APPENDIX A

to the Minutes of the January 29, 1985 Meeting of

SUBCOMMITTEE ON STANDARDS FOR
CONNECTORS FOR GAS APPLIANCES

Note: The following editorial revision was recommended to Accredited Standards Committee Z21 by the subcommittee. This revision applies to the Standard for Flexible Connectors of Other Than All-Metal Construction for Gas Appliances, ANSI Z21.45-1979, and Addenda, Z21.45a-1981 and Z21.45b-1983, plus those revisions recommended to the Z21 Committee by the subcommittee at its April 24, 1984 meeting.

Revisions are underscored. The paragraph denoted as "Remarks" provides explanations for changes not requiring "Rationale" statements.

This revision is being held in abeyance until more substantive revisions are recommended to the Z21 Committee.

PART I

CONSTRUCTION

1.6 FITTINGS - DESIGN AND DIMENSIONS

1.6.4 Each end of the connector shall be equipped with a flare or other union fitting. A quick-disconnect device assembled to the connector shall be considered a union fitting.

REMARKS: This is a clarification of intent and makes this standard consonant with the metal connector standard, ANSI Z21.24.

APPENDIX B

to the Minutes of the January 29, 1985 Meeting of

SUBCOMMITTEE ON STANDARDS FOR
CONNECTORS FOR GAS APPLIANCES

Note: The following revisions are based on the Second Draft of Proposed American National Standard for Connectors for Outdoor Connection of Manufactured (Mobile) Homes to Fuel Gas Supplies, which was distributed for review and comment during February 1984, plus those modifications adopted by the subcommittee at its April 24, 1984 meeting. The proposed standard was recommended by the subcommittee to Accredited Standards Committee Z21.

Revisions to the draft standard are either indicated or underscored, additions are so indicated, and deletions are indicated. The paragraphs denoted as "Remarks" provide explanations for changes not requiring "Rationale" statements.

(Extensively Revised) AMERICAN NATIONAL STANDARD FOR GAS CONNECTORS FOR CONNECTION OF FIXED APPLIANCES FOR OUTDOOR INSTALLATION AND MANUFACTURED (MOBILE) HOMES TO THE GAS SUPPLY

PART I

CONSTRUCTION

1.1 SCOPE

1.1.1 This standard applies to newly produced assembled connectors constructed entirely of new, unused parts and materials. Such connectors are intended for exterior use above ground for making the following nonrigid connections:

a. (Added) Between the gas supply and the gas inlet of a fixed appliance for outdoor installation;

b. Between the permanent gas outlet of a manufactured home community (mobile home park) or individual site and the piping inlet on a manufactured (mobile) home; or

c. Between sections of a multiple section manufactured (mobile) home.

REMARKS:

Z21 Connector Subcommittee Position on Expansion of Scope of Proposed American National Standard for Connectors for Outdoor Connection of Manufactured (Mobile) Homes to Fuel Gas Supplies

The subcommittee, at its January 29, 1985 meeting, expanded the scope of the above proposed standard and retitled it American National Standard for Gas Connectors for Connection of Fixed Appliances for Outdoor Installation and Manufactured (Mobile) Homes to the Gas Supply. The subcommittee agreed this modification need not be distributed for review and comment prior to submittal to the Z21 Committee for the following reason:

A review by the subcommittee of reported field problems with metal connectors design certified under the metal connector standard (Z21.24) which failed after relatively short periods of time were due to their misapplication by using them to connect fixed appliances installed outdoors to a gas supply. This led to recognition by the subcommittee that, although no Z21 standard exists for connectors for outdoor use, there is no technical difference between connectors used to connect fixed appliances for outdoor installation to a gas supply and connectors used to connect manufactured homes to a gas supply.

The subcommittee accordingly expanded the scope of this proposed standard to also cover connectors for outdoor use to connect fixed appliances to a gas supply. The proposed revisions to expand the scope do not change the technical content or test procedures which were previously distributed for review and comment.

Following approval of this proposed standard by the American National Standard Institute, the subcommittee will propose revisions to the metal connector standard, Z21.24, to clarify that connectors covered by that standard are intended for indoor use only.

1.5 INSTALLATION INSTRUCTIONS

1.5.2 The instructions shall include a statement concerning the intended uses of the connector. This statement shall state in effect that the connector is for use only for making:

a. (Added) The gas connection between the gas supply and the gas inlet of a fixed appliance for outdoor installation;

b. The gas connection between the permanent gas outlet of a manufactured home community (mobile home park) or individual site and the gas piping inlet of a manufactured (mobile) home; or

c. A crossover gas connection between sections of a multiple section manufactured (mobile) home.

1.5.6 (Added) The instructions shall include a statement that the connector installation for a fixed appliance for outdoor installation must conform with the National Fuel Gas Code (Z223.1-1984).

1.5.7 The instructions shall include a statement that the connector installation for a manufactured (mobile) home must conform with the Manufactured Home Construction and Safety Standard, Title 24 CFR, Part 3280 [formerly the Federal Standard for Mobile Home Construction and Safety, Title 24, HUD (Part 280)], or when such standard is not applicable, with the Standard for Manufactured Home Installations (Manufactured Home Sites, Communities and Set-Ups), ANSI 225.1-1984 (includes the Standard for Firesafety Criteria for Mobile Home Installations, Sites and Communities, NFPA 501A-1982).

(Proposed 1.5.7 through 1.5.9 become 1.5.8 through 1.5.10 respectively, unchanged.)

1.6 HOMEOWNER'S INSTRUCTIONS

Information for the owner of the manufactured (mobile) home shall be provided with each connector and shall include as a minimum the following:

a. The connector must be maintained so that it is not in contact with the ground or with foreign objects or materials, and, unless used to make a crossover connection, the entire connector must be visible for inspection.

b. The installed connector must not be subjected to sharp bends, kinking, stretching, twisting, repeated movement or vibration or to corrosive materials.

c. The connector must not be reused. if the manufactured (mobile) home is moved. A new connector must be installed if the appliance is changed or the manufactured (mobile) home is moved.

d. The connector must be replaced if it is exposed to fire.

e. The connector must be replaced if the connector or its coating is damaged or deteriorated.

1.7 MARKING

1.7.1 Each connector shall bear a permanent marking, on either a nonremovable ring or a portion of a nonremovable fitting not subject to tool usage, on which shall appear the following:

a. Outdoor Appliance and Manufactured (Mobile) Home Connector.

(Proposed "b" through "f," unchanged.)

PART IV

DEFINITIONS

CONNECTOR, GAS APPLIANCE. A factory-fabricated assembly of gas conduit and related fittings designed to convey gaseous fuel, and used for making connections between a gas supply piping outlet and the gas inlet to an appliance or a manufactured (mobile) home. It is equipped at each end for attachment to standard taper pipe threads. A gas appliance connector is not for vibration isolation.

