are requesting a postponement of the Z21 connector subcommittee meeting until at least the end of November 1985. This would allow sufficient time for the ongoing work to be completed, reviewed by the working group and recommendations developed for distribution to the Z21 connector subcommittee prior to its meeting.

Best regards,

Frank

Frank A. Stanonik
Associate Director of
Technical Services

FAS/vly

cc: Forrest G. Hammaker, American Gas Association Laboratories

bcc: Sydney Greenfeld, Consumer Product Safety Commission

Dist 5/20/87

UNITED STATES GOVERNMENT

Memorandum

RECEIVED-OFFICE OF THE SECRETARY
'87 MAY 20 P3:41

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

DATE: 15 MAY 1987

TO: The Commission
THROUGH: Sadye E. Dunn, Secretary
THROUGH: James V. Lacy, General Counsel
THROUGH: Leonard DeFiore, Executive Director
THROUGH: Douglas L. Noble, Director, OPMB
THROUGH: James F. Hoebel, Program Manager, Household Structural Products Program, OPMB

FROM: Ronald L. Medford, Project Manager, Household Structural Products Program, Office of Program Management and Budget (OPMB)

SUBJECT: Voluntary Standard for Flexible Gas Connectors

In accordance with the Commission's policy concerning timely notification of the Commission of significant events relating to voluntary standard activities, we are providing you with information on flexible gas connectors.

On March 5, 1987, during a staff briefing on the status of the Gas Heating Systems Project, the staff informed the Commission of the results of a March 4, 1987, meeting of the ANSI subcommittee for Metal Connectors for Gas Appliances. At the meeting, the subcommittee decided not to revise the "resistance to ammonia test" requirement[1] in the standard despite information which demonstrated that flexible gas connectors were: a) being subjected to bending stresses more severe than those required in the existing standard, and b) that a significant portion of the connectors would fail the resistance to ammonia test prior to being installed and used on an appliance.

[1] The resistance to ammonia test is performed to ensure that the metal used in the connector will not stress corrode and crack. This requirement was written into the voluntary standard because of the susceptibility of brass (the typical material used for residential connectors) to corrode and crack when exposed to ammonia which is found in many household cleaners.

NOTE: This document has not been reviewed or accepted by the Commission.
Initial _____ Date 5/15/87

CPSA 6 (b)(1) Cleared
5/15/87
No Mfrs/Prvtlblrs or Products Identified
Excepted by _____

On March 26, 1987, the Commission staff wrote to the Chairman of the ANSI Committee which oversees the subcommittee for Metal Connectors, Z21, on Gas Burning Appliances (Tab A), expressing concern that the connector subcommittee did not revise the resistance to ammonia requirements in the standard. The staff requested the Committee to review the available data on the subject and to direct the subcommittee to revise the standard.

On April 7, 1987, the Z21 Committee met and voted unanimously to direct the subcommittee to revise the indoor connector standard to allow only the use of stainless steel or to develop suitable tests for other materials. The implication of the vote is an acknowledgement by the Committee that the standard is deficient. As a result of this action, we expect that the subcommittee will initiate action to revise the standard at its next meeting scheduled for December, 1987. The staff will keep the Commission apprised of the progress made to revise the standard.

Attachment

A

U.S. CONSUMER PRODUCT SAFETY COMMISSION

WASHINGTON, D.C. 20207

MAR 26 1987

Mr. Howard I. Forman
Chairman, Z21 American National Standards Committee
P.O. Box 66
Huntingdon Valley, PA 19006

Dear Mr. Forman:

I am writing to express my concern over the March 5 and 6, 1987 meeting of the ANSI Z21.24 Subcommittee for Metal Connectors for Gas Appliances. It is my understanding that the Subcommittee decided not to revise the standard because available field data do not demonstrate a widespread safety problem. While I agree that the field data are limited, the subcommittee should not ignore the available laboratory test data. Those data demonstrate that flexible connectors currently being tested and certified by AGA Laboratories to meet a safety requirement are not capable of meeting that requirement if tested in a manner that reasonably simulates their handling and use by product packagers, retailers, service personnel and the consumer.

