LISTING OF DOCUMENTS WITH C. LAMAR LETTER TO _____ DATED APRIL 2, 1982

1. Letter of 12/14/79 from R.A. Gross of U.S. C.P.S.C. to George Lawrence of AGA (see suggested utility company service bulletin attached)

2. Letter of George H. Lawrence dated 12/19/79 to all delegates of A.G.A. member companies, with proposed safety notice attached.

2.a. News article from Denver Post dated 2/21/80 "Connectors May Be Fire Hazard".

3. Letter from E.C. Calvert of AGA Lab to C. Lamar dated 3/29/82.

3.a. Lamar letter to Chabek of AGA dated 3/18/82 with notes of telephone call and corrections.

4. Copy of AGA Directory listing for connectors design-certified for U.S. Brass.

5. Memorandum S.L. Blachman to R.E. Cramer at AGAL dated 10/3/72 summarizing field survey of flexible metal connectors.

6. Chicago Daily News Item 6/22/76 "Evanston Explosion Injures Three".

7. Copy of notice in AGA Directory for January, 1980 and thereafter regarding problem of failure with Cobra connectors.

8. Chicago Sun Times article July 8, 1974 "Nine Hurt in Skokie".

9. Lamar letter to Mattocks and members of Z21 Committee dated 3/21/75.

10. Handy & Harmon technical data sheet #D-4-Sil-Fos and Sil-Fos-5.

11. Excerpts from Z21.24 - 1963 with section 3.7.2 covering brazed joints.

12. Excerpts from Z21.24a - 1968 with section 3.7.2 revised to prohibit phosphorus in brazing alloys.

13. Letter dated 5/24/76 from T.J. Croddy to O.C. Davis regarding brazed-on end fittings and elimination of brazing alloys containing phosphorus, to "eliminate such catastrophic failures". This recommends either eliminating brazed end fittings or providing mechanical strength and limiting gas flow prior to brazing.

14. Letter from C.A. Miller of Pacific Gas & Electric dated 2/15/77 recommending elimination of brazed joints.

15. Letter from Paul Heilmann of Pacific Gas and Electric dated 5/2/80 urging prohibition of brazed or soldered joints.

16. Copy of Page 4/86 of Gas Engineers' Handbook regarding hydrogen sulfide in natural gases and its removal.

17. Copy of pages 769 and 770 from "Dangerous Properties of Industrial Materials" covering toxicity of hydrogen sulfide.

LISTING OF DOCUMENTS WITH C. LAMAR LETTER TO [redacted]
CONT'D

18. Copy of warning to customers of Northern Illinois Gas Company about possible failures of connectors and the warning of CPSC.

19. Letter of 7/14/75 from Texas LP Gas Association to American Gas Association about the high incidence of fire due to failures of appliance connectors and corrosion from inside; attached is a copy of letter from Walter Johnson, Technological Vice President of National LP Gas Association stating the position of NLPGA on this, and mentioning that I represent them on the subcommittee for standards.

20. Cover Page from a report titled "An Investigation of Failure of Brazed Flex Tube Connections in a Natural Gas Service" dated November, 1971 from the Research Council of Alberta. This report concludes that the inter-action of sulfur in fuel gases with phosphorus in brazing alloys has been the cause of the failure of brazed joints in Canada.

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NEWS RELEASE

SAGINAW FIRE DEPARTMENT

SUBJECT: Flexible Gas Tubing

RELEASED: December 8, 1981

FOR ADDITIONAL INFORMATION CALL: Fire Prevention Bureau at 776-1383

The Saginaw Fire Department would like to alert the citizens to a potential fire hazard which may exist with the flexible gas tubing used on gas fueled kitchen cooking ranges and clothes dryers. The flexible gas tubing used with these appliances connects the rigid gas pipe to the cooking range or clothes dryer.

The flexible gas tubing is breaking at the fittings on either end of the gas line tubing. So far this year we have had twenty (20) fire alarms because of broken flexible gas line connections. Thirteen (13) of these broken connections resulted in fires.

The fire department hereby advises home owners and or occupants using gas fueled appliances to have the flexible gas tubing changed by a qualified person if the tubing is six (6) years old and older. If the age of the present tubing is unknown, have it replaced as a safety measure.

Anyone having questions concerning this matter may contact the Fire Prevention Bureau, Saginaw Fire Department, 801 Federal Street, phone number: 776-1383.

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December 7, 1981

Consumer Product Safety Commission
1111 18th Street N.W.
Room 303
Washington, DC 20207

Gentlemen

The City of Saginaw is having a large number of ruptures in the flexible gas line which is connected from the gas service to the kitchen stove. Many of these resulted in a fire when the leaking gas is ignited by the pilot.

The fracture is occurring at either end of the connector next to the fiting. Most connectors show signs of corrosion from the inside out and the age varies from five (5) years to sixteen (16) years old. The problem seems to be just within the City limits, a check with fire departments in the surrounding area and State did not turn up a similar problem with only a few being recorded in these areas.

Has your organization conducted any testing on these connections to determine why they fail or would it be possible for us to send you the flexible lines for testing. As far as we know it's not the same manufacturer or supplier. Any help you could give us in this matter will be greatly appreciated.

A list of the fire alarms is attached.

Sincerely

Donald Couturier, Lieutenant
Fire Prevention Bureau
Saginaw, MI 48607

DC/jw

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March 5, 1982

Mr. Rudy H. Frostman
Consumer Product Safety Commission
477 Michigan - Room M-24
Detroit, MI 48226

Dear Mr. Frostman

This is to inform you that we have had numerous other incidents where the flexible gas line connection ruptured which resulted in fire.

We have collected these gas lines which you can pick up the next time you are in the area.

Also, if you have any results in the testing of these connectors, would you send this information to this office.

Sincerely

Donald Couturier, Lieutenant
Fire Prevention Bureau
Saginaw Fire Department

DC/jw

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ALL OFFICERS AND MEMBERS:

MAY 14, 1981

READ AND DISCUSS AT COMPANY SCHOOL:

COMMUNIQUE

FLEXIBLE BRASS CONNECTOR FAILURES

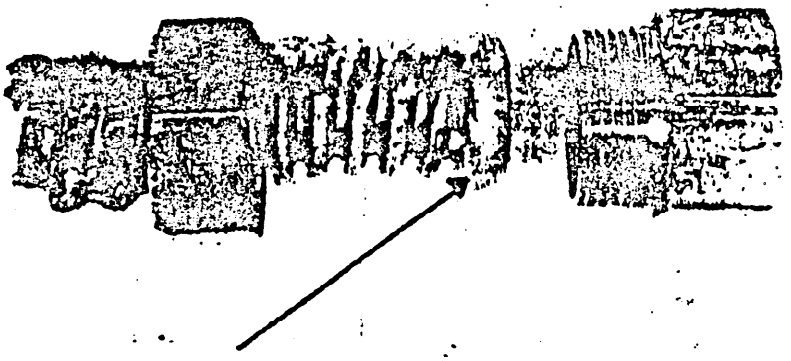
We have been informed by the Consumer Product Safety Commission, through the American Gas Association, of a potential failure of a certain flexible brass range connector. Although there are several brands that have been identified as being the cause of serious gas leakage and involved in two fires, their type, age and construction all appear to be nearly the same.

The construction, common to all, as can be seen in the photo below, has the end ferrules being soldered to the bellows section by only its wall thickness, which allows only a minimum of strength. Another common feature is that all the connectors were manufactured prior to 1968.

If a connector with this type of construction is encountered while on the job, the customer should be made aware of its history of failure, due to its end ferrule separating from the corrugated main section of the connector. As a precautionary measure a warning (orange) tag, form 376, shall be filled out and attached to the connector.

From checking past records, Consumers Power Company has never purchased this type of connector.

Note: In most instances, where this type of flexible tubing is used, a gas shut off valve should be on the gas piping.



Soldered Surface

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RUPTURE FLEXIBLE TUBING

FIRES		NO FIRES	
1-02-80	1433 Acacia	6-11-80	452 S. 21st
1-16-80	916 Monroe	12-24-80	1237 Owen
1-20-80	1714 Division	3-28-81	1710 N. Charles
3-21-80	2014 Glenwood	4-29-81	544 S. 16th
4-14-80	727 N. Hamilton	7-25-81	2927 Salina
12-17-80	115 S. Oakley	7-29-81	134 S. 5th
12-16-80	705 E. Remington	9-20-81	632 S. Jefferson
1-09-81	1925 Fairfield	11-11-81	903 Congress
2-10-81	1321 Cooper	11-26-81	1108 West Genesee
2-11-81	614 S. Michigan		
5-04-81	1905 Gilbert		
5-20-81	1008 S. Michigan		
5-28-81	1806 Allegan		
9-14-81	414 S. Jefferson		
9-11-81	649 S. 14th		
9-07-81	215 E. 11th		
9-06-81	314 Storch		
11-6-81	618 E. Warren		
11-26-81	1448 Acacia		
12-02-81	332 E. 17th		

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SAGINAW FIRE DEPARTMENT

801 FEDERAL • SAGINAW, MICHIGAN 48607

EMERGENCY - 776 1370 BUSINESS - 776 1376

For the Record.

