TABLE 1B

Oxide Coated 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
B_1	0	Straight	Ammoniated Cleaner	Oxide coating removed leaving a dull, "bright dipped," appearance over most of the surface.
B_2	5	Straight		
B_3	10	Straight		
B_4	20	Straight		
B_5	20	U-Shaped		
B_6	0	Straight	Kerosene Base Cleaner	No Damage
B_7	5	Straight		
B_8	10	Straight		
B_9	20	Straight		
B_{10}	20	U-Shaped		
B_{11}	0	Straight	Water	No Damage
B_{12}	20	Straight	"	

had pinholes in the coating covering the unstressed (straight) portion of the connectors. Neither connector had holes in the coating covering the stressed ("U" shaped) portion of the connectors.

The observations made during an examination of the metal surfaces after 8.5 days are reported in Table 2.

The coating on the oxide coated connector (F) had separated from the metal surface. It was easily peeled off revealing a multitude of cracks beneath the surface of the coating in the stressed area. The cleaner solution had apparently traveled between the coating and the metal surface to reach the stressed area.

Sample E, which had leaked after five days, had only one hole in the metal surface when examined after 8.5 days. This hole, approximately 1/16 inch in diameter, was located at one of the pinholes in the coating. When the coating was cut away around the remaining pinholes, only tiny dark spots were found on the surface of the metal. The coating was still bonded to the metal surface even in the vincinity of the pinholes.

To examine the metal surface beneath the coating, it was necessary to "bake" the connector until the coating dried out and could be easily removed. This was accomplished by placing the connector in an oven at a temperature of 450F for 2.5 hours. After the coating had been removed, an examination of the rest of the metal surface revealed no sign of corrosion. This lack of corrosion could be attributed to the bonding between the coating and the metal surface which prevented the liquid cleaner from traveling between the two materials.

TABLE 2

Connectors Immersed in Ful Strength Ammoniated Cleaner

Sample	Type	Coated	Pinholes in Coating	Observations Made After 8.5 Days.
C	Bright Dipped	No	—	Severely corroded below the surface of the liquid. Marked ridge on the connector indicating the liquid level. Several cracks in the outer radius of the bend.
D	Bright Dipped	Yes	No	No Damage
E	Bright Dipped	Yes	Yes	One hole in the metal beneath a pinhole in the coating. No other damage.
F	Oxide Coated	Yes	Yes	Extensive cracking in the outer radius of the bend. The liquid cleaner was trapped between the coating and metal surface.

NOTE: An oxide coated connector with a P.V.C. coating without pinholes was not available.

4.3 Corrosion by Ammonia Vapors

4.3.1 Uncoated Connectors

A series of accelerated corrosion tests were conducted on several uncoated connectors, including one double-wall sample, to compare the rate of corrosion from ammonia vapors of oxide coated and bright dipped connectors in both a stressed and unstressed condition. Two connectors (one bright dipped, and one oxide coated) were cut in half. The four pieces were capped, sealed with sealing wax, and checked for leaks at six inches mercury pressure. Two of these one foot long samples (H and K in Table 3A) and the one two foot long double-wall connector were bent into a U shape.

All samples were suspended in the sealed plastic container above 500 ml. of a solution containing 250 ml. of full strength ammonia (28 percent) and 250 ml. of water for several hours. The exposure time and the observations made at the end of this time are shown in Table 3A.

The double-wall connector (I) did not leak after 140 hours. The examination revealed only hairline cracks in the outer Admiralty brass wall. Apparently the aluminum internal wall had absorbed part of the stress and prevented extensive cracking in the outer wall. However, the outer wall did crack open in several spots when the connector was flexed several times.

4.3.2 Coated Connectors

Several P.V.C. coated connectors including connector Q, which had an extra thick coating, were tested as described in Section 4.3.1 "Uncoated Connectors." These connectors were tested in the stressed (U shaped) position. Results are shown in Table 3B.

TABLE 3A

Ammonia Vapor Test on Uncoated Connectors

Sample	Type	Condition During Test	Exposure Time (Hrs)	Observations
G	Oxide Coated	Straight	67.5	Corroded - No cracks or leakage either before or after flexing.
H	Oxide Coated	U-Shaped	3.3	First sign of leakage occurred at 3.3 hours - cracked in outer radius of bend.
I*	Oxide Coated	U-Shaped	140.0	No leakage - Hairline cracks in outer wall only-limited flexing resulted in extensive cracking in outer wall (still no leakage).
J	Bright Dipped	Straight	67.5	Corroded - No cracks or leakage either before or after flexing.
K	Bright Dipped	U-Shaped	2.3	First sign of leakage occurred at 2.3 hours - cracked in outer radius of bend.

* Double-Wall - (outer wall of oxide coated Admiralty brass with inner wall of aluminum)

The oxide coated connector (L), which had pinholes in the P.V.C. coating covering the unstressed portion of the connector, leaked in less than 18 hours. Since several connectors were being tested in the container at one time, the connector was not removed and examined until the test had been completed (140 hours). An examination then revealed that the connector was extensively cracked beneath the coating in the stressed portion of the connector. This cracking occurred because the vapors had entered through the pinholes in the coating covering the unstressed portion of the connector, loosening the oxide coating to which the P.V.C. was attached, resulting in complete separation of the coating from the metal surface. This separation allowed the ammonia to reach the stressed area. The P.V.C. coating had become a fitted sleeve which could easily be peeled off.

Connector N which had several pinholes in the coating covering the unstressed (straight) portion of the "U" shaped connector showed no sign of corrosion beneath the coating covering the stressed area. Unlike the coating on the oxide coated connector (L), the coating on connector N had not separated from the metal surface. Consequently, the vapors could not travel between the coating and metal to reach the stressed area. (In order to fully examine this connector, it had to be "baked" until the coating could be removed.)