Despite evidence that connectors are being subjected to bending stresses greater than those in the standard, the Subcommittee failed to act to revise the Resistance to Ammonia requirements in the standard. As reported by the American Gas Association Laboratories (AGAL) in work sponsored by the Gas Research Institute, these stresses, which may be caused by packaging or installation, frequently occur from bending the connector to a 1/2" radius while the standard test method requires the connector to be bent only to a 1-1/8" radius. Testing by AGAL of new connectors bent to a 1/2" radius demonstrated quite clearly that a large portion (about 50%) will not pass the ammonia atmosphere test after being bent to a 1/2" radius and straightened before testing. These results agree with earlier laboratory tests conducted by the Commission staff when 26 connectors were tightly packaged and tested to the ammonia resistance requirements. Ten of these 26 failed the tests conducted by CPSC. These data were shared with the subcommittee.

Based on the available data, I request that the Z21 Committee place the possible revision of Z21.24 on its agenda for the upcoming meeting on April 7. If the Committee agrees with the Commission staff that the

available laboratory data justify a change in the standard for flexible appliance connectors, then I request that the Committee direct the Subcommittee to revise the standard to more realistically reflect the packaging, handling and use of the connectors. If you agree to place this item on the agenda, please let me know and we will have Commission staff present at the meeting to answer any questions.

These are the views of the Commission staff and have not been reviewed or approved by the Commissioners.

Thank you for considering this issue.

Sincerely,

Ronald L. Medford, Project Manager
Household Structural Products Program
Office of Program Management and
Budget

cc: Richard Deringer, Chairman, ANSI Z21.24 Subcommittee
Richard Schulte, AGA Laboratories
Forest Hammaker, AGA
Anthony Kavenaugh, AGA
Jack Langmead, GAMA

6(b) CLEARED: 2-28-88
X No Mfrs Identified
Accepted
Mfrs Notified
Comments Processed
43 pages

UNITED STATES GOVERNMENT — U.S. CONSUMER PRODUCT SAFETY COMMISSION

MEMORANDUM — WASHINGTON, D.C. 20207

'88 APR 19 P1:27

TO : Colin Church, EXPM
Through: William W. Walton, AED, ES
Through: James I. Price, Director, ESMT
FROM : Thomas E. Caton, ESMT Thomas E Caton

SUBJECT: Flexible Gas Connector Status Report

INTRODUCTION

Flexible gas connectors are used to connect gas appliances to incoming gas lines. The majority of the connectors are made of corrugated brass tube, though a small percentage are made of stainless steel. The brass connectors are subject to corrosion when exposed to common household cleaning agents, i.e. ammonia. Brass connectors are coated with an epoxy coating to shield them from the corrosive effects of household cleaners. These indoor connectors are made to American National Standards Institute, Inc. (ANSI) Standard Z21.24-1981 "Metal Connectors for Gas Appliances" which requires a resistance to corrosion test. Despite these precautions, CPSC still receives reports of coated flexible gas connectors that have corroded in service resulting in a potential fire hazard when gas leaks through the corroded connector. CPSC initiated an effort with ANSI and the relevant trade organizations, American Gas Association (AGA) and Gas Appliance Manufacturers' Association (GAMA), to improve the standard for evaluating the corrosion resistance of flexible connectors especially with respect to protective coating performance. This memorandum will apprise the Commission of the progress of and future plans for industry/voluntary standards activities since the last ES report on December 5, 1986.

BACKGROUND

Due to reported field corrosion problems during the years of 1971 and 1972, a subcommittee of the ANSI Accredited Standards Committee Z21 authorized a field survey. The field survey established that ammonia induced stress corrosion was the principal factor in field corrosion of brass flexible gas connectors. Direct contact with household cleaning agents and, to some extent, the household atmosphere are believed to be the ammonia source. Based on this information, the subcommittee proposed a revision of the standard to include a resistance-to-corrosion test. The revised standard was adopted by the ANSI Accredited Standards Committee Z21 on April 11, 1973, and approved as a standard by ANSI on October 8, 1973. Further revisions to the standard were made and approved on September 8, 1981.