Betty Fees of the Products Safety Commisson called on January 13 1982 at approx . 2:15 P.M. in regard to our problem with the flexible cable. She informed me a Chicago Rep. would be getting in contact with us. They would like to work with us to find a cause of the problem.

Richard Hoffman.

Betty Fees
[redacted]
Phone 1301-4926626.

Note; American Gas Industry interested in our problem.

Brand Name .....Cobra...or Coebra of flexible cables having problems.

Cables to be manufactured according to American Standard Spec;

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HARPER-WYMAN COMPANY

930 NORTH YORK ROAD HINSDALE, ILLINOIS 60521 (312) 325-3400 CABLE HARWYCO

June 4, 1982

Mr. O.C. Davis, Chairman
Subcommittee on Standards
for Connectors for Gas Appliances
c/o Mr. F. G. Hammaker
Administrative Secretary, Z21
8501 East Pleasant Valley Road
Cleveland, OH 44131

Dear Red:

As requested in your letter of May 13, 1982, this letter is written to give my comments and criticism of the proposed AN Standard for Outdoor Connection of Mobile Homes to Fuel Gas Supplies, dated May, 1982.

I believe there is a real need for such a standard, but I also believe this proposal has some very serious deficiencies, and should not be adopted without major changes, for the reasons outlined below.

It is generally recognized that brass has a strong tendancy to undergo stress corrosion cracking when bent or in tension, due to the presence of ammonia in the environment (in the air and in animal urine in outdoor applications, etc).* It is also recognized that stress corrosion cracking has been the main cause of failure and hazard in "corrugated"brass gas connectors (aside from brazed joint separations and mismating of fittings, which are now thought to be under control). It is because of this that convoluted brass connectors are made with protective coatings, intended to prevent ammonia from the air from reaching the susceptible areas of the connectors which are in tension.

However, there appears to be no adequate provision in this proposed standard to verify the integrity and durability of such coatings, especially as to:

Adhesion of coating to connector when subjected to bending or twisting or to water, freezing and thawing, etc.

Completeness of coating coverage

Resistance of the coating to abrasion

* - See Chapter 5 "Stress Corrosion Cracking in Copper Base Alloys" in THE STRESSCORROSION OF METALS by Hugh L. Logan of the U.S. National Bureau of Standards. This quotes extensively from the paper "Influence of Composition on the Stress-Corrosion Cracking of Copper Base Alloys by D.H. Thompson and A.W. Tracy in METALS TRANSACTIONS for Feb. 1949, which covers detailed research on this.

The tests specified in Section 2.10, "Resistance to Ammonia Atmosphere" are really intended to demonstrate the ability of the coating to protect the copper alloy from stress corrosion cracking, although the simple, single bend involved, with light bending force before exposure to moist ammonia atmosphere,is less than we expect to see in service, and no straightening of the tube after exposure is required. (If the coating is defective, the ammonia atmosphere may cause embrittlement in unprotected areas, cracking if straightened.)

Section 2.1.4 specifies the only procedure for examination for defects or failure of coating, and this is strictly visual,"without benefit of magnification", and only "obvious evidence of cracks, voids or loose adhesion" will be a cause for failure. This same loose specification in 2.1.4 is referenced for checking the coating after the tests in 2.3 Bending, in 2.4, Torsion, 2.5 Evaluation of Conduit End Construction and 2.6 Performance after Exposure to Temperature Extremes. Also, in Section 2.2.3, "chipping of the coating is not cause for failure" as the result of applying the very light squeezing load of 75 lbs. per lineal inch.

In relation to integrity and durability of protective coatings on brass connectors, the need for sequential testing of connectors was pointed out very well by Mr. Allen M. "Pat" Thomas of Consumer Product Safety Commission at the meeting of our subcommittee on May 10, 1977. *

Because reliable protection must be provided against stress corrosion cracking, I recommend that some of the flexing test cycles from each of Sections 2.2.2, 2.2.3, 2.3, 2.4, 2.5 and the test of temperature extremes in 2.6 should be performed in sequence on each of six samples of a connector, after which good continuity and integrity of the coating must be demonstrated. Such demonstration can be either by testing in 2.10 (moist ammonia atmosphere test) including straightening of the connector, or at the manufacturer's option by the following quick immersion test which checks for electrical insulating value of organic coatings:

> "Section XX - COMPLETENESS OF COATING - Continuity and integrity of coatings on connectors shall be demonstrated by immersion in a suitable electrolyte solution with connection to a 6-volt DC source, with the current passing to a separate electrode in the electrolyte not exceeding 20 milliamperes.
>
> METHOD OF TEST - The connector under test shall be lowered into an electrolyte solution having 5 grams of sodium chloride per liter of local tap water until the end of the connector is 1/2 inch from the liquid surface. It shall be held in this location by electrically non-conducting means. The metal portion of the connector shall be electrically connected to the positive terminal of a 6 volt battery. The negative terminal of the battery shall be connected through a milliameter capable of reading in the range from 0 to 50 ma, to a copper electrode approximately 1" by 6" by .030 to .065" thick, located about 3" from the connector. A large plastic container may be used to hold the electrolyte solution, and a plastic-coated wire may be used to support the endsof the connector. Six sample connectors shall be tested in this manner, and shall not show a current reading higher than 20 ma.

* - CPSC had conducted national sampling and testing of coated connectors, certified under Z21.24, and found defective and flexure-damaged coatings which caused stress corrosion cracking in moist ammonia test.

This method of testing for completeness of coating may also be used on new samples. Because it is a non-destructive test, it is recommended for in-plant sampling inspection of coated connectors, and should be required in Part III of this proposed standard.

In Section 3.3, I recommend adding the following item:

"e - completeness of coating test, where applicable".

Since the gas connectors for mobile homes will be subjected to all sorts of weather variations, and abrasion from contact with other objects and even dust storms, I recommend changing Section 2.6 to cover:

Soaking of coated connectors in water for a week, followed by 25 cycles of alternate freezing in water to -40° F and thawing to +40° F, followed by 10 cycles alternating between room temperature and 150° F, followed by whichever of the abrasion tests of ASTM appears to be the most appropriate, followed in turn by the test for completeness of coating. Following is a list of ASTM tests which should be evaluated for this purpose:

(G6) 21.30 "Abrasion Resistance of Pipeline Coats, Test for"

(D658)21 "Abrasion Resistance of Coatings of Paint, Varnish, Lacquer, and Related Products with the Air Blast Abrasion Tester, Test for"

(D968)21 "Abrasion Resistance of Coatings of Paint, Varnish, Lacquer, and Related Products by the Falling Sand Method, Test for"

On this subject, it should be pointed out that the letter of transmittal of the first draft of proposed standard for mobile home connectors, dated May 30, 1973, included the following sentence on page 2:

"Abrasion and adherence tests to evaluate the durability of protective coatings are also being investigated".

In relation to Section 2.6, I recommend that the subcommittee consider requiring some flexing testing of connectors at -40° F, or at least subjecting connectors which are already bent substantially to this temperature, because some of the coatings may be brittle at -40° F.

I believe the torsion testing in Section 2.4 is unreasonably extreme, and that the torque figure should be reduced from 500 to 100 inch-pounds wherever it occurs in the Method of Test. Certainly these connectors are not designed to operate in torsion. Section 1.5.5 of the instructions reads:

"e - The connector shall not be kinked, twisted about its own axis --".

In relation to this, Section 1.4.2 states that both ends of each connector shall have a union fitting, for which a flare type tube fitting is acceptable. This

is intended to eliminate the likelihood of twisting the connector. The extreme stringency of the present wording seems design-restrictive, as it will accept a structurally weak material such as brass of .010" thickness, but may make it difficult for a structurally strong material, such as stainless steel of equal or greater thickness to pass. There seems to be no good reason for this extreme twisting requirement, up to 90° rotation and return, forcibly for three cycles.

In Section 2.2.2, the proposed specification calls for a pull test of only 600 pounds. This appears to be quite low, because connectors for mobile homes are usually exposed, and are likely to encounter high accidental forces.* Section 4.2.2 of Z21.24 for appliance connectors used in homes, requires a pull test of 800 pounds for applications which are not usually exposed. The attached copy of page 7 of UL Standard 109, "Tube Fittings for Flammable and Combustible Fluids, ---" lists the pull strength in Table 5.1. For gas fittings, the pull loads are 1600 lbs. for 5/8" o.d. tubing, 2000 lbs. for 3/4", and 2500 lbs. to 7/8" and 2900 lbs. for 1". I recommend that the pull test limit in the proposed standard be increased accordingly.