The bright dipped yellow brass connector Q with the extra thick coating leaked after 10 hours. This connector unlike the other two coated connectors had a pinhole in the coating covering the stressed portion of the connector.

TABLE 3B

Ammonia Vapor Test on Stress Polyvinyl Chloride Coated Connectors

Sample	Type	Pinholes in Coating	Approx. Coating Thick.(In.)	Leaked After 18 Hrs.	Observations After 140 Hrs
L	Oxide Coated	Yes	.015	Yes	Extensive cracking in outer radius of bend — coating separated from metal surface
M	Oxide Coated	No	.015	No	One small crack in outer radius of bend — coating separated from metal surface.
N	Bright Dipped	Yes	.015	No	Black discolorations at each pinhole. No other damage.
P	Bright Dipped	No	.015	No	No Damage.
Q*	Bright Dipped	Yes	.094	Yes	Ruptured after 10 hours — severely corroded when examined at 140 hours.

* Special yellow brass connector.

4.4 Dielectric Strength Tester

The dielectric strength of non-rigid polyvinyl chloride normally ranges between 250-1000 volts/mil*. Based on this information, a dielectric strength test was devised to detect cuts, pinholes, and thin spots in the P.V.C. coatings. The test apparatus used in this test has been described in Section 3 "Test Equipment."

One lead of the transformer was attached to the metal portion of the connector. The other lead to which a wire brush had been attached was used as a probe. When the wire brush came in contact with the external coating, arcing occurred at points where there were flaws such as pinholes, etc.

After several trials, 1000 volts was found to be the minimum voltage at which the flaws could be located. It should be pointed out that 1000 volts is well below the minimum dielectric strength of a well coated connector assuming the dielectric strength to be 250 volts/mil.

To determine the reliability of this test, a specific number of holes in addition to those already located were deliberately made with a pin in several coatings. The coatings were then tested by a second person who had been asked to locate the holes. At 1000 volts, the holes could be accurately located.

There were several flaws in the coatings on most of the coated connectors supplied by the manufacturer. These flaws were especially prevalent on the P.V.C. coated connectors which had not been bright dipped prior to the coating process.

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* Modern Plastics Encyclopedia, McGraw-Hill Publishing, September 1965, pages 534-535.

5. CONCLUSIONS AND RECOMMENDATIONS

Polyvinyl chloride coated connectors made from either bright dip ped or oxide coated tubing proved more resistant to corrosion from soap sc tions and ammonia than did uncoated single-wall connectors. However, as s by the accelerated corrosion test, the P.V.C. offers considerably less prc tection to oxide coated connectors than it does to bright dipped ones. Furthermore, the coating thickness is not as important as the quality and consistency of the coating.

The findings in this investigation do not completely agree with those of the Con Gas Service Corporation as reported in their Research Rep No. 48, "Stress Corrosion Cracking of Brass Tubing Used in Flexible Metal Appliance Connectors." Their report indicates that the oxide coated conne when P.V.C. coated are superior to the P.V.C. coated bright dipped connect

The apparent disagreement in results may be due to some procedu other than bright dipping used in the preparation of the different groups connectors before the application of the polyvinyl chloride coatings. The is also the possibility that the polyvinyl chloride coating on the two di ferent batches of coated connectors examined by the Laboratories were not uniform. It is expected that the same difference might have been found be tween two batches of either bright dipped or oxide coating tubing.

Findings of this investigation indicate that appreciable protec tion against corrosion is afforded to flexible metal connectors of double-wall construction or when coated with polyvinyl chloride or an equivalent coating. Results also indicate that caution should be exercised in the ap plication procedures used especially when there is an additional coating such as an oxide between the polyvinyl chloride and the base metal.

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. Through this test, the Laboratories could make an additional term of certification available to the connector manufacturers. As an option to the normal certification, connectors which comply with the provisions of the corrosion test could also be certified as "corrosion resistant."

To distinguish these connectors from other connectors after they have been placed in service, it would be advisable to require marking the connectors either on a nonremovable end fitting or on a permanently attached band. The words corrosion resistant or an equivalent could be used.

The dielectric strength test discussed in Section 4.4 is not recommended as part of the optional test since it appears that the state of the art has not developed to the point where a completely flawless coating can be economically produced, and coatings presently available afford appreciable corrosion resistance.

6. CONSIDERATION OF THE PROPOSED TEST METHOD

The optional corrosion test outlined in Appendix A is similar to the one used in conducting the tests described in Section 4.3. The data obtained using this test procedure (see Tables 3A and 3B) indicates that, of the connectors examined, the double-wall connectors and the single-wall connectors which were reasonably well coated with P.V.C. could comply with this standard. Although two out of the five P.V.C. coated connectors subjected to this test leaked in less than 18 hours, it should be noted that both of these connectors had pinholes in the coating which permitted the ammonia vapor to reach the metal surface.

APPENDIX A

Recommended Revisions to American Standard Listing Requirements for Metal Connectors for Gas Appliances

Z21.24-1963

Note: Revisions and additions are underlined, and deletions are indicated thus --------------