(Proposed "1" through "5," unchanged.)

6. Connector for Fixed Appliance for Outdoor Installation. A connector for use between the gas supply and the gas inlet of a fixed appliance installed outdoors.

APPENDIX C

to the Minutes of the January 29, 1985 Meeting of

SUBCOMMITTEE ON STANDARDS FOR
CONNECTORS FOR GAS APPLIANCES

Note: The following draft revisions were adopted by the subcommittee for distribution for review and comment. These revisions apply to the Standard for Connectors for Movable Gas Appliances, ANSI Z21.69-1979, and Addenda, Z21.69a-1983, plus those revisions adopted by Accredited Standards Committee Z21 by letter ballot dated December 28, 1984.

PART I

CONSTRUCTION

1.6 FITTINGS

1.6.4 ~~At least one end of the connector shall be equipped with a permanently attached union fitting.~~ Each end of a connector shall be equipped with a flare or other union fitting. A quick-disconnect device assembled to the connector shall be considered a union fitting.

RATIONALE: A union fitting is needed for each end of a connector to eliminate torque problems during installation.

1.7 INSTRUCTIONS

1.7.6 **The instructions shall include** ~~a caution to the effect that if the connector is used with a quick-disconnect device, reference should be made to~~ information on the **capacity in Btu per hour of the** ~~quick-disconnect device.~~ connector both with and without the quick-disconnect device.

RATIONALE: This is a clarification of intent.

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Gama

50th Anniversary

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February 20, 1985

TO: GAS APPLIANCE CONNECTOR GROUP of the
GENERAL PRODUCTS DIVISION
(Delegates, Alternates, and Technical Representatives)

Z21 Connector Subcommittee Task Force

At the January 29, 1985 meeting of the Z21 connector subcommittee, a task force consisting of this Group's Technical Committee and staff members of the Consumer Product Safety Commission was established to evaluate the need for developing revisions or additions to the Z21 standard for metal connectors for gas appliances. In particular, CPSC believes that there is a need to improve the protective coating used on flexible connectors.

CPSC staff has requested that a meeting be scheduled to review the various tests specified in the Z21.24 standard and discuss tests which would verify coating integrity. This meeting is tentatively being scheduled for March 15 at the GAMA offices in Arlington, Virginia. If you are unable to attend this meeting, please let us know as soon as possible, along with your suggestion for an appropriate alternative date.

Based on the discussion at the January 29 Z21 connector subcommittee meeting, consideration should be given to methods of determining various aspects of the protective coating, such as uniformity, continuity, adhesion and durability. The purpose of the proposed meeting would be to more clearly focus on what methods should be explored. This would provide guidance to manufacturers in conducting in-house evaluations of possible alternative methods of verifying the integrity of protective coating.

While it will be difficult to discuss possible alternate methods without the benefit of information obtained from your own test evaluations conducted in your test labs, this meeting will help ensure a common direction in that testing. The establishment of guidelines for test evaluations will provide a common base for all the test evaluation work that will be done and may simplify the consideration of the information generated by that work.

Frank A. Stanonik
Associate Director of Technical Services

FAS/lsg

GAS APPLIANCE MANUFACTURERS GAMA

cc: Sid, WHK, (Tom C.) Ron M.

ACCREDITED STANDARDS COMMITTEE ON PERFORMANCE AND INSTALLATION OF GAS BURNING APPLIANCES AND RELATED ACCESSORIES

HOWARD I. FORMAN, Chairman - P. O. Box 66, HUNTINGDON VALLEY, PA 19006 - (215) 947-1151
W. H. JOHNSON, Vice Chairman - 1301 W. 22nd STREET, #610, OAK BROOK, IL 60521 - (312) 986-1800
F. G. HAMMAKER, Adm. Secy. - 8501 E. PLEASANT VALLEY RD., CLEVELAND, OH 44131 - (216) 524-4990

'85 -1

February 26, 1985

Mr. J. P. Langmead
Vice President
Gas Appliance Manufacturers
Association, Inc.
1901 N. Fort Myer Drive
Arlington, VA 22209

Mr. William W. Walton
Associate Executive Director for Engineering
U. S. Consumer Product Safety Commission
5401 Westbard Avenue, Room 738
Bethesda, MD 20207

Gentlemen:

At the Z21 connector subcommittee's January 29, 1985 meeting, after review of Items 3, 4 and 6 all of which dealt with possible failures of connector coatings, the subcommittee agreed a working group should be established to study connector coatings for connectors for indoor and outdoor use and to determine the necessity of developing tests for such coatings. If it is determined such tests are necessary, the working group is to develop them.

This working group is to consist of members of the Technical Committee of the Connector Division of the Gas Appliance Manufacturers Association (GAMA) and staff members of the U. S. Consumer Product Safety Commission.

It is expected that a report from the working group will be available for the next connector subcommittee meeting, presently scheduled for October 29-30, 1985.

Best regards,

Kay E. Broughton

KAY E. BROUGHTON
Standards Engineer

cc: R. Derringer

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SID, TOM

1 MAR 1985

85-136

NERO, WRO, SERO, MWRO. 95626
(Information STPO)
Through: Otto Hall, EX-P HIGH
FROM: David W. Thomas, CACA
Betty Pecs, CACA 2-4 weeks

3-492-6608

Flexible Gas Connectors

Your staff collected a number of flexible gas connectors in response to our STI's dated August 3, 1984. CACA had received information that flexible gas connectors tightly coiled in packaging for sale at the retail level could possibly experience some damage as a result of the coiling process which could lead to early failure.

We believed that the connectors might be overstressed (flexed) during the packaging as the bend radius of the inner coil could be significantly smaller than that required to be tested in the ANSI Standard For Metal Connectors for Gas Appliances Z21.24-1981 Part 4.10 Resistance to Ammonia Atmosphere. This standard was revised on 10/3/73 to include a stress corrosion test following complaints of field corrosion problems. A field survey at that time established that stress corrosion of the connectors was caused by exposure to ammonia found in household cleaning agents and to some extent in the atmosphere. Manufacturers generally went to plastic coatings on the connectors to comply with the performance requirements of the Standard. (Further background can be found in the Investigation Guideline for Flexible Gas Connectors dated November 27, 1984).

Packaging, therefore could introduce permanent stresses, greater than those induced in the test. The overstressing could result in stress corrosion of the connector when exposed to ammonia vapors in the house or atmosphere.

ESES has completed testing of the samples. A copy of the results are attached. Attachment 1. These results have been forwarded to the manufacturer by the writer, who has advised the firms that in view of the failures, a representative from the Regional Office would be contacting them to discuss manufacturing, quality control and packaging procedures.