Section 1.3.4 calls for certification that exterior construction of the connector is resistant to deterioration from exposure to sunlight and ozone. I recommend the addition of water, freezing water and animal urine.

Section 1.2.4 states "There shall be no visible porosity in brazes or welds". This specification is difficult or impossible of compliance without destructive testing, as porosity in a brazed or welded joint may be completely concealed. Because the separation of connectors at the brazed joints has caused many explosions and fires with injuries and deaths, both in the U.S. and Canada (with many failures recently in Flint and Saginaw, Michigan), and because the "human element" can result in poor joints with no non-destructive test to evaluate them, I recommend the following wording to replace Section 1.2.4 in the proposed text:

> "Section 1.2.4 -- Flexible connectors which depend in any way on soldered or brazed joints for strength or for gas tightness shall be capable of withstanding a steady lengthwise pull of 50 lbs. before such soldering or brazing, with maximum leakage of 2 cubic feet/hr of air at 7" w.c. both during and after application of the force".

Underwriters Laboratories has found it necessary to require mechanical holding of wires subjected to strain, in addition to any soldering, where a hazard could result from a separation, and the same principle should apply here. I believe the old wording of Section 1.4.4 requiring a "retention skirt" is not clear, and is actually design-restrictive. A designer should be free to accomplish mechanical holding against a definite force by whatever means is best.

Section 2.2.3 would subject mobile home connectors to a transverse load of only 75 lbs. per lineal inch, to demonstrate resistance to crushing. Please consider that a man weighing 200 lbs., carrying a load of 100 lbs. or more, may step on such a connector, with a shoe about 2" wide at the instep. Thus, I recommend that a load of 300 lbs. be applied over a length of 2" or 150 lbs. per lineal inch.

* -"Bowstring effect" on a horizontal connector can multiply loading tremendously.

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Section 1.5 "Instructions" include some very important instructions, warnings and prohibitions. However, the wording of 1.5.4 (a) is misleading:

> 1.5.4. (a) "(The connector) is not to be used for connection to an LP gas supply cylinder mounted on a mobile home."

This implies that it may be all right to use such a connector for connection to an LP-gas cylinder elsewhere, and this would be hazardous. I recommend 1.5.4 (a) to read: ---

> "Must not be used for connection to an LP gas supply cylinder because of excessive gas pressure".

Section 1.5.5 appears to be misleading in the same way, and I recommend changing it to read:

> "A connector covered by this standard is not for use in connecting an LP-gas supply cylinder because of high pressure hazards".

Section 1.5.8 reads as follows:

> "1.5.8 --- The instructions need not necessarily be permanent in nature, but shall be sufficiently durable and attached in a manner that they may be reasonably expected to reach the person who will install the connector." (A self-adhering label wrapped around the connectorwould seem to be acceptable.)

Such a connector for use with a mobile home may be connected and disconnected many times, by other individuals than the original installer, so a non-permanent paper label seems unacceptable. I believe this true despite instructions in 1.5.9 (a) against re-using a connector if the mobile home is moved. Probably 50% of owners would disregard such instructions, and many others may well have lost them if they are not permanently attached.

I recommend that instructions for a mobile home connector should be permanent, strong and weather resistant. Either a tough, durable plastic card or tough plastic lamination around a card should be required, permanently attached to the connector.

In the 1979 draft of this standard, the section on Resistance to Ammonia Atmosphere (now 2.10) called for straightening the connector from its U shape after completion of the 18 hour exposure to moist ammonia atmosphere. This is a very important part of the test to determine whether the coating is adequate to prevent corrosive attack by ammonia. One characteristic of this attack is embrittlement of brass parts. If the connector cannot be straightened without cracking or leaking, it means that the coating was defective, or had failed, so that ammonia had attacked the brass. I recommend that the straightening be added in Section 2.10 as before.

I note that Section 1.2.6 of the proposed text resembles closely Section 3.4 of Standard Z21.24 for appliance connectors, but the minimum wall thickness of 0.010" has been omitted. I believe it would be irresponsible not to specify a minimum for this very important feature of a connector. Probably a minimum greater than 0.010 would be desirable.

Section 1.2.6 reads as follows:

> "1.2.6 -- Metallic tubing shall be constructed of metal of uniform thickness (commercial tolerances allowed) and shall be free from dents, flaws or other defects."

The phrase "constructed of" can be taken to mean that the metallic tubing, before the corrugating or convoluting operation would have uniform thickness (within commercial tolerances), and thus Section 1.2.6 would not require any particular uniformity of wall thickness in the convoluted tube. We know of cases in which wall thickness of connector was highly variable and caused trouble. I recommend that this section be changed to specify a degree of uniformity of wall after fabrication, as well as a minimum wall thickness.

In Section 1.3.1, Materials, the listings for composition of copper alloys allow copper content to be as high as 85% for brass machined fittings, for tubing ferrules, and for tubing. (I do not believe any such parts now being made have more than 65% copper.) It should be noted that AN Standards for Gas Appliance Thermostats (Z21.23) and for Automatic Gas Ignition Systems and Components (Z21.20) both specify that "parts containing in excess of 65% copper exposed to fuel gas, other than cast or forged bodies, shall be protected from the effects of sulfur-bearing compounds". All fuel gases in domestic use contain mercaptans as odorant for reasons of safety and "sour" gases containing significant amounts of hydrogen sulfide are being distributed in some areas. I recommend that the range of copper content for the three categories mentioned should be changed to be 60% copper minimum and 65% copper maximum.

Section 1.3.2 reads as follows: "The manufacturer shall supply evidence satisfactory to the organization determining compliance with this standard that materials as applied in the internal, gas-carrying construction of the connector are resistant to deterioration from natural and liquified petroleum gases." I am not sure how this should be interpreted. If it is intended to mean deterioration from sulfur compounds as impurities in natural and LP gases, then a maximum limit of 65% copper should be sufficient. However, some of my notes show that this was in contemplation of future gas supplies, which might even contain ammonia in some cases. If this latter idea is correct, we need to be more specific. In any case, Section 1.3.2 needs clarification.

Section 1.6.1 reads: "Each connector shall bear a permanent marking, on either a non-removable ring, or a portion of a non-removable fitting not subject to tool usage, on which shall appear the following: ----" Investigators of accidents involving appliance connectors have told me that in at least 50% of accidents the "non-removable ring" was missing, due to either fracture of the tubing, or failure of a brazed joint allowing the ring to slip off. I recommend that the "non-removable ring" not be allowed in this standard, and that a permanent marking on the surface of a non-removable fitting be required.

In Section 1.6.1 (b), I recommend that the same date code marking specifications be incorporated here as in other accessory standards such as manual valves, thermostats, etc. These are more specific as to the year and the week of production, and this is desirable if a recall of such units is every necessary.

In Section 1.5.2, the first sentence would be more clear on deletion of "the following" from the first line.

Section 1.5.10 specifies a label to accompany each connector, and includes the wording "This Label Shall be Permanently Affixed to the Exterior Skin of the Mobile Home ---". This does not seem a proper provision of this standard. It is obviously not enforcible, and should be changed to provide a recommendation for attachment.

In Section 2.6, the last sentence reads: "A connector having a non-metallic gas conduit shall show no reduction in capacity as a result of the above test." Since the results of two consecutive tests will not be identical, it may well to allow for some minor variation such as 2% or 5%.

In Part IV, Definitions CONDUIT, GAS is defined as "the passageway of the connector." This is not a proper "dictionary" definition of conduit. It does not jibe with the title of Section 2.5, "EVALUATION OF CONDUIT END CONSTRUCTION, or with the use of the term of the next definition on page 13, or with the last sentence of Section 2.6.

Also, under Definitions, the following items do not seem appropriate in a standard which is strictly for gas connectors for mobile homes:

Item 3 under CONNECTOR, GAS APPLIANCE, which is for connectors for movable appliances.

GAS HOSE CONNECTOR and the 3 paragraphs under it.

As regards Section 2.8, SEASON CRACKING, I believe it should be pointed out that this standard test serves only to demonstrate that copper alloy parts do not contain residual stresses at the time of testing which would cause stress corrosion cracking later. Thus it only demonstrates that the parts are fully annealed at the time of test. This test, on uncoated brass parts has little meaning, because if it were run after any of the various flexing tests, the parts would fail. I am not sure that this test is worthwhile if the standard requires a good moist ammonia atmosphere test after sequential stress tests, followed by straightening of the samples.

I hope that these comments and recommendations will be helpful in developing a good, responsible standard for gas supply connectors for mobile homes. I know there is a temptation to adopt a weak standard and then try to improve it later. However, past experience has shown that this simply does not work. Thus, I am convinced that we need to "do it right the first time", or the third or fourth time as the case may be.

Best regards,

Charles C. Lamar

Charles C. Lamar, Consultant
Member, Subcommittee on Standards for Connectors
Representing NLPGA

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5. Pull Test

5.1 Tubing and piping shall not pull out of a tube fitting, nor shall the tube fitting rupture, when the ultimate loads designated in Table 5.1 are applied axially to the fitting and its connections.