One of the revisions identified the "Resistance to Ammonia Atmosphere Test" to be used as the resistance-to-corrosion test. The ammonia atmosphere test consists of bending a flexible connector

around a mandrel, suspending the connector in an ammonia atmosphere, pressurizing the connector with air, and monitoring any pressure drop that occurs if a crack penetrates the connector wall. If a pressure drop occurs before completion of 18 hours exposure to the ammonia atmosphere, the connector fails the test. The connector passes if no pressure drop occurs after testing for 18 hours. The ammonia atmosphere test is a severe test as no brass connector can pass it without a protective coating. The connector manufacturing industry has questioned whether or not the ammonia test is too severe even for an accelerated test and how the ammonia atmosphere test correlates with normal flexible connector usage. The correlation of the ammonia atmosphere test with normal usage will be addressed later in this memorandum.

DISCUSSION

Ammonia Atmosphere and Holiday Tests

Conflicting opinions regarding the usefulness of the ammonia atmosphere test resulted in CPSC tasking Artech Corporation to determine if a better methodology for evaluating the integrity of epoxy coating on flexible connectors existed or could be developed. Artech developed a holiday test based on electrical conductivity to evaluate coatings. The holiday test is based on the insulating properties of an epoxy coating and the fact that cracks/holes (holidays) in the coating will allow a greater electrical current to pass into an electrolyte than a coating without holidays. This methodology was demonstrated at an ANSI Z21 subcommittee meeting on December 17, 1985. The advantages of the holiday test were obvious to the subcommittee members. It is a non-destructive, simple, and direct test of the coating integrity.

Funding was obtained for an evaluation and AGAL concluded in a report dated June 1986 that the holiday test is a good quality control test, but not a substitute for the standard ammonia atmosphere test. AGAL determined that the holiday test did not show an interrelationship between epoxy coating flaws indicated by the holiday test and those that result in a connector failing the ammonia atmosphere test. AGAL suggested that a small holiday or even a group of holidays may not be ample enough to act as a stress corrosion site. A high density of small holidays might yield a high holiday current reading; however, a connector with a high holiday current reading may not fail the ammonia atmosphere test. Furthermore, any stress corrosion crack that does not penetrate the connector wall would not register, and the interrelationship of the holiday test to the ammonia atmosphere test would be lost. Engineering's impression is that a better test correlation in the AGAL study could result if all stress corrosion cracks developed in the ammonia test were identified, including those which have and have not penetrated the connectors. The AGAL study also concluded that there was considerable inconsistency in the connector coating

quality from the same manufacturer as well as from one manufacturer to another. The reason for this inconsistency was not investigated.

Packaging and Installation Studies

At the April 24, 1984, meeting of the ANSI Subcommittee on Standards for Connectors for Gas Appliances, it was reported that some metal connectors were being marketed in tightly coiled configurations. These connectors were being marketed after being bent during the packaging process to a 1/2-inch radius, which is smaller than the ANSI test mandrel 1-1/8 inch radius. The smaller radius can stress the connector coating and metal more severely than required in the ammonia atmosphere test section of the ANSI Z21.24 standard.

In 1985, based on bending radius concerns, CPSC tested (PSA 1441 and 1569) 26 packaged connectors from various manufacturers. Tests were conducted to the criteria of the ammonia atmosphere test with the connectors bent around a 1-1/8 inch radius mandrel to form a "U" shape, a configuration similar to that occurring in packaging. Twelve of the 26 connectors failed the test. The significance of these failures was that the failure sites were located away from the "U" shaped test section, thus indicating the existence of sufficient stresses (such as from packaging bends) to cause the connector to fail elsewhere. This effort influenced the ANSI Z21 subcommittee to re-evaluate the ANSI Z21.24 standard with respect to the test diameter specified in the ammonia atmosphere test section.