PART III

Appliance Connectors of Flexible Metal Tubing and Fittings

Construction Requirements

PRESENT TEXT	PROPOSED REVISION

3.2 TEST SAMPLES	3.2 TEST SAMPLES
3.2.1 Connectors submitted for test under these requirements shall be representative production samples.	3.2.1 No change.
3.2.2 For these tests, eight samples of each nominal diameter, type and material of assembled appliance connector on which certification is desired shall be provided: one 6 feet long, one 4 feet long, four 2 feet long, and two 1 foot long.	3.2.2 (1st paragraph unchange
If connectors are supplied with a protective coating, the required number of samples, as specified in the preceding paragraph, are to be supplied uncoated.	If connectors are supplied witl protective coating, the required number of samples, as specified i the preceding paragraph, are to t supplied uncoated. In addition, three 2-foot-long samples are to supplied coated.
	Two 1-foot-long samples of any connector which is to be certifie as corrosion resistant according to the provision of Section 4.10 must also be supplied.
3.7.5 When a connector is provided with a protective coating, the connector shall be capable of complying with these requirements without the coating. The coating shall be such that it shall not continue to burn after an ignition source has been removed, it shall not react with the metal of the connector, and shall have no adverse affect upon the performance of the connector.	3.7.5 When a connector is provided with a protective coating, ----------------- the coating shall be such that it shall not continue to burn after an ignitic source has been removed, it shal not react with the metal of the connector, and shall have no adverse affect upon the performance of the connector.
	3.9 MARKING
	3.9.1 Same a. Same b. Same c. Same (Add) d. Connectors certified a: corrosion resistant unc the provisions of the c tional corrosion test Section 4.10 shall be marked with the words "corrosion resistant," or equivalent marking.

4.10 CORROSION (Optional (Add)

Flexible metal connectors and fittings which do not develop corrosion faults which would result in gas leakage under the following condition of test may be certified as corrosion resistant.

Method of Test

A one foot long flexible connector shall be bent around a 2-1/4 inch diameter mandrel to form a U shape. The ends shall be secured with a nonmetallic material to hold the connector in this shape. One end of the connector shall be attached to an air supply system equipped with a manometer. The other end shall be sealed gas tight. Air shall then be admitted to the connector until a pressure equivalent to 6 inches mercury column is obtained. The connector shall be suspended in a sealed plastic container to which 500 ml. of ammonia solution containing 250 ml. of full strength ammonia (28 percent) and 250 ml. of water has been added. (More than one connector may be placed in the container at one time.)

Note: The connector(s) must not come in contact with the liquid ammonia at any time. See Figure 3.

An internal air pressure of 6 inches mercury shall be maintained throughout the test. If a sudden drop in pressure occurs, the test shall be discontinued. Otherwise, the connector shall be removed from the container after 18 hours and examined for leakage under not more than a 2 inch depth of water with an internal air pressure of 6 inches mercury.

When the connector is provided with a nonmetallic protective coating, the

PART IV

Appliance Connectors of Flexible Metal Tubing and Fittings

Performance Requirements

(Increase all section numbers so that the present 4.1 becomes 4.2 etc. — add the new Section 4.1 shown below)

4.1 GENERAL (Add)

Before the conduct of all tests except Section 4.10 "corrosion," any nonmetallic coating shall be removed.

4.1

4.2

Present 4.1

coating shall be removed before checking for leakage.

This test shall be applied to each nominal diameter type and material of connector submitted.

. tests
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A. 1-1/8 Inch Radius
B. Nonmetallic Retainer
C. Sealed End
D. Pressure Tap
E. Five Gallon Plastic Container
F. Liquid Ammonia

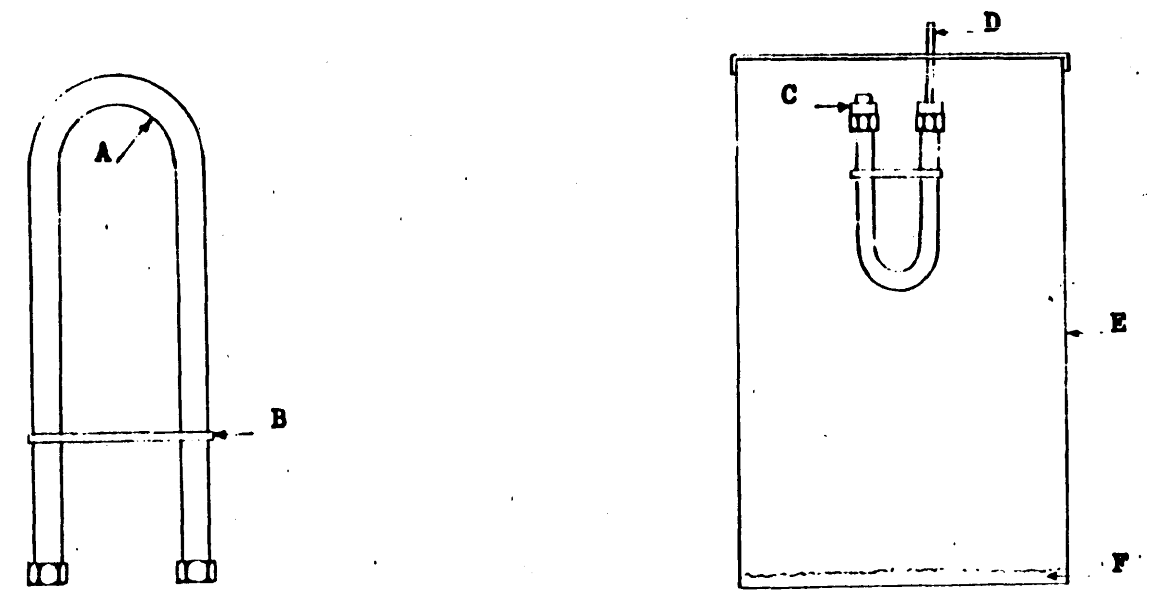

FIGURE 3

Illustration of Ammonia Vapor Corrosion Test

U.S Brass
Highway 11
P.O. Box 1031
Commerce, Tex. 75428
Tel. (214) 886 2580

APR 08 1985

U.S. BRASS

A HOUSEHOLD INTERNATIONAL COMPANY

April 2, 1985

Frank A. Stanonik
Assoc. Director of Tech. Services
GAMA
1901 N. Moore St.
P.O. Box 9245
Arlington, VA 22209

Dear Frank:

Enclosed is the analysis on the expected field life of a connector that passes an 18 hour ammonia test. As discussed in the meeting with CPSC, GAMA was going to distribute copies to those in attendance.