5.2 Two samples of each size fitting are to be used for this test.

5.3 The requirements of this test are not applicable to Marine use fittings.

5.4 Each end of a short length of annealed copper tubing is to be connected, in accordance with the manufacturer's instructions, to one of the two fittings to be tested. The tubing is to have the wall thickness for the size as indicated in Table 5.1.

5.5 The female pipe threaded ends of the two sample fittings are to be fitted with suitable lengths of steel pipe, exerting the turning efforts designated in Table 5.2. The male threads are to have been lubricated with SAE No. 10 machine oil prior to assembly. The opposite ends of each section of pipe are to be arranged for securing to the members of a tensile testing machine.

5.6 The load is to be increased at a uniform rate until rupture occurs or the tubing or piping pulls out of one of the fittings.

TABLE 5.1

PULL STRENGTH TEST

Tubing Size, Outside Diameter, Inch	Wall Thickness, Tubing, Inch	Pull Load, Pounds		
		Flammable Liquid and Refrigeration Fittings		Gas Fittings, All Types
		Compression Type	Flare Type	
3/16	0.030	350	400	400
1/8	0.030	250	250	250
3/16	0.030	350	400	400
1/4	0.030	450	500	500
5/16	0.032	450	650	650
3/8	0.032	450	800	800
7/16	0.032	500	900	900
1/2	0.032	500	1000	1150
9/16	0.035	700	1250	1350
5/8	0.035	900	1450	1600
3/4	0.035	1300	1900	2000
7/8	0.045		2100	2500
1	0.045		2600	2900
1 1/8	0.050		2850	3300
1 1/4	0.050		3050	3500
1 3/8	0.055		3250	3700
1 1/2	0.060		3450	3950
1 5/8	0.060		3650	4150
1 3/4	0.060		3850	4350
1 7/8	0.065		4050	4550
2	0.065		4250	4750
2 1/8	0.072		4500	5000

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS
5032 ALHAMBRA AVENUE, LOS ANGELES, CALIFORNIA 90032 • (213) 223-1471

June 15, 1982

Red Davis
Southern California Gas Co.
P.O. Box 3249 T.A.
Los Angeles, CA 90054

Dear Red:

I have just reviewed the proposed standard for outdoor connection of mobile-homes to Fuel Gas Supplies.

In addition, I have reviewed the comments from Charles Lamar.

Although I am not a member of this Committee I feel that I must respond.

First of all as I have stated in the past, IAPMO is getting out of the standards writing area in favor of nationally written standards. The national standards, first of all, must be good viable standards. At the present time this does not appear to be so. It's really not much better than the old IAPMO TSC 9.

I totally concur and support Charlie in his comments of June 4, 1982.

I intend to be present at the meeting in August to support him.

Should you have any questions please feel free to contact me.

Very truly yours,

Norman J. Latter
Director of Standards

INTERNATIONAL ASSOCIATION OF PLUMBING
AND MECHANICAL OFFICIALS

NJL:db

5 E

HARPER-WYMAN COMPANY

930 NORTH YORK ROAD HINSDALE, ILLINOIS 60521 (312) 325-3400 CABLE HARWYCO

CHARLES C. LAMAR, DIRECTOR OF QUALITY ASSURANCE

March 21, 1975

Chairman Mattocks and Members
Z21 Committee--ANSI

Re: Overdue Needs for Improvement in Connector Standards

Gentlemen:

The condition of our national standards for gas connectors is deplorable and the improvements needed are long overdue. One of the main problems is stress corrosion cracking failures of brass connectors, which was brought to the attention of the Z21 Committee at its April 5, 1972 meeting at the request of Messrs. W. H. Johnson and W. L. Walls. This problem is not yet covered satisfactorily in the connector standards. While some progress has been made, the provisions are so far from complete as to be misleading. Progress has been and continues to be entirely too slow in relation to the seriousness of this matter.

This problem was detailed in my letter* of February 1, 1966 to Mr. R. V. Myer, then Assistant Director of A. G. A. Laboratories, with reprints of research showing that all brasses are highly susceptible to stress corrosion cracking by ammonia normally in the air. Other correspondence and references to stress corrosion cracking failures of connectors are in the minutes of many meetings of the Connector Subcommittee.

A letter* dated December 8, 1971, signed by Walter Casella, Utilization Engineer of Connecticut Light and Power Company, to O. C. Davis, Chairman of the Connector Subcommittee, gave further details of the problem and formally brought this research to the attention of the Subcommittee.

Since the Subcommittee took no action on this matter at the December 14-15, 1971 meeting, the Z21 Committee, on April 5, 1972 directed the Subcommittee on Standards for Flexible Appliance Connectors, Z21.24, to distribute for review and comment a revision providing that the mercurous nitrate test be conducted on connectors of flexible metal tubing after the bending test provided in the Standard. Manufacturer members protested and refused to vote for this.

Instead, a survey of field experience with single-wall flexible connectors was requested for more information about alleged field failures. A survey including appropriate questionaires was conducted by A. G. A. Standards Staff, through the A. G. A. Customer

* See copy herewith.

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Service Committee, in the summer of 1972 to learn the experience of representative utility companies. The results of this brief study (30 working days) were reported to the October 12-13, 1972 meeting of the Connector Subcommittee. 318 failed connectors were reported and 288 failed samples were sent to A.G.A. during this time. The majority of these were shown to be the result of stress corrosion cracking, as determined by a metallurgist who examined them for A.G.A. Lab. Projected results indicated at least 96,000 connectors had failed during the 4 years, 1968-1971. The number of projected failures was shown to be increasing each year, from 16,703 in 1968 to 31,406 in 1971.

After this, a compromise proposal was adopted by the Subcommittee, to require exposure of a portion of the connector to a moist ammonia atmosphere for 18 hours without leakage, after being bent into a U-shape around a mandrel $2\frac{1}{4}$-inches in diameter. (The portions of the connector within 2 inches of the end fittings are specifically left out of the test chamber!)

The intent of this provision, which has been adopted as Section 4.10 of Z21.24-1973, was to require protection of brass connectors from corrosive atmosphere, by some sort of coating. However, this specification is inadequate in many ways:

(1) It tests only a short portion of the convoluted tube in the ammonia atmosphere, neglecting the end portions of the connector, which may remain uncoated. Portions near the ends usually are bent and stressed more highly in service due to greater bending moment and confinement by adjacent structure. Also, they are often exposed to corrosive bubble leak test solutions, which have been found to cause corrosion failure of the brass connectors, as do some food acids. A majority of connector failures have occurred within a few inches of the ends. Thus, the entire connector should be subjected to the ammonia atmosphere test; not just a portion of the tubing. ("The chain is only as strong as its weakest link".)

(2) There is no temperature test specified for coatings on connectors, despite exposure to elevated temperatures as in a gas range top burner box. Most gas appliance pressure regulators for use on gas ranges are rated for 225°F service. Coatings on flexible connectors should withstand this same temperature without significant change so as to continue to give protection against ammonia from the air.

(3) There is no test for adhesion of the coating.

(4) There is no test for abrasion resistance of the coating.

(5) There is no adequate warning in Section 3.8, "Instructions" against frequent bending or vibration of the connectors, which can cause high residual stresses, resulting in extreme susceptibility to stress corrosion cracking. On the other hand, they are called "Flexible Connectors" in the trade, and we have seen sale packages marked "Lets You SAFELY Move Your Appliance for Cleaning as Often as Desired."

All of these factors have been pointed out in Subcommittee meetings without any tangible result other than the setting up of working groups (ineffective, so far) to investigate and develop procedures. My letter* to Mr. O. C. Davis, Chairman of the Connector Subcommittee, dated December 5, 1972 urged the specification of meaningful temperature resistance of the coatings as well as adhesion of coating, continuity of coating and resistance to abrasion. This letter was sent to all members and was read at the Subcommittee meeting on January 9, 1973, but as yet no draft has been submitted to the Subcommittee to cover any of these points. It was pointed out to the Subcommittee that without such tests, a brass connector coated with beeswax or varnish could probably pass the ammonia atmosphere test but would be subject to stress corrosion cracking failure in service.

A cablegram* from Germany was also read at the meeting of January 9, 1973, stating that all brass alloys have been prohibited by German code authorities for gas flexible connector tube service and stainless steel has been specified. We understand that stress corrosion cracking was the cause of brass tube failures in Germany. We learned this week that brass single-wall connectors are now prohibited in the Province of Ontario, Canada because of experience with fires and explosions. Although a good protective coating may prevent such cracking in service, the present Section 4.10 is inadequate in failing to test the end portions of the connector tube.