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For your information, we are attaching a copy of a table (Attachment 2) which summarizes the test findings of all connectors sampled from each of the identified manufacturers. As you can see, there were failures across the board i.e. failures of connectors from each manufacturer. (Do not discuss the test findings of other manufacturer's units).

This assignment requests the inspection of the firms on the attached list, to determine why so many connectors are failing and whether or not corrective action should be taken.

The connectors failed because there were stressed areas in the brass and ammonia was able to penetrate the coating and get to the stressed brass. Many of the coiled connectors were stressed in the coiling operation and also by bending around the 2 1/4 inch diameter mandrel, which is part of the ammonia test. Failures occurred in these deliberately stressed areas, but more significantly, half the failures occurred in the areas that were not deliberately stressed. Of course, there had to be breaks in the coating to permit the ammonia to get to the brass from the outside of the connector at every place where failures occurred.

This SII is designed to gain information in order to help the staff to determine how stresses were introduced in the connectors, how the coating was applied, how breaks were introduced into the coating and whether or not manufacturers adequately test their connectors. If the breaks occurred during the manufacturing process, how did so many connectors slip through the manufacturing and quality control process?

Therefore, please inspect the manufacturer and observe the manufacturing process, the coating process, the application of the end fittings, the inspection, testing and packaging procedures.

1. Describe the forming, cutting and annealing processes? What kind of material is used (brass)? Get specifications. Who is responsible for the manufacturing process (engineer, metallurgist)? What temperatures are reached during the annealing process? How long are the connectors held at these temperatures? How long are they cooled and under what conditions?
2. Observe the post annealing process to try and determine what might introduce stress following the annealing process, such as bending or the use of clamps to hold the connectors.
3. In the coating process, how do they assure complete and continuous coating? Identify the composition of the coating.
4. Do they clamp the connector when introducing the flared end, coiling, or packaging?
5. Describe how the connectors are held when putting the end fittings on.
6. How is the final connector tested for integrity and resistance to ammonia atmosphere?

7. What tests are performed on every connector, or selected connectors? Obtain copies of tests performed. Is there a test for resistance to sulfur compounds? Obtain a copy of quality control procedures, test forms and sampling procedures.
8. If connectors are selected for testing, what sampling techniques are used?
9. Determine if the manufacturer coils and packages the connectors. Observe the process. If the connectors are packaged at another facility, arrange to observe the packaging process at that facility. Does the manufacturer test connectors after they have been coiled and packaged? Photograph?
10. Please use a magnifying glass to examine from 5-10 connectors between coiling and insertion into the packages to see if you can visibly observe any breaks in the coating.
11. Please obtain complete details of the firm's distribution of flexible connectors. Who are their customers?
12. What is the firm's explanation for the failures? What actions are they taking to correct the situation?
13. Samples: Please obtain 1 sample consisting of 3 units of 4 foot long straight connectors. Ship in straight lengths to Betty Fees through the Sample Custodian.
14. Please obtain copies of any complaints or lawsuits.
15. Identify their product return system, rate of return and test reports.
16. Identify by name and address the liability carrier.

Please assign field office investigation numbers and notify the contact person if a firm refuses to provide this information.

For your information the Commission staff met on January 29th with the Connector Subcommittee of the ANSI Z21 Accredited Standards Committee at the AGA headquarters in Arlington, Virginia to discuss this problem.

We will hold a conference call to discuss this STI prior to your closing the inspections.

GLOSSARY

Stress Corrosion: A type of corrosion that causes a metal to crack when it has residual stresses and is exposed to a specific corrosive environment. Frequently the metal will resist that environment in the absence of residual stresses or will corrode in a different mode.

Annealing: A process involving the heating of materials for prescribed periods of time to produce desired changes in properties; such as, the relieving of stresses introduced by the deformation of that material.

Coating: A surface material applied to another material to protect it from certain factors in the environment in which it is to be exposed.

Residual Stress: This is the stress that remains after the stressing force is removed.

Manufacturers of Flexible
Gas Connectors

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2.

3.

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NERO 4.

SWRO 5.

MWRO 6.

CPCA:B.FEES:ld:2/21/35

REPORT

Meeting of Working Group of the Z21 Subcommittee on Standards for Gas Appliance Connectors

Held at
GAMA Headquarters, Arlington, Virginia
Friday, March 15, 1985

ROLL CALL: The meeting was called to order at 11:00 a.m. EST. The following were in attendance:

Fred Hyman	Brass-Craft Manufacturing Company
Tom Cooper	Consumer Product Safety Commission
Sydney Greenfeld	Consumer Product Safety Commission
Ron Medford	Consumer Product Safety Commission
Jerome J. Segal	Dormont Manufacturing Company
Marvin Leffler	Flexible Fabricators, Inc.
Randell M. Smith	United States Brass Division of Household International

Guests

Bob Crawford	American Gas Association Laboratories
Harry A. Paynter	Gas Appliance Manufacturers Association
J. P. Langmead	Gas Appliance Manufacturers Association
Frank A. Stanonik	Gas Appliance Manufacturers Association (Acting Secretary)

The working group discussed the assignment which had been given to it by the Z21 connector subcommittee. Mr. Ron Medford, CPSC, noted that, from the CPSC standpoint, the objective is to review the Z21 connector standard and determine what tests may need revision, or need to be added, insofar as addressing the protective coatings applied to connectors. While there was general concurrence with this comment, it was pointed out that, as presently written, the standards address newly manufactured, [redacted]

Mr. Smith also agreed to attempt to find the supporting work and data that was used as the basis for the development of the present ammonia atmosphere test in the Z21 connector standards. Mr. Bob Crawford, American Gas Association Laboratories, also volunteered to gather whatever information the Laboratories have on the development of that same test.

The next meeting of the working group was tentatively scheduled for June 13, 1985.

The meeting was adjourned at 2:15 p.m.

Respectfully submitted,

Frank A. Stanonik
Acting Secretary

FAS/vly

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By WW Date 6-28-88

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APR 9 1985

Betty Fees, CACA
THRU: Nick Marchica, EX-P
THRU: James Price, Director, ESMT
Frank E. Brauer, ESMT

Metallurgical Analysis of Failed Generic/Coiled Flexible Gas Connectors, PSA Request #1441

REQUEST

PSA 1441 requested a metallurgical analysis of flexible gas connectors that had failed the test criteria of Part 4.10 "Resistance to Ammonia Atmosphere" of ANSI Z21.24-1981, Standard for Metal Connectors for Gas Appliances, in tests conducted at ESEL. The purpose of this analysis was to determine whether or not these stress induced failures of the brass are caused by either the manufacturing or packaging processes.