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.

Also enclosed is our old survey (1975) on household cleaning products for the committee's information.

Sincerely,

Randy Smith
Operations Manager
U.S. Brass

RMS/jp

Enclosures

Attachment #1

W. H. CLINGMAN & CO.

MANAGEMENT AND TECHNOLOGY CONSULTANTS

TELEPHONE 747-7973
SUITE 2626
2001 BRYAN STREET
DALLAS, TEXAS 75201

March 17, 1976

Mr. Dennis Blankenship
United States Brass Corporation
901 10th St.
Plano, Texas 75074

Dear Mr. Blankenship:

An analysis has been made of the expected life of brass connectors that have passed the AGA ammonia test. The basis of this analysis is a set of studies that have been supported by the federal government on the mechanism of ammonia stress corrosion cracking in brass. The results of these studies are summarized below and discussed further in the appendix. From these results one can convert the measured time to failure in the AGA test to an approximate expected life. The latter is a function of the ammonia vapor concentration levels to which the connector is actually exposed in normal use. Ammonia is toxic and its physiological effects set definite limits on the vapor concentration. Thus there are definite limits on time to failure. These results are summarized in Table 1.

One of the standard tests for coated flexible connectors requires exposure of the connector to the vapor of a 1:1 mixture of 28% ammonia solution and water. Exposure to the vapor is in a closed vessel for 18 hours. At the end of this time the connector tube must be able to withstand air pressure of 6 inches mercury without leaking. These test conditions are much more severe than the conditions of actual use.

In the Bureau of Mines Technical Paper No. 248, 1921, the maximum ammonia vapor concentration for prolonged human exposure is given as 0.01 volume percent. This would correspond to an ammonia partial pressure of 0.076mm mercury. In the <u>International Critical Tables</u> the partial pressure of ammonia vapor in equilibrium with an ammonia solution, pNH_3(mm), is given by the following expression for 25°C.:

$$pNH_3 = 12.9\ C\ (1+0.046\ C)$$

$$C = (\text{moles of } NH_3)/(\text{liters of solution})$$

This expression is valid for $C \leq 1.6$. If $pNH_3 = 0.076$mm, then $C = 0.0059$ moles/liter. This corresponds to 0.01 wt. % ammonia in the solution.

This is far less than the 14% concentration used in the above test. To relate results from this test to the expected life under normal conditions requires an analysis of the mechanism of stress corrosion cracking.

Extensive studies have been made of the dissolution of copper alloys in ammonia solution by E. N. Pugh, J.A.S. Green[1,2] and J. Halpern[3]. These studies have included the determination of the mechanism of stress corrosion cracking. About one year ago I visited Dr. Green at the Martin Marietta Research Laboratories to discuss this reaction. His group has made measurements under closely controlled laboratory conditions of the rate of attack of the metal. All of this work has been done with the metal in direct contact with aqueous solutions. It was the opinion of Dr. Green that the same mechanism would apply to metal corrosion in ammonia vapor. Both ammonia and water vapor would be adsorbed on the metal surface as a thin liquid film. The rate of metal corrosion depends on the concentration of ammonia and the amount of copper dissolved in the film. In the attached appendix there is an analysis of the published results. From this it is predicted that the corrosion rate is proportional to $[NH_3]$, where $[NH_3]$ is the concentration of the ammonia solution from which the vapor is derived.

This relation can be used to estimate life in the following way. Assume that the connector is exposed to the vapor from a 0.01 wt. % solution of ammonia for two hours a week. Both water and ammonia would be adsorbed on the surface of the connector tube. If there is not selective adsorption of either one by the metal, then the ammonia concentration in the adsorbed surface layer will be 0.01 wt. %. To a first approximation the corrosion rate is assumed proportional to the ammonia concentration at the surface. The rate of corrosion would be reduced over that in the AGA test by a factor of (14/.01) or 1400. Thus if a connector lasted only 18 hours in the AGA test it would last 25,200 hours upon continuous exposure to the above ammonia vapor concentration. If the exposure were two hours per week the connector would last 245 years.

In Table 1 a number of physiological effects are shown along with the ammonia vapor concentration at which they occur[4]. Using the same sequence of calculations as above, an equivalent lifetime is calculated for each case. The assumptions are as follows: the tube lasts 18 hours in the AGA standard test; the tube is exposed to ammonia vapor of the given concentration for two hours a week.

Under normal use of a household product the ammonia vapor concentration to which the connector tube is exposed will be below the threshold value for a serious physiological effect.

Sincerely,

W. H. Clingman, PhD.

WHC:ji
Enc.

TABLE 1

Physiological Effect	Threshold Ammonia Concentration	Equivalent Connector Tube Life
Least detectable odor	53 ppm	462 yrs.
Maximum concentration allowable for prolonged exposure	100	245
Maximum concentration allowable for short exposure (1/2 to 1 hour)	300-500	49-81
Least amount causing immediate irritation to the throat	408	60
Least amount causing immediate irritation to the eyes	698	35
Least amount causing coughing	1720	17
Dangerous for even short exposure (1/2 hour)	2500-4500	5-10
Rapidly fatal for short exposure	5000-10,000	2-1/2-5

REFERENCES

1. E. N. Pugh and J.A.S. Green, Metallurgical Transactions 2, 3129-3134 (1971).

2. E. N. Pugh and A.R.C. Westwood, Phil. Mag. 13, 167-83 (1966).

3. J. Halpern, J. Electrochem. Soc. 100, 421 (1953).

4. Y. Henderson and H. W. Haggard, "Noxious Gases", Chemical Catalog Co., New York, 1927.

APPENDIX

Relation Between Ammonia Concentration and Brass Corrosion Rate

It is assumed that an exposed metal surface is suspended in the vapor from an aqueous ammonia solution. A film of water containing ammonia will form on the metal surface. The film is assumed to be many molecular layers in thickness so that its properties approach those of the bulk liquid. Under these conditions the equilibrium concentration of the surface film will be the same as the liquid producing the vapor.