Based on CPSC's test results regarding bend radius, GAMA urged its members to institute procedures to insure that the product distributors did not bend the connectors greater than a 1-1/8 inch radius during the packaging process. GAMA also alerted manufacturers who are not members of the Z21 subcommittee and requested that they alert their distributors to avoid packaging connectors with a radius that is too tight. GAMA suggested that the minimum radius should be 1-1/4 inch.

AGAL also evaluated and reported in May 1987 (attachment) on the effect of packaging and installation on the stress corrosion resistance of flexible connectors. AGAL evaluated 94 connectors and recorded any leakage failures. Twenty-one flexible gas connectors were randomly collected at retail in areas served by 10 gas utilities. These connectors were used to define the minimum radii, number, and form of bends typically applied to brass connectors during packaging and distribution. Twenty-eight connectors, supplied by the same 10 gas utilities, were installed and immediately removed. These connectors were used to define the number, form of bends, and minimum radii typically experienced by connectors during installation and use of the product. Forty-five straight connectors were obtained directly from four manufacturers and used as a benchmark of unstressed, unused connectors. These

connectors were bent in a fashion simulating that observed with the first two sets above, then exposed in the ammonia atmosphere test, and any leakage failures were recorded.

The above study indicated that both packaging and installation can introduce bending radii smaller than 1-1/8 inch required by the ammonia atmosphere test. The packaging and installation report concluded that:

(1) the mechanical stresses applied to a connector after leaving the factory can be more severe than those specified in ANSI Z21.24 Part IV for mechanical preconditioning;

(2) an improved mechanical pre-conditioning procedure should include a two part bending procedure that includes bending straight connectors 180° around a 1/2-inch radius mandrel, straightening, then bending 180° in the opposite direction around the same mandrel prior to the ammonia atmosphere test;

(3) the present connector designs can comply with the conditions described above in (2);

(4) the percentage of leaking connectors from the 45 straight connectors obtained directly from four manufacturers varied significantly from manufacturer to manufacturer (e.g. 18 percent versus 73 percent). The factors influencing these differences in percentage of leaking were not identified; and

(5) the laboratory testing demonstrated that a large proportion (about 50 percent) did not pass the ammonia atmosphere test after being bent to a 1/2-inch radius and re-straightened before testing. This failure rate agrees with earlier CPSC tests conducted on 26 flexible connectors in 1985. Furthermore, the proportion of connectors found with leaks mentioned in (4) above did not correlate with actual lower overall field experience. The smaller number of reported field experience leaks may be due to the small number of coated connectors actually exposed to ammonia and/or a use location that protects the connector from ammonia attack by being under and behind the appliance. It is also probable that connectors that do develop leaks in use may be found during regular household maintenance and replaced by the consumer without incident.

Prospective work recommendations were that: (a) the packaging and installation evaluation reported in May 1987 should be reviewed by the connector subcommittee to evaluate the need for more severe mechanical pre-conditioning of straight connectors before the

ammonia atmosphere test; (b) studies should be conducted to address outdoor use conditions pertaining to a proposed standard for outdoor connectors; (c) further studies should be conducted to determine the effects of coating abrasion on connector performance for both indoor and outdoor applications; (d) packagers of connectors should again be requested by the connector manufacturers to use packaging procedures that do not create sharp bends in coated connectors.

Improved Corrosion Tests Based on Outdoor Connector Standard

At the February 10, 1987, ANSI Board of Standards Review meeting, approval was withheld for the proposed ANSI standard "Gas Connector for Connection of Fixed Appliances for Outdoor Installation and Manufactured (Mobile) Homes to the Gas Supply, Z21.75" because of "concern regarding the large number of unresolved objections..." received when voting to approve this standard. The lack of approval leaves a void in this area of outdoor connectors.

In July 1987, AGAL submitted a prospectus (attached) to GRI to obtain funding for an evaluation of gas connectors for outdoor use with the goal to develop necessary data to draft an acceptable version of the proposed ANSI standard Z21.75.