BACKGROUND

Flexible brass gas connectors can stress corrode in the presence of ammonia when the brass is in a state of stress. This stress can be a residual effect of the manufacturing process. In an effort to remove the residual stresses that develop in manufacturing, the connectors are annealed (heated) above the recrystallization temperature of the brass. The manufacturers claim that the independent distributors are inducing new stresses into the connectors via the packaging process which often involves tightly coiling the connector. In an effort to resolve this claim, CACA tasked ES to sample and test 20 new connectors from various manufacturers. Tests were conducted under the conditions of Z21.24-1981 (concentrated ammonia in water exposure) with the connectors in a tightly coiled (2½ inch diameter) configuration similar to that occurring in packaging. During this test eleven of the 20 failed with through the wall stress corrosion cracks. These results were presented in an ES memorandum to Betty Fees from Sidney Greenfeld dated December 11, 1984.

In reviewing the above results, ESMT suggested to CACA that a metallurgical evaluation be undertaken to confirm that the stresses were induced from the coiling (packaging simulation) and not from an inadequate anneal after manufacture which could have had the same effect. CACA agreed that this additional work was necessary and generated the subject PSA Request 1441. ES tasked the ARTECH Corporation to perform a metallurgical analysis of the eleven failed connectors to determine if the brass had been properly annealed after manufacture. Additionally they were asked to comment on the integrity of the coatings.

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DISCUSSION

ARTECH analyzed the failed connectors using optical microscopy and surface hardness tests. These examinations were made in regions adjacent to as well as away from the stress corrosion crack failures. ARTECH's major findings were: (1) that the connectors were properly annealed after manufacture, which indicates that the residual stresses are being developed in the packaging process; and (2) that the coatings easily cracked after coiling, exposing the brass to the ammonia atmosphere. The coatings appear to be a major deficiency, lacking both the ductility to deform without damage when the connector is bent as well as good adhesion to the metal surface.

Discussion with ARTECH during this investigation brought to light the important consideration that annealing may not be the best means of removing residual stresses from the brass. This is because an annealed connector will be susceptible to the reintroduction of residual stresses since the annealing process, while eliminating the accumulated residual stresses, substantially lowers the elastic limit of the brass. Residual stresses develop in coiling (packaging) when the elastic limit is exceeded. Thus, any lowering of the elastic limit increases the level of residual stresses when coiling occurs. It appears that a stress relief heat treatment, which is done below the recrystallization temperature of the brass, would be a more appropriate means of removing residual stresses. There would be no lowering of the elastic limit. Without this lowering of the elastic limit, the connectors would be less susceptible to the development of residual stresses during packaging or handling. The approach needs to be examined further by the manufacturers to determine its effectiveness. Although a proper stress relief heat treatment would reduce the residual stresses developed during packaging, there is no guarantee that it would eliminate them.

CONCLUSION

ARTECH's major conclusions were:

(1) The brass connectors did fail the ANSI Z21.24 test by the stress corrosion mechanism.

(2) The coatings did not protect the stressed brass from the ammonia.

(3) Most cracking occurred near the coiled areas with sporadic cracks occurring throughout the connector (a consequence of handling and straighting).

(4) The brass connectors were fully annealed after manufacture.

ESMT concurs with these conclusions and would further add that the annealing of the brass connectors after manufacturing contributed to the development of residual stresses during the coiling process because of the lowering of the elastic limit.

SUMMARY

The flexible connectors that failed in ESEL ammonia exposure tests were properly annealed after manufacture. The failure of the connectors was a result of a build-up of residual stresses in the coiled areas (packaging simulation) and a break down of the coating system. The build-up of residual stresses could possibly be minimized by a stress relief heat treatment after manufacturer as well as by avoidance of the use of sharp radii in packaging coils. The coatings need to be substantially improved to enhance their adhesion and ductility while maintaining an impermeability to ammonia.

Enclosure: Metallographic Examination and Evaluation of Eleven Failed (New, Unused) Corrugated Metal Connectors for Gas Appliances by Jean Bernshtayn and Paul J. Lare, ARTECH, March 15, 1985

cc: J. Hoebel, EX-P
R. Medford, EX-P
D. Thome, CA

bcc: Subject
Deppa
ES
Neily
FBrauer:jj/4/5/85

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UNITED STATES GOVERNMENT

Memorandum

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

TO : Paula Present, EPHA

DATE: April 16, 1985

FROM : George W. Rutherford, Jr., EPDS

SUBJECT: Status of Data Collection Effort on Flexible Gas Connectors

This memorandum provides a status report on the data collection activity on flexible gas connectors.

A total of 37 fire departments, seeing a total of over 60,000 fires annually, have been approached and have agreed to participate in the program.

Seventeen gas utilities have been contacted. Thirteen of these, serving approximately 11,000,000 customers, have agreed to participate.

In addition, the State Fire Marshalls for Ohio, California, Washington, Oregon, and Utah have been contacted and agreed to help. Contact has been made with two suppliers of liquified propane gas, as well.

So far, few cases have been found.

Following is a breakdown of the number of cases received from each of several types of sources:

In Scope of Study Framework:		5 cases
Fire Departments	1 Case	
Gas Utilities	4 Cases	
Outside Scope of Study Framework:		18 Cases
State Level Organizations	7 Cases	
Newsclips	7 Cases	
Cases from Fire Departments, and Gas Utilities, which predate the Project	4 Cases	

Altogether, there have been 23 cases initiated, five of which are in scope of the study period and plan.

Attached for your information are lists of the contacts, by category. We anticipate that some additional sources may be added.

I am concerned that we may get considerably fewer cases than anticipated but, as you can see, it doesn't appear to be for want of trying. Please discuss this with the team and provide me with any constructive suggestions you and they may have.

Attachments

FIRE DEPARTMENTS CONTACTED AS OF APRIL 9, 1985

City/Department	Number of Fires
Philadelphia, Pa.	3,547
Skokie, Ill.	2,000
Saginaw, Mich.	1,000
West Lake, Ohio	1,500
Maple Heights, Ohio	500
St Paul, Minn.	6,700
Richfield, Minn.	600
Minnetonka, Minn.	600
Riverview Garden, Mo.	725
Baytown, Tx.	500
Bellaire, Tx.	934
New Caney	300
Tulsa, Okla.	11,247
Jefferson Parish, La.	6,500
Fulton County, Ga.	3,000
Dekalb County, Ga.	1,700
Gwinnett County, Ga.	515
Atlanta, Ga.	5,000
Los Angeles Fire Commission, Ca.	unknown
Los Angeles, Ca.	unknown
Olympia, Wa.	1,000
Gig Harbor, Wa.	750
Kenmore, Wa.	600
Redmond, Wa.	800
Portland, Ore.	2,575
Clark County, Wa.	1,133
Clark County, Wa. Fire District #5	unknown
Beverly Hills, Ca.	175
Brea, Ca.	276
Coronado, Ca.	81
Hawthorne, Ca.	384
Covina, Ca.	2,662
Industry, Ca.	750
Oceanside, Ca.	619
Montebello, Ca.	1,000
Oxnard, Ca.	922
Memphis, Tenn.	unknown
TOTAL KNOWN	60,595