The experimental results discussed below are for a brass alloy containing 30% zinc. Initially the rate of weight loss is linearlv proportional to the amount of copper dissolved in the liquid contacting the metal.[1,2] This is due to the participation of cupric and cuprous ammonium complexes in the following series of reactions[1]:

1) $Cu(NH_3)_4^{2+} + e \rightarrow Cu(NH_3)_2^{+} + 2NH_3$

2) $Cu + 2NH_3 \rightarrow Cu(NH_3)_2^{+} + e$

3) $Zn + 4NH_3 \rightarrow Zn(NH_3)_4^{2+} + 2e$

4) $2Cu(NH_3)_2^{+} + 1/2O_2 + H_2O + 4NH_3 \rightarrow 2\ Cu(NH_3)_4^{2+} + 2OH^-$

The overall reactions can be summarized as follows:

5) $Cu + 4NH_3 + H_2O + 1/2O_2 \rightarrow Cu(NH_3)_4(OH)_2$

6) $Zn + 4NH_3 + H_2O + 1/2O_2 \rightarrow Zn(NH_3)_4(OH)_2$

The cupric ammonium complex in reaction 1) removes electrons from the metal surface. This accelerates reaction 2), and the rate of the latter is equivalent to the rate of corrosive attack. One would also expect the rate of reaction 2) to increase with increasing ammonia concentration. Halpern[3] in fact found this to be the case. He studied the effect on the rate of both $[NH_3]$ and $[NH_4^+]$. Even if concentrated ammonia is diluted 1:100, less than 2% of the original NH_3 is present as NH_4^+. Halpern found the rate of reaction to vary proportionately with $[NH_3]$.

Thus if all other variables are held constant, the time required for an equivalent effect should vary inversely with the ammonia concentration. This relationship can be used to estimate minimum lifetimes for connector tubes under actual use conditions.

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) 947-1154
W. H. JOHNSON, Vice Chairman - 1301 W. 22nd STREET, #610, OAK BROOK, IL 60521 - (312) 986-1800
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May 2, 1985

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

This is to inform the subcommittee that the Z21 Committee, at its April 11, 1985 meeting:

1. Returned to the subcommittee the Proposed Standard for Gas Connectors for Outdoor Connection of Fixed Appliances for Outdoor Installation and Manufactured (Mobile) Homes to the Gas Supply.

   The Z21 Committee considered the proposed standard in conjunction with correspondence from Mr. C. C. Lamar, Lamar Consultants, in which he objected to the standard on the basis it does not provide adequate coverage for evaluating the integrity and durability of protective coating materials on brass connectors. The Committee had also been provided with copies of a "background information and discussion of major provisions...." paper which had accompanied the proposed standard when it was distributed for review and comment. This paper and Mr. Lamar's letters of comment have been reviewed by the subcommittee. At the meeting Mr. Lamar and several Committee members stated similar concerns to that noted above.

   The Committee endorsed the sentiments expressed by Mr. Lamar, unanimously agreed to return the proposed standard to the connector subcommittee and hereby directs the subcommittee to report within 6 months the progress of the CPSC/GAMA ad hoc task group currently studying the subject of evaluative testing of protective coatings on connectors.

2. Returned to the subcommittee the subject of including in the date code markings the month as well as the year of connector manufacture.

   The Z21 Committee hereby directs the subcommittee to modify the connector standards to also include in the date code marking the month of manufacture, based on the final assembled product, for submittal to the Committee. The subcommittee's reason for not including the month, i.e., that parts of a connector are manufactured and assembled at different times, etc., was considered unacceptable. It was pointed out, for example, that the parts of a furnace are manufactured and assembled at different times but furnaces are provided with a month and year date code marking which has been useful in product traceability. This directive to the connector subcommittee was unanimously approved by the Committee.

3. Endorsed a project on regularization of common provisions in the standards.

   The Z21 water heater subcommittee, at its November 1984 meeting, and the Z21 thermostat and automatic ignition systems subcommittee, at its December 1984 meeting, questioned why provisions common among the standards are often stated somewhat differently from standard to standard. They agreed that coverage which is product independent logically should be the same in all standards. This project, as formulated at the February 12, 1985 meeting of the Z21 Chairman's Advisory Committee, anticipates Mr. O. C. (Red) Davis and Mr. Charles Visos (White-Rodgers) preparing the pertinent draft coverage with Mr. S. L. Blachman (A.G.A. Laboratories) as project coordinator.

   It is possible this regularization project could be in two stages: first, regularization of common provisions among the standards and, second, determine whether to form what were described as "generic" and "specific" product standards. A generic standard(s) would include provisions common among the standards. Specific product standards would reference the generic standards and include those provisions specific to the particular product. Also considered was the possibility of having a single combination control standard.

   The Committee agreed the subcommittees would be kept informed as the editorialization process progresses and that each subcommittee should establish small groups to monitor recommended changes.

If you have any questions or comments relative to the above actions of the Z21 Committee please feel free to contact us.

Very truly yours,

H I Forman

HOWARD I. FORMAN

cc: W. H. Johnson
R. J. Schulte
F. G. Hammaker
J. P. Langmead
Thomas Z. Cooper ✓
Ronald L. Medford

6(b) CLEARED 6-28-88
✓ No Mfrs Identified
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____ Mfrs Notified
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REPORT

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

Held at
GAMA Headquarters, Arlington, Virginia
June 20, 1985

Presiding: Marvin Leffler

ROLL CALL: Mr. Marvin Leffler called the meeting to order at 10:00 a.m. EDT. The following were in attendance:

Fred Hyman	Brass-Craft Manufacturing Company
Tom Cooper	Consumer Product Safety Commission
Sydney Greenfeld	Consumer Product Safety Commission
Andy Mayernik	Dormont Manufacturing Company
Jerome J. Segal	Dormont Manufacturing Company
Marvin Leffler	Flexible Fabricators, Inc.
James Brown	United States Brass Division of Household International
Guests	
Bob Crawford	American Gas Association Laboratories
Paul Lare	Artech Corp.
J. P. Langmead	Gas Appliance Manufacturers Association (Acting Secretary)

APPROVAL OF MINUTES: The minutes of the March 15, 1985 meeting were approved as circulated.