In December 1987, the ANSI Z21 subcommittee on Standards for Connectors for Gas Appliances met to decide which proposed revisions to ANSI flexible gas connector standards should be accepted. A summary of the meeting is attached. The subcommittee reviewed an AGAL prospectus entitled "Evaluation of Connectors for Outdoor Use." Several revisions were suggested: (1) the Artech holiday test should not be used, only the ammonia atmosphere test should be used; (2) all connectors for the outdoor connector study should be examined for coating defects; (3) all connector manufacturers should be given the test procedures to enable them to evaluate their connectors so they can decide whether to submit their connectors for testing. Research should be conducted on various test conditions including:

1. Freezing and thawing of wet connectors,
2. Flexing at temperature extremes of -40 and +140°F,
3. Ultraviolet light exposure,
4. Ammonia exposure,
5. Fertilizers and herbicides exposure,
6. Chloride exposure, and
7. Oxides of nitrogen exposure.

A working group was formed in December 1987, to evaluate the results of the research and the recommendations developed from it. These results are planned to be available after six months and will be submitted to the working group when available. The subcommittee was also willing to consider stricter standards for indoor flexible gas connectors that will meet conditions as severe as those being developed for the outdoor connectors. The test conditions containing ammonia and chloride would be of special interest to CPSC

as these chemicals are commonly found in a house. The subcommittee agreed that this requirement for indoor connectors is a worthwhile goal. The testing criteria for indoor connectors will be based in part on test requirements for outdoor connectors. Actual test requirements will be determined after the outdoor connector standard is finalized.

SUMMARY

After its evaluation, AGAL concluded that the Artech Corporation holiday test was a good quality control test, but not a substitute for the standard ammonia test.

Another AGAL study revealed that packaging and installation can introduce bending radii smaller than required by the ammonia atmosphere test. These mechanical stresses applied after leaving the factory can be more severe than those created during the quality assurance testing by ANSI Z21.24 standard.

The same study found that there is considerable inconsistency in flexible connector epoxy coating quality from the same manufacturer as well as from one manufacturer to another.

AGAL has submitted a prospectus for funding to conduct research to evaluate, with the goal to produce a standard, gas connectors for outdoor use. After many hesitations to resolve objection to the proposed standard, a working group was formed in December 1987, to evaluate the research. Results are due six months after formation of the working group.

The ANSI Subcommittee Standards for Connectors for Gas Appliances is receptive to CPSC staff recommendations that indoor flexible connectors should conform to requirements as severe as those (especially ammonia and chloride exposure) under development for outdoor connectors.

It continues to appear that the efforts of CPSC, ANSI, gas producers, and gas appliance industry are moving in a direction of developing a more realistic standard for coated flexible gas connectors. ES is hopeful that this will result in an improvement in the quality of the coatings on the connectors since the test procedures that appear to be evolving from these studies will test the coatings more rigorously than the existing standard.

cc: D. Switzer, ESES

Attachments:

S. R. Walzer, "Task Report for Work Area 2.8 Indoor Corrugated Brass, Connectors: Evaluation of Stresses Induced by Packaging and Use", AGA Laboratories Report, May 1987.

"Evaluation of Connectors for Outdoor Installation", AGA Laboratories Prospectus, July 1987.

Thomas E. Caton, "Log of Meeting of American National Standard Sub-Committee on Standard for Connectors for Gas Appliances" December 14, 1987, revised February 24, 1988.

GAS APPLIANCE TECHNOLOGY CENTER

1986 PROGRAM

FINAL

TASK REPORT FOR WORK AREA 2.8

INDOOR CORRUGATED BRASS CONNECTORS: EVALUATION OF STRESSES INDUCED BY PACKAGING AND USE

Prepared By

S. R. Walzer

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For

GAS RESEARCH INSTITUTE

Contract No. 5086-241-1220

GRI Project Manager
Robert J. Hemphill
Manager, Appliance Research

Work Done During: July - December 1986
Report Date: May 1987

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TABLE OF CONTENTS

LIST OF FIGURES

1.0 EXECUTIVE SUMMARY

1.1 Background

Corrugated brass connectors are designed to facilitate the installation of gas appliances, such as residential ranges. Such connectors have been known to leak in service. Some leaks have been attributed to stress-corrosion cracking, which can be accelerated by household cleaning agents which contain ammonia.

