Analysis of Flammable Vapor Resistant Water Heater Field Experience and Service Programs

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Natural Gas Codes and Standards
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400 N. Capitol St., NW
Washington, DC 20001

Prepared by

Daryl L. Hosler and A.L. Wilson
Wilson Environmental Associates
41 Valente, Irvine,
California 92602Energy

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Natural Gas Codes and Standards
Research Consortium
400 North Capitol Street, NW
Washington, DC 20001

American Gas Foundation

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SUMMARY

The Natural Gas Codes and Standards Research Consortium was initiated in 2004 to fund research and analysis on end use natural gas technical issues for the mutual benefit of the gas utility industry and its customers. Research and analysis issues considered for funding include national model codes and standards support, cost-effective energy efficiency for natural gas appliances, appliance and equipment safety, and associated public health issues. One of the first projects identified for funding dealt with the analysis of field experience and service programs of Flammable Vapor Ignition Resistant Water Heaters (FVIR) which had been introduced into the U. S. market in July, 2003 for 30, 40, and 50 gallon atmospherically vented models. These water heaters are certified to ANSI Z21.10.1.

FVIR water heaters represented a major design change for gas-fired residential storage water heaters. This design change was prompted by efforts to reduce the number of ignitions of flammable vapors by gas-fired water heaters and resulting deaths and injuries. As expected with a major design change, the first cost of gas-fired water heaters increased significantly, resulting in gas utility concerns with loss of market share in new housing projects due to higher first costs or extensive field problems with the new designs.

All manufacturers chose to design FVIR water heaters with the same basic features, namely a sealed burner combustion system and a flame arrestor protected combustion air opening to contain ignited vapors and prevent flash back into the room where the water heater was installed. In addition, because of concerns with blockage of the flame arrestor protected combustion air opening, a Lint, Dust, and Oil (LDO) requirement led to the addition of a temperature activated device to shut down the water heater in the event of excessive LDO blockage and/or a flammable vapor incident. Every water heater manufacturer applied the temperature activated devices in a different manner, depending on their particular designs. The use of this temperature activated device led to some early field problems.

The main goal of this analysis is to summarize, to the extent possible, identified field problems with FVIR water heaters, manufacturer programs to address those problems, and to allow the gas utility industry to utilize that information in communications with the public, codes and standards officials and bodies, and utility management regarding potential issues with new designs. This approach was felt necessary due to the proprietary nature of much of the manufacturer developed information regarding specific FVIR designs.

The U. S. gas water heater industry is highly competitive, and while the industry cooperates with utilities in the development of national safety standards, the Water Heater Joint Research and Development Consortium was formed by manufacturers to develop basic FVIR designs and field test them without the detailed involvement of utilities. This lack of direct involvement in the development and application of the new design features by utilities led to a concern that utilities could be negatively impacted by field problems resulting in increased field service calls and associated costs or loss of market share.

INTRODUCTION

The prevention of ignition of flammable vapors by gas-fired water heaters has been addressed by local, state, and national installation codes since the early 1950's. The best information available indicates that the National Electric Code (NEC) adopted a requirement for electrical outlets to be elevated 18 inches from the floor in garages and similar locations to eliminate the ignition of flammable vapors by electrical arcing. The 1964 American Standard for Installation of Gas Appliances and Gas Piping, Z21.30/NFPA 54, contained a requirement in section 3.1.6, Installation in Residential Garages, which stated that gas appliances may be installed on the floor of a residential garage provided a door of the garage opens to an adjacent ground or driveway level that is at or below the level of the garage floor. When that condition did not exist, appliances had to be installed so that the burners and pilots were at least 18 inches above the floor. This code requirement resulted in the installation of tens of thousands of water heaters on

garage floors throughout the United States.