GAS UTILITIES CONTACTED AS OF APRIL 9, 1985

Gas Utility	Number of Customers
Brooklyn Union Gas Company	1,500,000
Philadelphia Gas Company	500,338
Northern Illinois Gas Company	1,489,793
East Ohio Gas Company	930,076
Northern States Power Company	250,000
Oklahoma Natural Gas	640,000
Lone Star Gas	420,000
Atlanta Gas Light	950,000
CAL-GAS	350,000
Southern California Gas Company	3,000,000
Northwest Natural Gas Company	200,000
Washington Natural Gas Company	500,000
Washington Water Power Company	unknown
TOTAL KNOWN	10,730,207

Gas Utilities contacted, but which would not provide information

Name	Location
Pacific Gas and Electric	Northern California
St Louis Gas (May not be actual company name)	St. Louis, Missouri
Minnegasco	Minneapolis, Minnesota
Columbia Gas	Columbus, Ohio

STATE ORGANIZATIONS CONTACTED AS OF APRIL 9, 1985

Ohio State Fire Marshal

California State Fire Marshal

Utah State Fire Marshal

Washington State Fire Marshal

Oregon State Fire Marshal

Oregon Fire Marshal's Association

Oregon State Police Arson Division

OTHER SOURCES CONTACTED AS OF APRIL 9, 1985

Georgia Gas Inc., Union City, Ga. (LP Distributor)
Greens Fuel Company of Ga., Lawrenceville, Ga. (LP Distributor)

COOPER

1901 North Moore Street • P.O. Box 9245 • Arlington, Virginia 22209 • 703/525-9565

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May 2, 1985

TO: Working Group of the Z21 Subcommittee on Standards for Gas Appliance Connectors

Mr. Randy Smith
United States Brass
Division of Household International
P.O. Box 1031
Commerce, TX 75248

Mr. Fred Hyman
Vice President-Manufacturing
Brass-Craft Manufacturing Co.
27700 Northwestern Highway
Southfield, MI 48034

Mr. Marvin Leffler
President
Flexible Fabricators, Inc.
35-18 37th Street
Long Island City, NY 11101

Mr. Jerome J. Segal
President
Dormont Manufacturing Company
5601 Butler Street
Pittsburgh, PA 15201

Mr. Sam Foti
President
Hose Master Incorporated
1267 Babbitt Road
Cleveland, OH 44132

Mr. Sydney Greenfeld
Consumer Product Safety Commission
5401 Westbard Avenue
Bethesda, MD 20207

Mr. Tom Cooper
Consumer Product Safety Commission
5401 Westbard Avenue
Bethesda, MD 20207

Mr. Ron Medford
Consumer Product Safety Commission
5401 Westbard Avenue
Bethesda, MD 20207

Information on Ammonia Atmosphere Test

As discussed at the working groups March 15, 1985 meeting, attached are copies of some background information on the ammoni atmosphere test presently specified in the Z21 connector standards. The A.G.A. Laboratories Report No. 1445 was provided by Mr. B. W. Crawford. The March 17, 1976 letter to Mr. Dennis Blankenship of U.S. Brass and the survey of household cleaning products were provided by Mr. R. Smith. In his cover letter, Mr. Smith also noted:

/Continued . . .

"If the corrosion rate is assumed proportional to the ammonia concentration, then to simulate field conditions (25 years) with an 18 hour ammonia test the concentration should be reduced by a factor of 9.8. That is, the current strength ammonia (28°) should be mixed 9.8:1, water to ammonia. A 500 ml. solution would then mix approximately 46 ml. of ammonia and 454 ml. of water."

Frank A. Stanonik
Associate Director of
Technical Services

FAS/vly
Attachments

APR 11 1985

AGA ... Association Laboratories

April 8, 1985

Mr. Frank A. Stanonik
GAMA
1901 N. Moore Street
Arlington, VA 22209

Dear Frank:

At the Z21 Connector Working Group Meeting held in your offices on March 15, I was requested to review our records and attempt to determine the origin of the "Resistance to Ammonia Atmosphere" test which presently appears in Z21.24.

I found that the present test is based on experimental work conducted by the A.G.A. Laboratories Standards Investigation Activities Department in 1965-66 at the request of the Z21 Connector Subcommittee. The results of this work were reported in our Report No. 1445 which was reviewed by the Subcommittee at its December, 1966 meeting as part of Agenda Item 9.

At that meeting, the Subcommittee adopted for industry review and comment a proposed ammonia test based on our report. Unfortunately, the literature does not indicate rationale for the specific ammonia concentration or exposure time.

I am enclosing a copy of our Report No. 1445 entitled "Standards Department Investigation of External Corrosion of Flexible Connectors". Please let me know if additional information is requested.

Best regards,

Bob

B. W. CRAWFORD

cc: S. L. Blachman

(FOR COMMITTEE USE ONLY)

STANDARDS DEPARTMENT INVESTIGATION OF EXTERNAL CORROSION OF FLEXIBLE CONNECTORS

November, 1966

Report No. 1445

AMERICAN GAS ASSOCIATION LABORATORIES

1032 EAST 62nd STREET CLEVELAND 3, OHIO

Standards Department Investigation of
External Corrosion of Flexible Connectors

Report No. 1445 Job No. T206-

Purpose: To develop a corrosion test which would indicate the susceptibility of Admiralty brass connectors to external corrosion from ammonia and household cleaners, and to determine the degree of protection afforded by double-wall construction and various types of external coatings.

Summary: Except for connector Q, all connectors examined during this investigation were two foot long Admiralty brass connectors, all of which were supplied by the same manufacturer, included an assortment of double-wall, single-wall, bright dipped, oxide coated (before bright dipping) and polyvinyl chloride coated connectors. Connector Q supplied by a different manufacturer, was a bright dipped yellow brass connector with an extra thick polyvinyl chloride coating.

The connectors were examined for residual stress, and stress corrosion resulting from soap solutions and ammonia vapors. The coatings were examined for flaws such as cuts, pinholes and thin spots. They were also checked for permeability from liquid ammoniated cleaners.

The results indicate that polyvinyl chloride coated connectors of either type are more resistant to corrosion than uncoated ones. The P.V.C. coated bright dipped connectors examined proved to be superior to the oxide coated connectors with the same type of P.V.C. coating.

The one double-wall connector examined was apparently superior to the uncoated single-wall connectors in that it did not leak after being exposed to ammonia vapors for 140 hours. However, examination after the 140 hours of exposure revealed that the external brass wall had cracked in several spots. The aluminum internal wall prevented leakage.

Recommendations:

It is recommended that the corrosion test outlined in Appendix A be incorporated into the American Standard Listing Requirements for Metal Connectors for Gas Appliances as an optional test for corrosion resistant connectors.