Because of this, a motion was made and seconded at the March 5-6, 1975 meeting of the Connector Subcommittee to adopt for industry review and comment a proposal that the entire connector (after removal of any valve) be subjected to the moist ammonia atmosphere test of Section 4.10. Although the vote was 8 to 5 in favor of the motion, this was not sufficient to adopt for industry review. (Manufacturers said they would study the matter for future action.)

Just before the Subcommittee voted on the above motion, two items were discussed with the members:

(1). Evidence was presented showing that connectors may fail in the portion within two inches of the end fittings when subjected to the ammonia atmosphere test of Section 4.10, whereas this specification now exempts these Sections from the test. This emphasizes the need for protection of the entire connector and specifications for testing the complete unit.

(2) A photocopy of an article* from Chicago Daily News for July 8, 1974 about a gas explosion in Skokie, Illinois, which injured 9 persons, one of whom was in critical condition with burns over 70% of his body. 18 apartments were wrecked, with damage estimated at $200,000. It was not known at the time whether the failure of the brass connector which caused the explosion was due to stress corrosion cracking in the body of the tube, or whether it was a case of end fitting separation. The following statements from the news article illustrate the serious hazard of catastrophic failure of brass convoluted connectors from stress corrosion cracking,

*See copy herewith.

and the experience of gas company service personnel with the problem. This type of failure is especially pernicious in that it may occur suddenly, without warning:

From Chicago Daily News 7/8/74

"A gas company spokesman said the gas leak apparently was caused by a broken range connector.

Ed Koska of Northern Illinois Gas said that a preliminary investigation indicates that the flexible connector may have been broken earlier, when the range was moved, and it had not been completely repaired.

'Flexible connectors are a problem,' he said. 'We have warned customers that a lot of times metal fatigue and constant bending can make them snap.' "

Despite these items, the motion to adopt for review and comment the proposal to test the entire connector under Section 4.10 received insufficient support for adoption. I recommend that the Z21 Committee direct the issuance of such a proposal, for industry review and comment, without further delay.

I have just learned that it was determined by engineering and metallurgical examination that the connector failure in the Skokie apartment was due to complete separation of an improperly brazed joint between a union member and the brass convoluted tube. I recommend that Section 3.7 of Standard Z21.24, which includes specifications for brazed end fittings, be changed by adding an item to the effect that:

"Attachment of end fittings to tubing shall not depend entirely for strength or gas tightness on brazing, soldering or welding, but that the parts shall also be held together mechanically. A set of the parts as assembled, prior to brazing soldering or welding, shall be submitted. The joint shall be examined and tested for gas leakage, and then for tensile force required to separate the parts. Gas flow shall not exceed 0.1 cubic feet of natural gas per hour at 7 inches water column in this test, and the force to separate the parts shall not be less than 100 lbs per inch of tube diameter of the joint. For the purpose of this section, simple interference fit on diameter is not acceptable."

I recommend that the above provision be sent directly for review and comment. I also recommend that the Z21 Committee adopt for direct review and comment the following provisions:

"Two samples of each type of coated connector shall be tested for temperature resistance by being heated for two weeks in an oven maintained at $225^{\circ}F \pm 5^{\circ}F$ with end fittings attached and tightened according to the specifications of Section 4.7, Reconnection of Fittings. After cooling, one sample is to be examined for coating adhesion and abrasion resistance, which shall not show substantial

> deterioration. After cooling, the other entire sample shall be tested under Section 4.10, Resistance to Ammonia Atmospheres and shall comply with this test. This testing is in addition to testing of one sample under Section 4.10 as received, without heating."

While the above wording is directly applicable to Standard Z21.24, I believe this should also be extended to other standards for similar units as appropriate.

I recommend that the Z21 Committee direct the Connector Subcommittee to complete the development of specifications for coating adhesion and for abrasion resistance, and submit these to the Z21 Committee before its next annual meeting.

Every effort should be made to get rid of the idea that these connectors are "FLEXIBLE" in the sense that they can safely withstand repeated flexing (the ammonia atmosphere test in Section 4.10 bends the unit only once, carefully, around a mandrel $2\frac{1}{4}$ inches in diameter).

I recommend changing the title of Parts III and IV of Standard Z21.24 from "APPLIANCE CONNECTORS OF FLEXIBLE METAL TUBING AND FITTINGS" to "APPLIANCE ALIGNMENT CONNECTORS OF CONVOLUTED METAL TUBING AND FITTINGS", and changing the repeated "Flexible metal connectors", especially in Part IV, to read "Metal alignment connectors".

In Section 3.8 of Z21.24, "Instructions", Item "g" now reads "Connectors are not designed for continuous movement". I recommend adding the following wording in this Item:

> "Repeated bending, flexing or vibration must be avoided. Connectors should be disconnected from either the appliance or the supply piping prior to moving the appliance."

If the Z21 Committee agrees with these proposed revisions, I recommend that the Committee direct that they be issued directly for industry review and comment, for incorporation in Z21.24 and in other standards for similar items, without the long delays which would otherwise be encountered.

I hope that these suggestions will be helpful in improving our ANSI standards for connectors. If the connector standards are not improved substantially, and soon, they may be replaced by mandatory standards.

Sincerely,

Charles C. Lamar

CCL:
Member, Subcommittee on Connector Standards, Representing NLPGA
Member, ANSI Fuel Gas Technical Advisory Board and Consumer Council

CCL:jlw

Z21 AMERICAN NATIONAL STANDARDS COMMITTEE ON PERFORMANCE AND INSTALLATION OF GAS BURNING APPLIANCES AND RELATED ACCESSORIES

E. O. MATTOCKS, Chairman - P.O. BOX 403, PONTE VEDRA BEACH, FLORIDA 32082 - (904) 285-2028
W. L. WALLS, Vice Chairman - NATIONAL FIRE PROTECTION ASSN., 60 BATTERYMARCH ST., BOSTON, MASS. 02110 - (617) 482-8755
R. E. CRAMER, Adm. Secy. - 8501 E. PLEASANT VALLEY RD., CLEVELAND, OHIO 44131 - (216) 524-4990

Return to 14 Item 6

October 4, 1972

TO MEMBERS OF SUBCOMMITTEE ON STANDARDS
FOR CONNECTORS FOR GAS APPLIANCES:

Supplementing my letter of September 18, 1972, enclosed is an A.G.A. Laboratories' Memorandum to Mr. R. E. Cramer which details the results of the Field Survey of Single Wall Flexible Metal Connectors. This will be discussed under Item 1 of our October 12-13, 1972 meeting.

Very truly yours,

O. C. DAVIS, Chairman
Subcommittee on Standards
for Connectors for Gas
Appliances

Encl.
cc: E. O. Mattocks
W. L. Walls
J. P. Langmead
Alex A. Pena
A. C. Klein
Walter H. Johnson
Hubert Wank
Vincent Garni

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AMERICAN GAS ASSOCIATION

INTEROFFICE MEMORANDUM — CLEVELAND LABORATORIES

TO: R. E. CRAMER — DATE: October 3, 1972

SUBJECT: Summary of Field Experience Survey of Single Wall Flexible Metal Connectors

History

Over the years there have been sporadic reports of failure in service of flexible metal connectors. Unfortunately there was no information available as to the magnitude of this problem nor any indication of the specific causes for failure.

At their June 27, 1972 meeting, the ANSI Z21 Subcommittee on Standards for Connectors for Gas Appliances requested that the Laboratories develop information as to both the magnitude of the problem and the causes. They felt they would then be in a position to determine the area(s) in which the standard might be strengthened.

On July 6, 1972, a letter was mailed to 33 major utility companies having wide geographic distribution, requesting the information desired by the above Subcommittee. A total of 23 utilities responded; 14 provided statistical information concerning connector failures, 6 responded with less detailed information or indicated that the desired information was not available, and 3 utilities which were unable to provide statistical information forwarded samples of failed connectors to the Laboratories for detailed examination. A total of 12 utilities forwarded connector samples, and it is felt that the number received is adequate to be indicative of a reasonable cross-section of connector production during the past several years.

Summary of Flexible Metal Connector Field Survey

Shown below in Table I is a summarization of data received from 14 utilities, which serve 10,132,111 residential meters. This represents 25.85 percent of the 39,194,000 residential meters in the nation. (Meter data from Brown's Directory of North American Gas Co. 86th Ed, 1972)

TABLE I

FLEXIBLE METAL CONNECTOR SURVEY SUMMARY

1. Number of flexible metal connectors in use by reporting utilities:

7,842,799 (estimated)

on Ranges 4,771,039

on other appliances 3,071,760

2. Number of flexible metal connectors in use - projected on a National basis:

	30,338,264
on Ranges	18,457,780
on other appliances	11,880,464

3. Number of flexible metal connectors replaced by reporting utilities due to failure: (estimated)

during 1971	8,119
1970	6,580
1969	5,811
1968	4,318
4 yr. total	24,728

4. Number of flexible metal connectors replaced due to failure - projected on a National basis:

during 1971	31,406
1970	25,453
1969	22,478
1968	16,703
4 yr. total	96,040

5. Average percentage of replacements:

Range connectors	78%
other	22%

6. Indicator that replacement was necessary:

odor complaint	89%
fire	4%
other	7%

7. Cause for replacement:

crack in corrugation	53%
crack at end	12%
bad flare	4%
proper adapter not used	15%
other	17%

It should be pointed out that most of the data shown is based on utility company estimates. The four year failure rate (Total 4 year failures ÷ by estimated number of connectors) of 0.3 percent is a minimum figure since several utilities indicated that commercial service organizations as well as the individual user replace an unknown number of connectors.