An important note here is that this elevation requirement applied only to residential garages, therefore water heaters installed in utility rooms or closets inside a house were not required to be elevated or to have the floor slope away. These installation practices led to numerous flammable vapor ignition incidents when flammable liquids were stored or used inside the house. By the late 1980's and early 1990's, ignition of flammable vapors by gas-fired water heaters, regardless of where they were installed, was being addressed by the Consumer Products Safety Commission, a federal agency with regulatory authority over these products. In addition, civil lawsuits were being filed against manufacturers, installers, and servicing gas utilities primarily on the basis that they were not doing enough to properly warn consumers about the dangers of storing or using flammable liquids near operating, standing pilot equipped, gas-fired water heaters.

In addition to the "Failure to Warn" issue, some Expert Witnesses in civil lawsuits were promoting a "simple" design change to gas-fired water heaters, based on the "Davy Lamp". This is a technology that was used in coal mines to prevent the ignition of methane or other combustible gases by the flame of the lamp used for illumination. This device used a specifically designed flame arrestor screen to prevent the ignition of flammable vapors outside of the lamp itself. It was postulated that by developing a sealed combustion system for gas-fired water heaters and utilizing a flame arrestor, flammable vapor ignitions could be eliminated.

In the early 1990's, a proposal was submitted to the Z21 Committee's Water Heater Subcommittee that would require a Z21.10.1 storage water heater to not ignite flammable vapors outside of the unit in the event of a gasoline spill. This proposal led to a research project by the Gas Research Institute (GRI), and conducted by A. D. Little of Cambridge, Massachusetts, to determine if a gas-fired water heater could be designed in a manner that would prevent the ignition of flammable vapors and yet be cost-effective and as safe and reliable as existing models. A Technical Committee of Manufacturers, Gas Utility personnel, and other interested parties was formed to help evaluate and guide the

research.

After a significant period of investigation, a White Paper was written by A. D. Little that outlined several design options for gas-fired water heaters to prevent the ignition of flammable vapors outside of the unit. After the White Paper was reviewed and adopted, work commenced on developing prototype designs and a sophisticated test chamber was built to safely test gasoline spills that may be ignited explosively if a design failed to work. Manufacturers reported that the effort to design and build marketable FVIR water heaters cost industry approximately 100 million dollars to complete.

Once prototype development began in earnest, the aforementioned Water Heater Joint Research and Development Consortium was formed and became the vehicle by which participating manufacturers could share information and research, without making the data public. This was necessary because during the development–process, there was always one manufacturer who was not a member of the Consortium. Unfortunately, this also made it extremely difficult to publicly share information with gas utility personnel. While manufacturers attempted to assure utilities that they were building reliable water heaters that could be used as direct replacements for existing units, this partial information vacuum led many to wonder if these new water heaters would actually be relatively trouble free when they were installed in greater and greater numbers.

It is worth mentioning that water heater manufacturers, who were not able to share details about their individual designs during this design stage, still had to develop reliable FVIR water heaters or risk losing their own market share to highly motivated competitors. Interviews conducted during the background research on this project showed that while the manufacturers engineering and research departments worked together during the development of the new products, the marketing departments did not feel constrained about seizing on any perceived problem with a competitors model and sharing that with as many customers (and potential customers) as possible. This tended to make initial field problems or issues seem larger than they actually were.

METHODOLOGY

Based on the information contained in the Natural Gas Codes and Standards Research Consortium's RFP 04-002, WE Associated submitted a proposal that contained six tasks to gather actual field experience data and to summarize manufacturer programs for addressing identified problems with various designs. Those six tasks were: 1) Identify gas utilities performing appliance service willing to collect field information on FVIR water heater issues; 2) Develop data collection instruments for field survey and utility interviews; 3) Develop joint data collection and information transfer for FVIR water heaters with GAMA and/or individual water heater manufacturers; 4) Data collection and analysis and review of current installation instructions for FVIR water heaters; 5) Present preliminary findings to BECS Committee; 6) Report analysis findings for field experience with FVIR water heaters. This proposal was accepted by the NGCSRC on September 23, 2004 and work commenced.