Requested By: Subcommittee on Listing Requirements for Connectors for Gas Appliances

Dates of Work: May - 1965
July - 1966

Test Work By: L. Hassell
Report By: L. Hassell
Edited By: S. L. Blachman

AMERICAN GAS ASSOCIATION LABORATORIES
CLEVELAND, OHIO 44103
NOVEMBER, 1966

TABLE OF CONTENTS

1. HISTORY

1.1

At the October 19-20, 1961 meeting of the Subcommittee on Listing Requirements for Connectors for Gas Appliances, the subcommittee considered the problem of external corrosion of flexible metal connectors. Various members of the group reported that they experienced failures from external corrosion caused by household cleaners containing ammonia, chlorine compounds in paint removers and paint cleaners, and even from the green soap solution used by some utilities to check for leaks. Following an extensive discussion of the problem the subcommittee requested that the Laboratories conduct a standards investigation to compare the resistance to external corrosion between coated and uncoated connectors, where available, of the single-wall and double-wall type. The Laboratories were also requested to explore the relative merits of 70-30, 85-15, and Admiralty brass from the standpoint of their resistance to corrosion.

Subsequently, it developed that Con-Gas Service was investigating this problem. On May 19, 1964, the subcommittee reviewed and discussed Con-Gas Service Corporation Research Report No. 48, "Stress Corrosion Cracking of Brass Tubing Used in Flexible Metal Gas Appliance Connectors." This report described tests that had been conducted to determine the effect of cleaning compounds on connectors fabricated from both red brass and yellow brass flexible tubing having no external protection and on connectors fabricated of yellow brass flexible tubing having a plastic coating. The report included a suggested testing procedure to test connectors for resistance to corrosion by cleaning compounds and included a recommendation that steps be taken to urge revision of the metal connector listing standard to require provision of external corrosion protection on all convoluted tubing used for appliance connectors. The report also pointed out that all bright dipped connectors were subject to corrosion by cleaning compounds.

After considering the Con-Gas Research Report No. 48, the subcommittee requested the Laboratories to conduct tests guided by the procedure set forth in the report. This information was to be combined with the data from the previously requested investigation and presented in a report to the subcommittee.

From an examination of the American Gas Association's January, 1966 Directory, and correspondence with the manufacturers, the Standards Investigation Activities Department determined that it would not be possible to get identical connectors fabricated from different brasses from any one manufacturer. It had been pointed out to the Appliance Connector Subcommittee at their January 25-26, 1966 meeting that without identically manufactured connectors, any comparison between the corrosion characteristics of two different brasses would be subject to question, since the extent to which results of manufacturing techniques affect the characteristics of the connector could be more significant than the difference in material. It was also noted that there are no connectors either single or double-wall listed in the American Gas Association's January, 1966 Directory which have an outer wall of red brass. Of the 69 flexible connectors listed in the January, 1966 Directory, 55 had Admiralty brass exterior walls, and of these 10 were plastic coated. Of the remaining connectors listed, 8 were yellow brass and 6 were galvanized steel (double-wall with a red brass interior wall). In view of these findings, the Appliance Connector Subcommittee agreed that the Study should be limited to only Admiralty brass connectors from a single manufacturer.

2. LITERATURE SEARCH

2.1 Corrosion Resistance of Brasses

The first step in this investigation was to conduct a literature search to determine the factors contributing to the corrosion of copper, brass, and brass alloys. After reviewing the American Gas Association Research Bulletin No. 102, "Study of Gas Appliance Connectors," August, 1965, it was decided that Section III entitled "Literature Evaluation of Corrosion Resistance of Brasses" provided an up-to-date evaluation of the corrosion problem. The following is an excerpt from Research Bulletin No. 102.

"VI. LITERATURE EVALUATION OF CORROSION RESISTANCE OF BRASSES

One of the construction variables of flexible metal connectors which has produced considerable discussion is, 'Which brass is the most suitable for gas appliance connectors?' From time to time, flexible metal gas appliance connectors have been made from yellow brass (70 per cent copper — 30 per cent zinc), Admiralty brass (70 per cent copper — 29 per cent zinc — 1 per cent tin or antimony), and red brass (85 per cent copper — 15 per cent zinc). Eighty-nine per cent of the flexible metal gas appliance connectors listed in the American Gas Association, July, 1963 Directory were made from Admiralty brass. Of the remaining, 9.4 per cent were made from yellow brass and 1.6 per cent were made from red brass.

Evaluations discussed previously in this report indicated that the performance (bending and torque tests) of red brass was somewhat better than Admiralty brass and yellow brass, all parameters being equal with the exception of the material for the tubing construction. Therefore, the only other variable which would affect the life or performance of the connector, which had not been considered in the previous discussions, was corrosion.

The study of brass corrosion was limited to a literature evaluation which provides the basis of the following statements.

Corrosion, generally defined as a complex form of material deterioration, is divided into 13 basic types. The basic types of corrosion which affect the preformance of flexible metal gas appliance connectors are:

1. Galvanic Corrosion — accelerated electrochemical corrosion that occurs when one metal is joined to a more noble metal by the same corroding medium or electrolyte.

2. Corrosion Fatigue — corrosion combined with repeated stress.

3. Dezincification — corrosive phenomenon in which zinc is lost from the alloy.

4. Direct Attack — the most common type of corrosion, attack by corrosive media.

5. Stress Corrosion — deterioration that occurs when an internally or externally stressed metal is exposed to a corrosive environment.

'Galvanic corrosion, which can be likened to the action of a simple battery cell — usually produces a higher rate of reaction on the less noble metal and protects the more noble metal'. Evidence of galvanic corrosion of flexible metal gas appliance connectors was exported by Stanford Research Institute. Conditions which apparently caused the corrosion developed when brass connectors were butt welded to copper adapter end fittings, by a copper-zinc-silver brazing material. The Stanford report does not indicate whether red brass, yellow brass or Admiralty brass is more corrosion resistant under these conditions. But, within the past 4 or 5 years, this type of connector end fitting construction has been almost eliminated.

In a discussion of corrosion fatigue, Seabright and Fabian state that 'Corrosion combined with repeated stress is potentially more damaging than either corrosion or fatigue alone.' Also, 'One of the dangers of corrosion fatigue is that bending tends to break down protective film on the metal. This may not be important with metals that have good "self-repair" characteristics, but with most metals it enables corrosion to proceed more rapidly.' Corrosion fatigue of the three brasses considered cannot be compared at this time since the only acceptable data would require subjecting the materials to similar conditions. However, an examination of the material's resistance to both fatigue and corrosion may give an indication of the relative merits of each material. As demonstrated by the results of tests presented earlier in the report, red brass appears to have greater fatigue resistance than Admiralty brass. Because Admiralty brass and yellow brass have basically the same composition, there is no reason to believe that their fatigue resistance should differ.