UPDATE ON CPSC ACTIVITIES REGARDING GAS APPLIANCE CONNECTORS: Mr. Sydney Greenfeld, U.S. Consumer Product Safety Commission, summarized the work which has already been done for CPSC by Artech Corp. Mr. Greenfeld indicated that Artech had examined 20 coated corrugated connectors, many of which had been more tightly coiled than the diameter of the mandrel used in the "Resistance to Ammonia Atmosphere" test in the Z21.24 connector standard. It was reported that 42% of the connectors demonstrated leakage following the test, some in parts that had been tightly coiled, some where the connectors had been bent around the specified mandrel and some in areas that had not been knowingly stressed. In all instances, there were failures in the coating permitting ammonia vapors access to the brass.

REPORT BY CPSC STAFF METALLURGIST ON POSSIBLE OVER-ANNEALING PROBLEMS: Mr. Paul Lare of Artech Corporation then reported on two new tasks which Artech will perform for CPSC. An outline of the scope of work to be performed in both Tasks 1 and 2 is attached (Attachment 1). The first task involves a study of corrosion of connectors under ammonia conditions that might occur in normal usage. He indicated that after examination of the current literature, Artech will characterize the brass from which the connectors were made and how it performs in uncommon exposures, evaluate the effects of some of the processing and testing variables on stress corrosion and attempt to relate performance to stress distribution, ammonia concentration and time of exposure.

In the second task, Mr. Lare indicated that Artech will develop a methodology to test the integrity of coatings after searching the literature and discussing the problems with the American Gas Association Laboratories (A.G.A.L.) and Underwriters Laboratories Inc. (UL). Mr. Lare informed the working group that in evaluating connector coating integrity, he will be assuming a 25 year connector life. Mr. Lare further indicated that it would be approximately 16 weeks from the start of Task 2 to its completion. This means that Task 2 of the Artech report for CPSC would be completed about the end of October.

This timetable led to a general discussion as to when the next Z21 Connector Subcommittee meeting should be scheduled. It was noted that the Z21 Committee, during its April 1985 meeting, had requested a response from the Connector Subcommittee to the connector coating issue by October. Following further discussion, it was unanimously

VOTED

> To recommend that GAMA request a postponement of the Z21 Connector Subcommittee meeting until at least after the next meeting of the Working Group which will be scheduled as soon as possible following the Artech Task 2 report.

During this discussion, the belief was expressed by several working group members that the Z21 Committee had inappropriately coupled the subject of coating integrity of connectors intended for outdoor use with the coating integrity question of connectors designed and intended for assistance in piping alignment in indoor locations. It was noted that coating integrity tests for these two distinctly different types of connectors could be quite different in view of differing exposure conditions.

DISCUSSION OF BACKGROUND AND POSSIBLE REVISION TO AMMONIA ATMOSPHERE TEST: Mr. Leffler discussed a set of tests proposed by his coating supplier for consideration as a method of determining coating adhesion. These tests suggested testing the coating on flat samples of the base metal rather than on the connector itself. It was agreed that the flat sample used should be brass.

Mr. Bob Crawford, American Gas Association Laboratories, then presented a suggested ammonia modified atmosphere test procedure. A copy of this proposed revision is attached (Attachment 2). Following discussion, it was agreed to defer further consideration of these proposed revisions until after the final Artech study is available.

Mr. Fred Hyman then discussed some testing which he had conducted on connectors. The connectors had been subjected to 20 bends around the mandrel specified in the Z21.24 standard and 5 torques as specified in that standard. These same connectors were then exposed to the ammonia atmosphere for a three hour period and none had demonstrated failure. This led to a general discussion on the need for data as to what concentration of ammonia connectors are exposed to and for what period of time.

DISCUSSION OF TESTS TO EVALUATE "AS RECEIVED" CONNECTORS: At the previous working group meeting, it was suggested that a test may need to be developed to simulate the condition of connectors which are tightly coiled in packaging. As another way of addressing this concern, it was reported that manufacturers have written to packagers of connectors and recommended changes in packaging to eliminate sharp bends. The response of one packager was demonstrated by a connector packaged in a manner that did, in fact, eliminate sharp bends.

DISCUSSION OF TEST TO EVALUATE CONNECTOR COATING: Consideration of this item was addressed under the item, "DISCUSSION OF BACKGROUND AND POSSIBLE REVISION TO AMMONIA ATMOSPHERE TEST," noted above. In determining what steps should be followed next, it was agreed that Mr. Hyman will write up a draft of the sequential testing he had performed so that similar tests could be conducted by others. This draft write-up will be distributed once it is received.

NEXT MEETING: Since the Artech report for CPSC is due to be completed by the end of October, it was agreed that the next meeting be scheduled to be held on November 14, 1985.

<u>ADJOURNMENT</u>: The meeting was adjourned at 1:30 p.m. EDT.

Respectfully submitted,

J. P. Langmead
Acting Secretary

JPL/lsg
Attachments (2)

CPSC-C-84-1130
PROPOSED TASK ORDER
ARTECH Reference P9485/J8450.09

ANALYSIS/TEST OBJECTIVE: To develop a correlation between the ANSI Z21.24 ammonia induced stress corrosion cracking (SCC) test relative to brass corrugated gas appliance connectors and normal ammonia exposures which can be expected to occur in the home from various commercial household cleaners.