One utility (of 989,559 meters, with an estimated 483,000 connectors on their lines) forwarded statistical information from a controlled sampling effort covering a 30 day period; shown below are the results of this project.

Defective Range Connectors Received	43
Number of Work Days During Survey Period	30
Range Connectors Defective Per Day	1.43

Summary of Field Failure Reports

A total of 318 Field Failure Reports on Flexible Metal Connectors and 288 failed connectors were forwarded to the Laboratories by participating utilities. Shown below in Table II is the summarization of the data contained in these reports.

TABLE II

SUMMARY OF
FIELD FAILURE REPORT
FLEXIBLE METAL CONNECTORS

1. Reason for removal:
   a. crack in corrugation: 192
   b. crack or separation at end: 96
   c. bad flare: 8
   d. proper adapter not used: 21
2. Condition under which evidence of defect was noted:
   a. gas odor: 241
   b. broke when shifting appliance: 41
   c. utility turn on or leak check: 20
   d. fire: 16
3. Was connector properly installed:
   a. yes: 298
   b. no: 14
   c. not answered: 6
4. Was there evidence of physical abuse of connector:
   a. yes: 14
   b. no: 298
   c. not answered: 6

5. Did homeowner habitually move appliance with connector attached:

   a. yes: 30
   b. no: 282
   c. not answered: 6

6. Length of time connector was installed. (Note: Since this was not answered on many of the survey forms, actual date code information has been used.)

1972 date code	= 2
1971 "	" = 10
1970 "	" = 8
1969 "	" = 15
1968 "	" = 16
1967 - 1965 "	" = 14 per year avg.
1964 - 1960 "	" = 5 per year avg.

1960 and older with no date code = 195*

* A large number of this group are end fitting solder failures and separations.

Most reports indicated that the sample was forwarded as it was found in the field.

A previous field survey conducted in 1966 and discussed at the December 15, 1966 Connector Subcommittee meeting, indicated that connector failure from external corrosion was at that time a major problem. Results of the current survey would indicate that this is still true.

Metallurgical Examinations

Several of the failed samples were examined by Prof. Edward Trela, Associate Professor of Metallurgical Engineering at Cleveland State University. A report of his examination is attached. Prof. Trela also visually examined several batches of connectors with members of the Laboratories' staff in an effort to acquaint staff with visual appearance of failure mode characteristics.

In an effort to determine the major cause of failure on the samples received, Laboratories' staff examined each sample to classify failure modes.

Table III below details the results of their examination.

TABLE III

VISUAL EXAMINATION OF FAILED
CONNECTORS FOR FAILURE MODE

Failure Type	Number of Failures
Stress Corrosion (Many showed deposits of external chemical corrosion)	149
End Fitting Solder Failure	79
Mechanical Failure Due To Abuse	39
Bad Flare	8
Hole Due To Electrical Short	7
Visual Material Fault	6

Information received from other utilities, manufacturers, and the LPG industry follow in general the data shown above.

Conclusions

It can be concluded from the statistical information received, the results of the consultants metallurgical examination, and the sample examination that:

1. Connector field failure on a percentage basis is on the minimum estimated order of 0.3 percent, but in all probability not more than approximately 0.5 percent.

2. Most failures occur on connectors used with cooking appliances and appear to be the result of stress corrosion accelerated by external exposure to ammonia rather than physical abuse or repeated flexing. No geographic influence was noted for this failure mode.

3. Metallurgical examination indicates that the stresses induced by handling and installation after manufacture are of low magnitude compared to the yield stress of the material. Connectors examined showed signs of proper annealing during manufacture.

4. Conduct of the Season Cracking Test after the conduct of the Bending Test may not be the solution to the field stress corrosion problem as this test applies to stress levels beyond those thought to be typical.

5. Solder joint failure of multiple piece connectors is also a problem of definite concern.

6. End fitting solder joint failure or separation, proved a definite geographical failure mode. Seventy of the 79 failures of this type were from the west coast.

7. Connector age was not demonstrated to be a major factor in the stress corrosion failure problem.

8. Sporadic reports of holes due to electrical arcs were received.

Recommendations

Based on the above conclusions it is recommended that the standard be revised to require that:

1. All single wall flexible metal connectors of copper based alloy materials be provided with a non-metallic external coating and shall comply with Section 4.10 (Protectively Covered Connectors) of the current standard.

2. Single wall connectors of non-copper alloy materials shall also comply with the provisions of Section 4.10.

3. All flexible metal connectors be of one piece construction.

It is further recommended that the Season Cracking Test as currently specified in Section 4.5 be retained.

Adoption of the above revisions should minimize connector field failure by providing protection against external corrosive materials, limiting excessive flexure and torsion of the installed connector, and reducing the probability for damage by electrical arcs.

S. L. BLACHMAN

Attachment

October 2, 1972

REPORT

FAILURE ANALYSIS OF FLEXIBLE GAS CONNECTORS

(American Gas Association)

By

Edward Trela
Associate Professor of Metallurgical Engineering

Fenn College of Engineering
The Cleveland State University

This report has been prepared to summarize my findings concerning the failures of brass flexible gas connectors.

The following information and connectors were submitted for examination:

Utility	Connector No.	Make	Material *
A (Midwest)	4	T	70/30 Cartridge Brass
A (Midwest)	3	U	70/30 Cartridge Brass
B (Northeast)	30	V	70/30 Cartridge Brass
B (Northeast	9	U	70/30 Cartridge Brass
B (Northeast)	6	W	Admiralty Brass
B (Northeast)	8	V	Admiralty Brass
B (Northeast)	7	V	70/30 Cartridge Brass
C (West Coast)	28	X	70/30 Admiralty Brass
C (West Coast)	37	X	70/30 Cartridge Brass
C (West Coast)	99	Y	70/30 Cartridge Brass
C (West Coast)	31	X	70/30 Cartridge Brass
C (West Coast)	56	Z	70/30 Cartridge Brass

All of these connectors showed evidence of corrosion cracks.

*Material type based on chemical analysis performed by Cleveland State University.

The following investigative procedures were undertaken:

(1) Chemical analysis to identify alloy

(2) Macroscopic and microscopic examination of subject part to classify type of failure

(3) X-Ray diffraction analysis of corrodents

(4) Evaluation of findings and recommendations:

TABLE I

Sample No.	Grain Size, mm.	Corrosion Product (Ammonia)
3	0.100/.110	Trace
4	0.045	Trace
6	0.045/.050	Trace
9	0.035/.040	Trace
30	0.090/.100	Trace
56	0.100/.110	Trace
8	0.045	Trace
28	0.090	Trace
99	0.110/.120	None (High Sulfates)
31	0.075	Trace
7	0.090	None
37	0.150	Trace

X-Ray diffraction studies of the greenish corrosion product identified: $Cu(NH_3)_4 \cdot CO_3$ and 4 Z_{NO} $CO_2 \cdot 4H_{20}$ with some complex sulphates.

The microscopic examination of the fracture indicated intergranular failure. Sections through various tubings exhibited a clean uncorroded inside surface, indicating that the corrosion environment was exterior.

The micro section conducted on samples 3, 4, 56, 6, and 9 exhibited classic examples of stress corrosion cracking. The shape of the matrix grains indicate that the material was originally in the annealed condition.

Briefly the evidence so far indicates that the corrodent in all cases is most assuredly ammonia and the stress arises from what the flexible tube is subject to during installation and use. The corroded areas appear to be the result of splashing or spilling of possibly household cleaners containing large amounts of ammonia.

Discussion:

Stress corrosion failure which is typical of 70/30 brasses is caused by the simultaneous presence of tensile stresses and specific corrodent or environment - ammonia - air - carbon dioxide. The stresses have to be tensile, compressive stress rarely incubate stress corrosion failure. The standard method of Mercurous Nitrate test is an accelerated test for the purpose of detecting the presence of residual (internal) stresses that might bring about failure of the material. However, this test really applies to high stress levels and the stresses that are causing the connector failures may be as low as about 10% of the yield stress.

The ammonia is generally considered to be the specific corrodent causing stress corrosion. Water vapor must be present - oxygen and carbon dioxide accelerate the cracking in brass exposed to amines in moist air.