'Dezincification, as its name implies, is a corrosive phenomenon in which zinc is lost from the alloy'. It occurs with many copper-zinc (brass) alloys containing less than 85 per cent copper when they are used in contact with water having a high content of oxygen and carbon dioxide, or a high content of oxygen and carbon dioxide, or in stagnant solutions. The effect tends to accelerate as temperature rises. Brasses containing at least 85 per cent copper, and special brasses, can be used with many acids, but in general, high zinc brasses should not be used with acids due to the danger of rapid corrosion by dezincification. Binary copper zinc alloys containing more than approximately 15 per cent zinc should not be used with alkalis due to the possibility of dezincification corrosion.

Direct attack by corrosive media is, of course, one of the most common type of corrosion. The obvious way to prevent it is to select a more resistant material. Sulphides are more corrosive to copper and alloys high in copper than to brasses such as yellow brass, Muntz metal, Admiralty or Tobin bronze. In the present of moist air, odorant compounds are quite corrosive to copper and brass. Hydrogen sulfide corrosion of copper will be a problem at room temperature at concentrations below the conventional maximum limit of 0.25-0.30 grains per 100 cubic feet. Mercaptans attack brass, only at high temperature.

Stress corrosion is the deterioration that occurs when an internally or externally stressed metal is exposed to a corrosive environment. Damage usually takes the form of localized cracks. The cause of stress corrosion in copper alloys is attributed to several factors which operate together:

1. Stress

2. Corrodent

3. Time

Copper alloys are sensitive to an atmosphere containing ammonia, moisture and air. A trace amount of ammonia is all that is needed and this may be present nearly anywhere. Gaseous ingredients produce rapid cracking. Brasses are extremely susceptible to stress corrosion cracking. Brasses containing over 20 per cent zinc have a low resistance to stress corrosion cracking. Addition of small amounts of carbon dioxide in the air will accelerate stress corrosion cracking.

The literature indicates that red brass is less susceptible to corrosion than yellow brass or Admiralty brass in most applications, with the exception of sulfur corrosion. In order to determine the relative degree of susceptibility of red brass to sulfur corrosion, questionaires were sent to utility personnel who were observing the field installation of experimental rubber-covered red brass flexible connectors. Replies indicated that internal corrosion was observed in some of the connectors. Eight replies indicated that flakes or scale were noticed on the inside of the connectors."

2.2 Protection by External Coating

The results obtained during a research study conducted by the American Gas Association's Research Department and reported in the A.G.A. Research Report No. 1351, "Development and Field Study of Flexible Heat Resistant Gas Appliance Connectors,' December, 1962, shows a comparison between the corrosion protective properties of several coatings. The following is an excerpt from this Research Report:

"V. STUDY OF EXTERNAL PROTECTION SURFACES FOR FLEXIBLE CONNECTORS

A study of flexible connectors' external surface coverings as also conducted during Phase III. The purpose of the study was to evaluate coatings as a method of preventing deterioration of the outer surface of flexible connectors due to the action of ammonia, fatty acids, caustic cleaning agents and other deposits which form on connectors during normal use. The basic connector must be gastight prior to coating. The coating is not meant to stop leaks in inferior connectors.

The type of connector used in this study was a bronze, annular corrugated connector with removable end fittings. The connector had nine corrugations per inch.

Three types of coatings were studied. They were polyvinyl chloride plastic, room temperature vulcanizing silicone and a chemically deposited nickel.

Connector samples coated with polyvinyl chloride, which melts at 250F, were prepared by a plastics company. They are evaluated initially as to strength of bending. Three methods were employed in applying the coatings: (1) loose fitting sleeve, (2) sleeve shrink fitted, and (3) dipped. Of the three methods, the dipped coating seemed to give the best results and was selected for the corrosion study. The results of bending tests were as follows:

Sample No.	Description of Coating	Center Bend Cycles Around 3 Inch Mandrel	Remarks
1	Uncoated	81	Slight leak
2	Sleeve Shrink Fitted	166	Break noticed in in connector under coating, no leak
3	Dipped and Air Dried	200	No leak or break noticed
4	Loose Fitting Sleeve	77	Slight leak

The dipped polyvinyl chloride coating did not completely fill in the convolution of the connector, as shown in Figure 11. On the top crown of the convolution, the coating is approximately 1/64 of an inch thick.

The second type of coating used in the corrosion study was a room temperature vulcanizing silicone, which could be either sprayed or dipped. For the purpose of the study, the coating was sprayed on to a thickness of 2-5 mils over the entire surface of the connector. The catalytic curing agent was sprayed over the silicone and allowed to cure at room temperature for approximately 10 hours. Additional heat resistant properties could be added to the silicone if it were further cured in an oven, but this was not done.

The third type of coating studied was a chemically deposited nickel coating. Prior to chemically depositing the nickel coating, the connector was degreased and sandblasted. As the ends of the connector was not capped, the nickel plated on both the inside and outside. The thickness of the coating is controlled by the strength of the plating solution and the time the connector remains in the solution. The thickness of the nickel coat used in this study was about 0.0005 inches.

The three types of coated connectors and also a similar uncoated connector were then exposed to the severest corrosion conditions which a connector might encounter.

Results of the exposure tests, given in Table 14, indicate that silicone coating as an external surface protection of flexible connectors is not favorable material. It is readily attacked by caustic solutions and concentrated household detergent solutions, both of which are commonly used in the cleaning of appliances.

The best corrosion resistant material of the three coatings seems to be the nickel coating. The polyvinyl chloride coating is considered to be the best over-all coating because its corrosion resistance to common household chemicals is similar to the nickel, but the dipped polyvinyl chloride coating also doubled the bending strength of the connector whereas there was no change in the bending strength with the other two coatings.

There is more to consider in the use of protective coatings other than just chemical attack. Some less obvious points for consideration, which were not taken into account during this study are:

1. Thickness of coating, minimum and maximum.

2. Resistance to abrasion.

3. Is electrical resistance of the coating required?

4. Minimum and maximum temperature limits of coating.

After reviewing these two research reports, it was decided that very little if any, additional information of value could be gained from a continuation of the literature search.

3. TEST EQUIPMENT

3.1 Connectors

All connectors except connector Q were supplied by a single manufacturer. They were two foot long Admiralty brass connectors with a 1/2 inch nominal internal diameter. Bright dipped, oxide coated, polyvinyl chloride coated (both types) and double-wall (outer wall of oxide coated Admiralty brass with an inner wall of aluminum) connectors were supplied. The oxide coated connectors with and without the polyvinyl chloride coatings were the same as the bright dipped connectors except for the final bright dipping process. The polyvinyl chloride (P.V.C.) coating thickness on these Admiralty brass connectors was approximately 15 mils.