SCOPE OF WORK: The following work shall be performed:

1. Conduct a literature search on SCC of brasses for the past 5 year period and review the state of the art testing for SCC of brass products.
2. Characterize the chemical composition, microstructure, and microhardness of the starting brass tubing material from which the corrugated tubing is formed.
3. Conduct ammonia resistance tests per Section 4.10 of the ANSI Z21.24 standard for base line purposes.
4. Modify standard test mandrel to include 3 proportionately larger diameters for test specimens and conduct testing of these formed connector specimens in the standard concentration of ammonia.
5. Analyze the exposure of connectors to indoor pollutants, particularly those produced by gas appliances, and their effect on ammonia reactivity with the connectors. Develop rationale for estimating and defining the range of ammonia exposure likely to be associated with connectors.

6. Modify standard test mandrel to include 3 proportionately smaller diameters for test specimens and conduct testing of these formed connector specimens in 3 levels of ammonia concentrations below the standard by control of the pH using H_2SO_4.
7. Subject immersed connector test samples to full strength and recommended diluted solutions of selected commercial ammonia containing household-cleaning solutions and vapor relative to results of #3-#6.
8. Subject samples of unannealed corrugated tubing to several different stress relief heat treatments and test their susceptibility to season cracking by the mercurous nitrate test per ASTM B154 as well as their resistance to ammonia induced SCC.
9. Repeat #8 for samples subjected to standard annealing practice.
10. Metallographically characterize #8 and #9 and compare with the original material (#2 above) before and after corrugation prior to heat treatment.
11. Analyze obtained data relative to the SCC of brass connectors and submit report correlating the ammonia resistance test of ANSI Z21.24 with the obtained data.

METHODOLOGY: ARTECH's approach to successfully completing the analysis/test objective stated above is dependent upon determining the time to initiate surface cracks on the variously stressed connector test specimens. Frequent careful microscopic examinations of the connectors' surfaces will be required to determine this threshold time on triplicate test specimens.

For test setup purposes, stress levels will be determined for the connectors carefully wrapped around the variously sized mandrels through the use of strain gages attached to the corrugations at critical locations. A three dimensional plot might then be possible, knowing the ammonia concentration, connector stress level, and threshold time to surface cracking, for interpolation of intermediate conditions. A duplicate set of stressed connector test specimens will be required to test the threshold time required for surface cracks to form using commercial household cleaners, since these may contain agents that change the reactivity of the ammonia. With this information established it may then be possible to test the predictability of SCC in connectors having different states of heat treatment.

The data produced is presently considered necessary prior to any design and testing of new connector test specimens that are based on a flat coil (pancake) and on a tapered coil profile of increasing diameter and therefore decreasing stress. These can be subjected to three different ammonia concentrations, for liquid and vapor states, considered likely for connector exposure in the home. Alternately flowing heated air and cooled air through the test specimen configurations to accelerate attack by heating and accelerated condensation of vapors by cooling (summertime condition) might simulate environmental conditions over a 25 year projected lifetime of the connectors. Periodic axial displacement of the coils can be incorporated into the test to simulate annual or semiannual movement of the connector.

PERIOD OF PERFORMANCE

After receiving the collected connector samples, a period of eight (8) weeks will be required to complete the laboratory work and analysis of the generated data. The additional one (1) week period will be needed to complete the draft of the final report. The final report can be delivered one (1) week after receiving approval of the draft report.

CPSC-C-84-1130
PROPOSED TASK ORDER
ARTECH Reference P10085/J8450.10

ANALYSIS/TEST OBJECTIVE: To develop and demonstrate an improved methodology for evaluating organic, protective coatings for flexible gas connectors with an expected life of twenty-five years.

SCOPE OF WORK: The following work shall be performed:

1. Conduct a literature search, including phone consultations with ASTM and UL, for recent developments of the previous five (5) years in testing and evaluating life expectancy of organic coatings applied to brass. Review resulting information with CPSC staff for impact on Test Objective and Scope Of Work.

2. Obtain samples of connectors from CPSC that have little or no residual stresses and perform exploratory testing of several coated connector samples, based on the results of #1, to evaluate and demonstrate an acceptable test method, such as a conductivity change, that might be employed to monitor a change in coating protection as a function of mechanical stressing and/or chemical deterioration.

3. For base-line purposes characterize the state of coating perfection for each sample through measurement of the connector's conductivity when the coated portion is immersed in a suitable, chemically non-reacting electrolyte.

4. Form "U" shaped bends around the variously sized mandrels used in Task 09 and repeat the conductivity test to detect loss of coating integrity.

5. Axially stretch a ten-inch length near the center of the connector for several increments (one increment per connector) and remeasure conductivity.

6. Axially compress a ten-inch length near the center of the connector for several decrements (one decrement per connector) and remeasure conductivity.

7. Conduct torsion tests as contained in the ANSI Z21.24 standard and remeasure conductivity after each 90° twist and return cycle.

8. Conduct three levels of impact tests on connector samples using metallic shapes of known mass free falling from known heights and remeasure conductivity.

9. Conduct appropriate abrasion tests for several time intervals and remeasure conductivity.

10. Thermal cycle connector samples from -40°F to 300°F (maximum temperature, ANSI Z21.24) at several time intervals and remeasure conductivity.

11. Subject connector samples to concentrated and diluted household cleaners and remeasure conductivity.

12. Estimate the cyclic stresses occurring over a twenty-five (25) year period and subject connector samples to superimposed stresses that simulate yearly mechanical movement, based on results of #4 through #10 above and measure conductivity as a function of time.

13. Repeat the above incorporating the effect of household cleaning agents and/or indoor pollutants, if found detrimental in #11 above.