The X-Ray diffraction results seemed to indicate the following reaction:

$$4\ Cu + 8\ NH_3 + O_2 + 2H_2 = 4\ Cu(NH_3) + 4OH$$

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$$2\,Cu + NH_3 + O_2 + 2H_{20} = 2\,Cu\,(NH_3)_4 + 4OH$$

In order to eliminate the failure problem:

(1) Alloy could be changed to a red brass, namely 80 Cu, 20 zinc with low limits of phosphorus, arsenic and antimony.

(2) An electrolytic deposited tin would act as a barrier to amonnia agents.

(3) Non-metallic coatings would act as a protective coating and reduce the "kinking" which is the principal source of stress. Phenol lacquers have been used successfully as well as the new cross-linked polyethylene tubing.

Respectfully submitted,

Edward Trela

Edward Trela

~~RESTRICTED~~

UNITED STATES GOVERNMENT

Memorandum

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

TO : Robert Northedge, ESES
For: Stanley Morrow, OPM

DATE: September 7, 1982

FROM : Sidney H. Greenfeld, Technical Assistant, AED, ES

SUBJECT: Flexible Metal Connector Discussions at ANSI Z21 Meeting, August 25 and 26, 1982

I attended the meeting of the Subcommittee on Standards for Connectors for Gas Appliances of the American National Standards Institute (ANSI) Committee Z21 on Gas Appliances scheduled on August 25 and 26, 1982. Before, during and after the formal Subcommittee meetings I had the opportunity to discuss the potential problems associated with flexible metal gas connectors with a number of those present for the meetings. The official actions of the Subcommittee are reported in the attached meeting log and the official Minutes of the Meeting. This memo is an overview of the discussions that occurred in Cleveland. As always, the ANSI Subcommittee meetings are open meetings and have representatives of manufacturers, consumers, regulators and general interests present, as defined by ANSI. However, there were no "pure" ultimate users, representing true consumers and speaking as individuals, present.

There are well over 100 million flexible metal connectors in service in the United States, for use in connecting gas appliances to fuel gas lines, both natural and LP gas. These connectors make it unnecessary to provide perfect alignment between the appliances and the gas supply pipes and permit limited movement of the appliances. However, they are not recommended for frequent movement or for applications where there is continual or continuous movement or motion. In practice, many of these connectors are flexed only when the appliances are installed or replaced, as when remodeling is done to the room in which they are used.

Flexible metal connectors for home use are made primarily of corrugated or spiral brass tubing with union type end fittings. They are also made of stainless steel. They are made of relatively thin, deformed metal to permit a limited amount of flexing during connection and use. Their thin walls make them vulnerable to damage and corrosion. However, they have provided many years of satisfactory service. Some of these connectors are coated externally with non-metallic materials, principally vinyl or epoxy plastics, to protect them from corrosive atmosphere. Others are made with inner linings, principally aluminum, to protect them from corrosive elements present in the gas in some parts of the U.S. All flexible metal connectors are constructed to meet ANSI standards. There are other metal (pigtails) and hose connectors constructed to both ANSI and Underwriters Laboratories (UL) standards for special uses. These latter connectors will not be discussed.

Members of the gas industry, representing manufacturers of components and accessories, gas suppliers, utility companies and regulators (AGA), recognize that flexible connectors occasionally fail in service. The two most frequently encountered failure modes have been corrosion cracking of the connector tubing and brazing failures where the end flares are connected to the tubing. Other, less frequently encountered failures involve mechanical failure of the connector, corrosion from foreign components in the gas stream, mismatching of end fittings and failure of the fittings.

Many of the gas utility people at the meeting were involved, or had been involved, in the consumer complaint area in which gas leaks occurred. They all had experienced complaints of connector failures and reported that their companies had replaced failed connectors. However, it was unanimous that the failures tended to be slow and progressive for the most part and were replaced because people smelled gas. They said the incidence of failure seemed (subjectively) to be no worse or more frequent than other types of leaks. No one had any statistical data to back up their feelings. However, everyone seemed to feel that there may be a potentially serious problem "out there" and that they would like to do something about it. Many of the 100 million plus connectors in use have been in service for many years; one person present stated his were over 20 years old and another had one over 17 years old. No one had any idea what the useful life of a connector is. Nor did they know how many connectors over 5, 10 or 20 years old were still in service. They all knew, however, that they recommend new connectors whenever a replacement appliance is installed and, equally, that many people do not replace their connectors under these circumstances. Similarly, although recommended, connectors are frequently reused when mobile homes are moved. The recommendations to replace flexible metal connectors whenever appliances are replaced or mobile homes moved are contained in existing or proposed standards. The Subcommittee on flexible connectors is considering means for improving the effectiveness of these recommendations.

The procedure used to notify consumers when the "cobra" connector was recalled was discussed. While it was reasonably effective then, the number of cobra connectors was small and, consequently, the cost of contacting the the owners not prohibitively high. It was felt that it would be too costly to try to use this procedure for the large number of connectors in use. It was also felt that if the public became aware of the potential problem and many people moved their appliances in attempts to inspect them, potential slow-leak failures might become immediate, large-leak failures. Similarly, any other procedure for notifying the general public of this potential problem might precipitate the same results. Thus, notifying the public through public media of any form or through gas company inserts with bills was rejected.

The concept of having gas company meter readers inspect flexible connectors in the course of their periodic readings was also discussed and rejected. The cost would be high and the "imagined" magnitude of the problem did not justify those costs.

The concept of publicizing, without mention of potential failure, the need to have flexible metal connectors inspected periodically by competent persons was also discussed. But the gas company personnel felt that the public would try to inspect their own (with the potential for precipitating failure) or deluge the gas companies with requests to make the inspections again; the cost was felt to be too great for the "imagined" hazard. It was felt that very few people would go to the expense of employing a plumber to make periodic inspections.

The concept of working periodic inspections by building officials into the local codes was considered. However, it was felt that this would be a long, drawn-out process and, because officials were not accustomed to inspecting homes except when under construction or modification, there would be sufficient resistance to doom this approach.

Publicizing in appliance manufacturer's literature the desirability of replacing connectors every five years (or any other period of time selected) was discussed. The manufacturers thought that would help business, but most people felt there was insufficient information to select any definite period of time for replacement. So much depended on where and how the connectors were used.

As the discussions progressed, it became evident that, while everyone was familiar with some failures, no one had sufficient information to determine the magnitude of the problem. The latest quantitative information was over 10 years old, having been obtained through a survey conducted by AGAL. It was generally felt that a new survey was in order.

Stan Blachman stated that if CPSC requested such a survey and would be willing to work out the details with AGA, he felt AGA management might be receptive to AGA's conducting another survey. It was generally felt that a properly designed survey of the gas utilities would yield sufficient information to define the magnitudes of the different types of flexible connector failures and their relation to other types of gas connector failures. It would provide the Commission with a basis for deciding whether there is a problem and leads for coping with this problem if it did exist. It would also provide AGA and ANSI Z21 with information that might lead to amendments to the existing standards.

I agreed to report on these discussions and get a decision from the proper authorities in CPSC on the action to be taken.

Attachment

MEETING LOG

ENGINEERING SCIENCES

DATE OF MEETING: August 25 & 26, 1982

PLACE OF MEETING: Marriott Inn, Cleveland, Ohio

SUBJECT OF MEETING: Flexible Gas Connectors - Subcommittee of American National Standards Committee Z21

NAME OF PERSON MAKING LOG ENTRY:
Sidney H. Greenfeld, ES

NAMES AND TITLES OF MEETING PARTICIPANTS & COMMISSION UNITS REPRESENTED:
Sidney H. Greenfeld, Technical Assistant AED, ES

NON COMMISSION PARTICIPANTS AND NAME OF ORGANIZATION:
O. C. Davis, Chairman (Southern California Gas Co.)
Approximately twenty people, both members and guests, representing utilities, manufacturers, AGAL, & general interests. An official set of minutes with a list of attendees will be provided by the Chairman prior to the next meeting, June 8 & 9, 1983.

ISSUES DISCUSSED, DECISIONS MADE, ACTION TAKEN OR PLANNED:
The nine items on the attached list were discussed, with the following decisions made (keyed to the list):

1. The Subcommittee voted to continue to document reasons for charges (rationales) as separate statements for all standards within its jurisdiction.

2. Gas Hose Connectors for Portable Indoor Gas-Fired Appliances ANSI Z21.2.

The Subcommittee voted to send this standard with proposed revisions to the full ANSI Z21 Committee for approval. Certain caution statements were added. Several

suggested modifications in the test procedures were discussed. It was decided to include these on the agenda for the next meeting because the attendees had no knowledge of them in advance of the meeting.

3. Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances - ANSI Z21.54

The Subcommittee voted to send this standard with proposed revisions to the full committee Z21 for approval.

4. Metal Connectors for Gas Appliances - Z21.24

The Subcommittee voted to send the standard with proposed revisions to the full committee Z21 for approval.