Table 14

Results of Connector Corrosion Exposure Tests

Conditions*	Final Condition of Connector			
	No Coating	Nickel	Polyvinyl Chloride	Room Temperature Vulcanizing Silicone
1) NH_4OH-H_2O vapors at room temperature for 2 weeks	Bluish deposits over full length of connector. Many cracks in the connector.	No noticeable damage—bending at center unchanged	No noticeable damage—bending at center unchanged	No noticeable damage—bending at center unchanged
2) Abrasive Resistant	—	Good	Good	Poor
3) 50 per cent acetic acid immersed in solution at room temperature for 2 weeks	White-gray film on surface—No change in bend strength	Ni coat discolored — no decrease in bend at center	N.N.D.**	N.N.D.**
4) 10 per cent NaOH immersed in solution at room temperature for 2 weeks	N.N.D.**	N.N.D.**	N.N.D.**	Silicone had appearance of fresh red paint and was easily wiped off
5) CCl_4 immersed in solution at room temperature for 2 weeks	Gray film on surface of connector. No change in bending.	N.N.D.**	Many 1/8 inch bubbles in coating — No change in bend strength	N.N.D.**
6) Unsaturated cooking oil immersed for 2 weeks at room temperature	N.N.D.**	N.N.D.**	N.N.D.**	N.N.D.**
7) Concentrated liquid household cleaner immersed for 2 weeks at room temperature	N.N.D.**	Coating completely discolored — No change in bending	Coat discolored bluish—No bond between metal and coat. No effect on metal connector.	Coat peels off easily — No effect on metal connector
8) Support combustion***	No	No	Yes	No
9) Immersed in boiling water for 1/2 hour	N.N.D.**	N.N.D.**	Coat seemed softer than normal and retained an imprint	N.N.D.**

*Both ends of connector capped.

**N.N.D. — No noticeable damage. Bending at center unchanged.

***The connector was exposed to a yellow flame for 20 seconds.
When the connector was removed from the flame, it did not continue to burn."

Connector Q, submitted by a different manufacturer, was a polyviny: chloride coated yellow brass connector of 1/2 inch nominal internal diameter. The interesting characteristic about this connector was the 3/32 inch thick coating.

3.2 Corrosive Chemicals

The household cleaners used in this investigation included a liquic ammoniated cleaner and a liquid kerosene base cleaner. The other two chemica used included a commercial grade of full strength liquid ammonia (26-28 perce and a mercurous nitrate solution (standard season cracking solution).

3.3 Dielectric Strength Tester

The test apparatus used to locate small pinholes, thin spots, and other flaws in the polyvinyl chloride (P.V.C.) coating consisted of a 4,800 volt transformer, a variac, and a volt meter. A wire brush was soldered to one of the transformer leads. The other lead was attached to the metal porti of the connector. By changing the variac setting, the output of the transfor could be adjusted to the desired voltage.

3.4 Apparatus Used for Ammonia Vapor Corrosion

A five gallon plastic container was used as a corrosion chamber. The top of the container was provided with a rack from which the connectors could be suspended. Several taps were made in the lid of the container allowing an internal pressure to be maintained on the connectors while they were under test. By maintaining a constant internal pressure on each connector, it was possible to determine the elapsed time of exposure at which each one ruptured.

4. PROCEDURE AND DISCUSSION

4.1 Season Cracking Test

Season cracking tests were conducted as outlined in Section 4.5, Season Cracking, of the American Standard Listing Requirements for Metal Connectors for Gas Appliances, Z21.24-1963, on several samples of the Admiralty brass connectors.

It was concluded from the results of these season cracking tests that the connectors had been properly annealed to remove residual stress.

4.2 Corrosion by Soap Solutions

4.2.1 Periodic Wettings with Soap Solutions

Six two foot long, 1/2 inch, bright dipped, Admiralty brass connectors were cut in half. Each piece was capped, sealed with sealing wax, and checked for leaks at 6 inches mercury pressure.

In order to simulate field conditions, the connectors were studied with respect to corrosion in both the stressed and unstressed condition. To impose stress, the connectors were bent a number of times as outlined in Section 4.2, Bending, of the American Standard Listing Requirements for Metal Connectors for Gas Appliances, Z21.24-1963. As noted in Table 1A, some of these bent connectors were then straightened before the corrosive solutions were brushed on while others were held in a "U" shape.

This identical procedure was followed in preparing twelve oxide coated samples as noted in Table 1B.

The three corrosive agents used in this phase of the study included the two cleaner solutions and water. Water, although not a corrosive agent in itself, could combine with any acid salts which might have been left on the connector by improper cleaning after the bright dipping process and contribute to corrosion. In all cases, the corrosive agent was liberally applied full strength three times each week using a one inch paint brush.

After eighteen weeks, the accumulation of residue was washed off and the connectors were visually examined at a magnification of 15X. The observations made during this examination are given in Tables 1A and 1B.

4.2.2 Uncoated Connectors Immersed in the Ammoniated Cleaner

One sample of a bright dipped connector was capped, sealed with wax, and bent into a "U" shape. This connector, sample C in Table 2, was partially immersed with the ends pointed up in a beaker of full strength liquid ammoniated cleaner. The top of the beaker was sealed to prevent evaporation. An external pressure of four inches mercury was maintained on the connector during the test.

The first sign of leakage occurred after 8.5 days at which time the connector was removed and examined. Several cracks were found in the outer radius of the "U". There was also a marked ridge around the connector corresponding to the surface of the liquid. The portion above the surface of the liquid was slightly corroded and blackened. The portion below the surface of the liquid was actually corroded away leaving the metal thinner than it had originally been. The liquid ammoniated cleaner had a very dark blue color.

4.2.3 Coated Connectors Immersed in the Ammoniated Cleaner

Three P.V.C. coated connectors (two bright dipped, and one oxide coated) were prepared and tested as described in Section 4.2.2. The oxide coated connector, sample F, and one of the bright dipped connectors, sample E,

TABLE 1A

Bright Dipped Connectors Subjected to Periodic
Wettings With Various Soap Solutions

Sample No.	No of Bends*	Condition During Test	Corrosive Agent	Observations at 15X After 18 Weeks
A1	0	Straight	Ammoniated Cleaner	Very dull appearance. Partially blackened, especially on the bottom of the connector where residue had collected. Slight traces of green discoloration.
A2	5	Straight		
A3	10	Straight		
A4	20	Straight		
A5	20	U-Shaped		
A6	0	Straight	Kerosene Base Cleaner	Dull finish, slightly blackened on bottom where residue collected.
A7	5	Straight		
A8	10	Straight		
A9	20	Straight		
A10	20	U-Shaped		
A11	0	Straight	Water	No Damage
A12	20	Straight		

* Section 4.2, Bending, of the American Standard Listing Requirements for Metal Connectors for Gas Appliances, Z21.24-1963.