METHODOLOGY: ARTECH's approach to successfully accomplishing the TEST OBJECTIVE relies on a simple conductivity test to determine the existence of pores or breaks in the electrically non-conductive, organic protective coating as it exists on unstressed connectors. By intelligent selection of electrolyte concentration, electrode size, applied voltage, and instrument sensitivity, a good estimation of exposed area may be possible. Some degree of electrode polarization and other perturbations are anticipated, but electrolyte immersion is presently thought to be a means of monitoring change in the continuity of the protective coating due to imperfections (such as thin areas, bubbles, poor adhesion) that open when the connector is mechanically stressed.

Using the conductivity as a reference, determined in a suitable electrolyte, the mechanical properties of the coating can be evaluated by controlled application of forces that can be experienced by the connector during packaging, unpackaging, installation, and use over a projected twenty (25) year life. The application of these forces is expected to cause an increase in the conductivity due to mechanical breakage of the coating at a critical stress level. This methodology provides a means of determining a loss in the protection of the coating that is independent of the composition of the coating whether the loss is due to chemical or mechanical failure.

It should be noted that the forming of the "U" bend specimen for the ammonia resistance test does not address the various diameters of flexible connectors that are available. While the annealed brass is capable of deforming without failing, the stress levels incurred in the coating should be substantially different when comparing the largest diameter to the smallest diameter. Data generated during this investigation and on Task 09 should clarify this size dependency omission of the standard.

PERIOD OF PERFORMANCE

After receiving the collected connector samples, a period of twelve (12) weeks will be required to complete the laboratory work and analysis of the generated data. An additional two (2) week period will be needed to complete the draft of the final report. The final report can be delivered two (2) weeks after receiving approval of the draft report.

Proposed Revisions To Ammonia Atmosphere Test (ANSI Z21.24)

4.10 RESISTANCE TO AMMONIA ATMOSPHERE

Corrugated copper alloy metal connectors and fittings shall not develop faults which would result in gas leakage under the following Method of Test.

Method of Test

The test specified below shall be applied to each nominal diameter, type and material of connector submitted.

On connectors employing a protective coating, this test shall be conducted with the coating in place.

Four sample connectors, each 2 feet long, shall be subjected to the following conditions prior to placing in the ammonia atmosphere:

Sample No. 1 - shall be subjected to a pull force of ___ pounds per inch of nominal inside diameter, using the procedure specified in 4.2.2.

Sample No. 2 shall be subjected to ___ 180° bends, using the procedure specified in 4.3.

Sample No. 3 shall be subjected to ___ 90° twists, using the procedure specified in 4.4.

Sample No. 4 shall be subjected to impacts by holding the connector horizontally and dropping from a height of ___ feet to a smooth concrete surface. This shall be repeated ___ times.

Each

~~A~~ connector shall be bent around a 2¼ inch (57.2 mm) diameter mandrel, to form a "U" shape. The ends shall be secured with a nonmetallic material to hold the connector in this shape. One end of the connector shall be attached to an air supply system equipped with a manometer downstream from a shutoff valve and the other end sealed gastight. Air shall then be admitted to the connector until a pressure equivalent to 6 inches mercury column (20.3 kPa) is obtained and the shutoff valve closed.

Each

~~The~~ connector, from the back of one connector nut to the back of the opposite connector nut, shall be suspended in a sealed plastic container to which 500 milliliters of ammonia solution containing ~~250~~ milliliters of full strength ammonia (28 percent) and ~~250~~ milliliters of water have been added. (More than one connector may be placed in the container at one time.)

Note: The connector(s) must not come in contact with the ammonia solution at any time. See Figure 5.

If a sudden drop in pressure occurs, the test shall be discontinued. Otherwise, the connector s shall be removed from the container after 18 hours and examined for leakage under not more than a 2-inch (50.8 mm) depth of water with an internal air pressure of 6 inches mercury column (20.3 kPa).

Rationale: In practice, appliance connectors and their coatings are subjected to some degree of stressing, impact and abrasion during shipping, vendor packaging and installation. The ammonia atmosphere test, which is intended to assure integrity of protective coatings, has been revised to take into account the anticipated handling of a connector prior to and during installation. The test solution concentration has been reduced ---------- (remainder of wording to be developed).

Gama
50th Anniversary
1901 North Moore Street · P.O. Box 9245 · Arlington, Virginia 22209 703/525-9565

July 23, 1985

6(b) CLEARED: 6-28-88
✓ No Mfrs Identified
____ Excepted ________
____ Mfrs Notified
Comments Processed

Mr. Richard Deringer
Chairman, Z21 Connector Subcommittee
c/o Columbia Gas Distribution Companies
P.O. Box 117
Columbus, Ohio 43216-0117

Dear Dick:

On behalf of the working group established by the Z21 connector subcommittee to study connector coatings, I am requesting a postponement of the next Z21 connector subcommittee meeting presently scheduled for October 29-30, 1985.

As you know, this working group consists of the Technical Committee of the Gas Appliance Connector Group of the GAMA General Products Division and several staff members of the U.S. Consumer Product Safety Commission (CPSC). This working group has met twice already and is diligently working on the task assigned to it.

CPSC is having studies performed to examine existing connector designs in relation to variations of the ammonia atmosphere test and the continuity of the coating. The work contracted out by CPSC is scheduled to be completed at the end of September. Subsequently, the report of this project will be available 2 or 3 weeks after that.

Individual connector manufacturers also are conducting studies on connector coatings including methods of checking coating continuity and a more realistic ammonia atmosphere test. Several months are needed for manufacturers to complete this work.

On its present schedule, the working group will not have additional information to consider until the end of October. In fact, its next meeting is tentatively scheduled for November 14. Consequently, the working group will not be able to have recommendations prepared in time for consideration at the subcommittee meeting planned for October 29-30. Therefore, we

/Continued . . .