It has previously been established that ammonia-induced leaks in brass connectors occur primarily in areas where the connector metal is under mechanical stress. Examination of packaged connectors indicates that compact packaging can cause mechanical stresses in connectors, even before they are installed. These pre-installation stresses in the connector metal can be compounded by stresses induced during the installation of the gas appliance and subsequent movement of the appliance for cleaning.

Most corrugated brass connectors for indoor use are made using designs certified under American National Standard Z21.24 entitled, "Metal Connectors for Gas Appliances". Standard Z21.24, Part IV, provides for testing copper alloy connectors to demonstrate that the connectors will not be adversely affect by corrosion caused by ammonia in the atmosphere. The current standard has a three-step test procedure for determining resistance to an ammonia atmosphere:

1. Mechanical pre-conditioning - the sample straight connector is bent once around a 2-1/4" dia. (1-1/8" radius) mandrel to form a "U" shape.

2. Exposure to ammonia - the bent connector is suspended in a sealed plastic bucket containing ammonia vapor for 18 hours.

1.2 Objective

This GATC task was conducted to review and evaluate procedures for mechanical stressing (pre-conditioning) new, coated, corrugated brass connectors prior to application of the standard ammonia test. Existing and alternate pre-conditioning procedures were evaluated in light of actual bends (mechanical stresses) observed in purchased connectors and in connectors used with residential gas range installations.

1.3 Summary of Work Done

This report discusses work on three (3) sets of connectors. Set I included 21 sample units supplied by 10 gas utilities. These connectors were purchased on a random basis in the area served by the utility. The 21 connectors were sent to A.G.A.L. unused, with the shapes and in the retail packages used to transport, display and sell the connectors. This set was used to define the minimum radii, number, and form of bends which are typically applied to brass connectors during packaging and distribution.

Set II consisted of 28 used connectors supplied by the same 10 gas utilities. These connectors were purchased by the utilities, installed on a customer's gas range (moving and range briefly into operating position), then immediately removed. The removed connectors were sent to A.G.A.L. in the same configuration they were in at the time of removal. This set was used to define the minimum radii, number, and form of bends typically experienced by connectors during installation and subsequent use of the product.

Connector Set III included 45 connectors obtained directly from four manufacturers in a straight configuration. These connectors were identified as Groups A, B, C and D. This set was used as a benchmark group of unstressed and unused connectors.

example, 18% of the connectors in Group B and 73% of the connectors in Group D leaked. The factors influencing these differences were not identified.]

5. The extent of connector leaks found and reported in Conclusion 4 above does not correlate with actual, overall field experience. [The A.G.A. Laboratories Certification Department has no conclusive evidence that significant numbers of coated, corrugated, brass connectors are developing leaks in service due to stress-corrosion cracking or any other cause. The difference between experimental results and the Laboratories' knowledge of field experience implies that loss of coating integrity does not necessarily lead to loss of connector integrity. This result may be explained by one of the following factors:

   - The number of coated connectors actually exposed to ammonia atmospheres of a strength or duration sufficient to produce stress-corrosion cracking may be small. It is believed, for example, that thousands of uncoated brass connectors are in service and performing satisfactorily despite the threat of ammonia attack.

   - Brass connectors with flawed coatings may be somewhat protected from attack by ammonia because of their location under and behind appliances. Ammonia, if present, may not be deposited on the connector where the coating is flawed and the metal is stressed.

Also, of the connectors that do develop leaks in service, most are found and replaced without incident in the course of routine appliance maintenance activity by consumers and service companies.]