5. Flexible Connectors of Other Than All Metal Construction for Gas Appliances - Z21.45

The Subcommittee voted to send this standard with the proposed revisions to the full Committee Z21 for approval.

6. Connectors for Moveable Gas Appliances

The Subcommittee voted to send this standard with the proposed revisions to the fill committee Z21 for approval.

7. Proposed Standard for Outdoor Connections of Mobile Homes to Full Gas Supplies.

The Subcommittee voted to modify this draft standard significantly to make it consistent with the other flexible connector standards and recirculate it for comment before the next meeting. Its title will also be changed to "Standard for Outdoor Connections of Manufactured (Mobile) Homes to a Fuel Gas Supply." The most significant change was to require that all tests except the flammability and corrosion tests be conducted on uncoated connectors.

8. Markings for Purposes of Identification

The Subcommittee voted to include the standard identification information on the metal band on the connector and more detailed information on the tag as guidance for the installer in ANSI Z21.69. The Subcommittee rejected putting the model number on the band.

9. The next meeting will be held on June 8 & 9, 1983 in Cleveland, Ohio.

10. Connectors for Recreational Vehicles (to a stationary fuel supply)

Because no one from the recreational vehicle industry was willing to work with S. Blackman (AGAL) to develop a standard, it was voted to table this issue. S. Blackman will notify Mr. Meacham, who requested development of a standard, to this effect. Without interest or help from the industry, the subcommittee felt it lacked the expertise to develop such a standard.

List of Items

For Consideration at the August 25-26, 1982 Meeting of

SUBCOMMITTEE ON STANDARDS FOR
CONNECTORS FOR GAS APPLIANCES

1. RATIONALE STATEMENTS FOR THE Z21 STANDARDS

2. REVIEW OF PROPOSED REDRAFT OF AMERICAN NATIONAL STANDARD FOR GAS HOSE CONNECTORS FOR PORTABLE INDOOR GAS-FIRED APPLIANCES

   a. Copy of proposed redraft dated May 1982

   b. Compilation of comments received on the proposed redraft

3. REVIEW OF PROPOSED REVISIONS TO AMERICAN NATIONAL STANDARD FOR GAS HOSE CONNECTORS FOR PORTABLE OUTDOOR GAS-FIRED APPLIANCES

   a. Copy of proposed revisions dated May 1982

   b. Compilation of comments received on the proposed revisions (Attached to Item 2)

4. REVIEW OF PROPOSED REVISIONS TO AMERICAN NATIONAL STANDARD FOR METAL CONNECTORS FOR GAS APPLIANCES

   a. Copy of proposed revisions dated May 1982

   b. Compilation of comments received on the proposed revisions

5. REVIEW OF PROPOSED REVISIONS TO AMERICAN NATIONAL STANDARD FOR FLEXIBLE CONNECTORS OF OTHER THAN ALL-METAL CONSTRUCTION FOR GAS APPLIANCES

   a. Copy of proposed revisions dated May 1982

   b. Compilation of comments received on the proposed revisions (Attached to Item 4)

6. REVIEW OF PROPOSED REVISIONS TO AMERICAN NATIONAL STANDARD FOR CONNECTORS FOR MOVABLE GAS APPLIANCES

   a. Copy of proposed revisions dated May 1982

   b. Compilation of comments received on the proposed revisions (Attached to Item 4)

7. REVIEW OF PROPOSED AMERICAN NATIONAL STANDARD FOR OUTDOOR CONNECTION OF MOBILE HOMES TO A FUEL GAS SUPPLY

   a. Copy of proposed standard dated May 1982

   b. Compilation of comments received on the proposed standard

8. CONSIDERATION OF MARKINGS FOR PURPOSES OF IDENTIFICATION

9. TIME AND PLACE OF NEXT MEETING

~~RESTRICTED DATA~~

DEC 28 1982

David Thome, CACA
THROUGH: Douglas L. Noble, Program Manager for Emerging Hazards, OPM

Stan Morrow, Project Manager for MPI, OPM
Nick Marchica, Program Manager for PSA, Office of Program Management

Potential Explosion/Fire Hazards with Flexible Gas Connectors effected by UFFI Ammonia Treatment

The Emerging Hazards staff received information that homes in the Tacoma, Washington area have been treated with anhydrous ammonia gas by [redacted] to counter the off-gassing of formaldehyde from urea-formaldehyde foam insualtion. Engineering Sciences advises that the concentration of the gas is strong enough to cause the deterioration of brass components in flexible gas connectors creating a potential explosion/fire hazard from leaking gas. Brass electrical fittings in the house may also be effected adversely by exposure to the gas.

In following up on the initial report, the Emerging Hazards staff was told that only 2 homes have so far been treated by [redacted] and neither had gas service. No information was available about the effect on electrical components in the homes.

It is our opinion, in consultation with Alan Schoem, OGC, that the ammonia gas treatment may present a hazard that CACA should investigate.

The Emerging Hazards Program is now taking steps to find out if the problem is wider spread than the Tacoma, Washington area. A chronology of events and the current status of our investigation in this matter is attached at Tab A. Additional background information is also included. A report on the ammonia treatment process is being prepared by Bernie Jenson, WRO, and will be forwarded to you when received.

cc: J. Liskey, OPM
J. Hoebel, OPM
B. Northedge, ES
S. Greenfeld, ES
A. Schoem, OGC
L. Glatz, CA

bcc:OPM FILE:chron/central
OPM:SMORROW:jd:12/27/82

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Attachments

Tab A - Memo from D. Noble to E. Morgan, dated December 10, 1982, on Staff Action to address Potential Explosion/Fire Hazards with Flexible Gas Connectors in Seattle-Tacoma, Washington Area

Tab B - Letter with attachments from [redacted] to Joseph Fandy, August 31, 1982, about the ammonia process to treat formaldehyde off-gassing.

Tab C - Memo from B. Jenson to D. Noble, November 26, 1982, on Use of Anhydrous Ammonia as a Treatment for Formaldhyde Off-Gassing

Tab D - Memo from Limberg to D. Noble, November 24, 1982, on Use of Anhydrous Ammonia to Neutralize free Formaldehyde in UFFI Insulated Homes

UNITED STATES GOVERNMENT

Memorandum

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

TO : Jim Hoebel, Program Manager for FTBH, OPM DATE: DEC 29 1982
THROUGH: Douglas L. Noble, Program Manager for Emerging Hazards, OPM

FROM : Stan Morrow, Project Manager for NPI, Office of Program Management

SUBJECT: Flexible Metal Gas Appliance Connectors

Attached is the New Project Identification team's product review of flexible metal gas connectors. You may wish to consider additional work on this product under the FTBH Gas Appliance Project. For your information, Compliance & Enforcement has sent samples of several failed connectors to the warehouse to be stored and held for 6 months. After 6 months, I understand they will be destroyed unless a request is made to hold them longer. NPI and CA have no further use for the samples. The samples are:

F 855 - 4463
E 840 - 7300
F 815 - 4203
F 815 - 3502

cc: B. Fees, CA
S. Greenfeld, ES
N. Marchica, OPM
NPI Team

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AMERICAN GAS ASSOCIATION

INTEROFFICE MEMORANDUM — CLEVELAND LABORATORIES

TO: R. E. CRAMER — DATE: October 3, 1972

SUBJECT: Summary of Field Experience Survey of Single Wall Flexible Metal Connectors

History

Over the years there have been sporadic reports of failure in service of flexible metal connectors. Unfortunately there was no information available as to the magnitude of this problem nor any indication of the specific causes for failure.

At their June 27, 1972 meeting, the ANSI Z21 Subcommittee on Standards for Connectors for Gas Appliances requested that the Laboratories develop information as to both the magnitude of the problem and the causes. They felt they would then be in a position to determine the area(s) in which the standard might be strengthened.

On July 6, 1972, a letter was mailed to 33 major utility companies having wide geographic distribution, requesting the information desired by the above Subcommittee. A total of 23 utilities responded; 14 provided statistical information concerning connector failures, 6 responded with less detailed information or indicated that the desired information was not available, and 3 utilities which were unable to provide statistical information forwarded samples of failed connectors to the Laboratories for detailed examination. A total of 12 utilities forwarded connector samples, and it is felt that the number received is adequate to be indicative of a reasonable cross-section of connector production during the past several years.

Summary of Flexible Metal Connector Field Survey

Shown below in Table I is a summarization of data received from 14 utilities, which serve 10,132,111 residential meters. This represents 25.85 percent of the 39,194,000 residential meters in the nation. (Meter data from Brown's Directory of North American Gas Co. 86th Ed, 1972)

TABLE I

FLEXIBLE METAL CONNECTOR SURVEY SUMMARY

1. Number of flexible metal connectors in use by reporting utilities:

7,842,799 (estimated)
on Ranges 4,771,039
on other appliances 3,071,760

6(b) CLEARED: 6-28-84
✓ No Mfrs Identified
Excepted
Mfrs Notified
Comments Processed