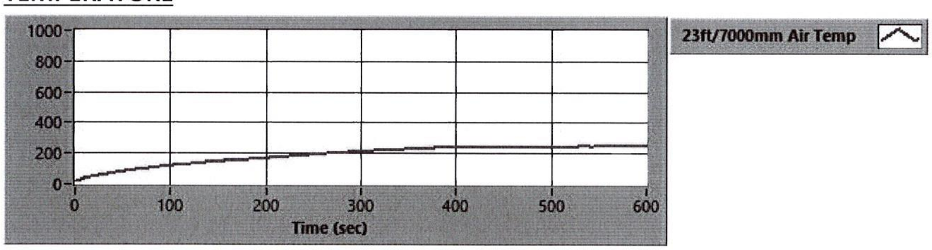
FLAME SPREAD



SMOKE (%A)



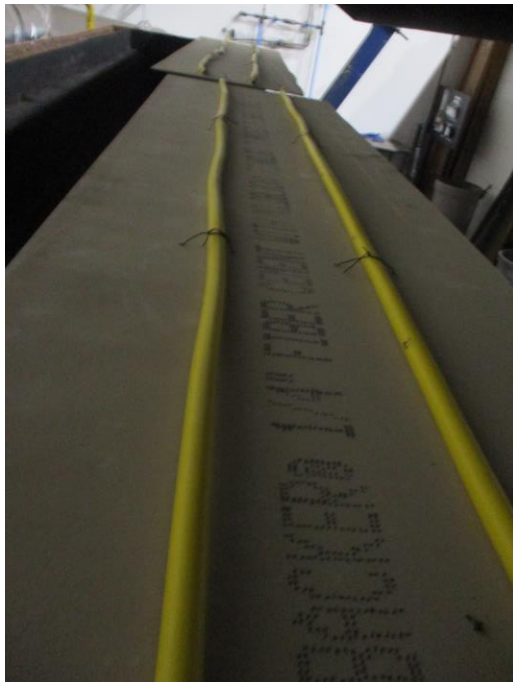
TEMPERATURE



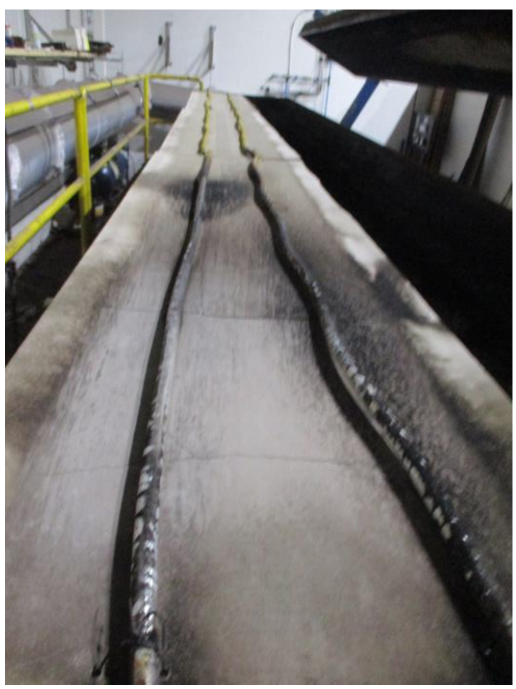
Tested by: ST

Reviewed by: [signature]

Photos



PEXALGAS Metal Tubing 20 x 2 Pre-Test



PEXALGAS Metal Tubing 20 x 2 Post-Test

PEXALGAS Metal Tubing 32 x 3 Pre-Test

PEXALGAS Metal Tubing 32 x 3 Post-Test