The first two tasks were addressed simultaneously. During the development of the data collection instrument, the Southern California Gas Company was contacted for assistance by the author, who had been an employee of that company for 30 years. With over 5 million customers in central and southern California and a robust New Construction Department that maintained contact with area builders, it was felt that they would have information on field issues that would be of benefit in designing the data collection form for other utilities. Customer Service Field Staff was contacted to see if they had been receiving reports from the over 1300 SoCalGas field employees who serviced gas appliances on a daily basis, and the Residential New Construction Department was contacted for information from builders on their experience with FVIR water heaters. Neither group was able to identify any problems related to the installation and use of FVIR water heaters. The builders all mentioned first cost as a concern, but not operational problems.

Based on this information, it was decided that a field data collection approach would not likely be productive, for two reasons. The first was that significant technical

problems that could be captured and analyzed by a utility survey form did not seem to exist, and that any major problems were being handled through manufacturers warranty programs, meaning they would be the best source of information if they were willing to share the data. In conjunction with this effort, an internet search was done for Chat Rooms that might be discussing FVIR water heater problems. That effort resulted in finding one posting on November 6, 2003 asking if anyone was having problems with FVIR water heaters, and no reply was received. The posting itself did not indicate any problems existed. Industry magazines, primarily plumbing related, and manufacturer and utility websites were also monitored for any posted information on problems with FVIR water heaters. This effort has been ongoing since the inception of the project, without any significant information or discussions found.

It was also decided that going directly to manufacturers for information related to field experience with FVIR water heaters was the best approach. Accordingly, the author received permission to attend the Technical Committee of the Water Heater Division of the Gas Appliance Manufacturers Association, Inc. meeting at the Crowne Plaza Atlanta Airport Hotel on November 10, 2004 to discuss the research project and solicit cooperation in completing it. A short presentation was given to the attendee's on the goals of the research project, and the status to date. In addition, information from GRI Topical Report GRI-97/0319, A Review of U.S. LDC Residential Customer Attachment Policies was discussed to illustrate the importance of gas-fired water heaters to utilities.

American Gas Association Laboratories Report No. 1408, August 1965, Progress Report, National Appliance Field Observation Program, was also discussed to illustrate a relatively successful program of sharing information on field issues between gas utilities and manufacturers that could be considered again in the future. The meeting resulted in the unanimous support by water heater manufacturers to share their field experiences with FVIR water heaters, as well as their field bulletins and installation instructions that pertained to FVIR water heaters. The manufacturers present also endorsed the concept of developing a communication program with gas utilities designed to share information on a timely basis for the benefit of the industry and consumers as a whole. After the meeting,

contacts were made with individual water heater manufacturers, and water heater control manufacturers for follow up discussions.

Also during this period, the author attended three AGA Building Energy Codes and Standards Committee (BECS) meetings to update utilities on the status of the research project. This was done because most of the members of the Natural Gas Codes and Standards Research Consortium were also members of the BECS Committee. After the status reports were given, a request was made at each meeting for participants to provide the author with any information they had related to field problems with FVIR water heaters.

This effort resulted in obtaining a copy of a memo outlining a problem with FVIR water heaters in attics in the southeastern United States. It appeared that the problem was temperature related from the memo. Contact was also made with representatives from three different natural gas utilities who had volunteered internal contacts who were involved in marketing or servicing FVIR water heaters. Those contacts did not result in any identified field problems with FVIR water heaters. Several other verbal reports of potential problems obtained at BECS Committee meetings were investigated with manufacturers representatives, and all were determined to be either not directly related to the FVIR design changes or no concrete information on the problem was obtained.

RESULTS

Initial discussions with a control manufacturer highlighted the issue of appropriate temperature settings and location for LDO switches and the proper installation of water heaters. If used, LDO switches are specified by the water heater manufacturer for a certain temperature that will correlate to shutting off the water heater before failing the maximum 400 PPM CO requirement in the LDO test. If a switch is used inside the combustion chamber and the switch shutoff temperature is set to low, nuisance shutoff's can occur. This appeared to be the case with the one documented field problem that was obtained during the initial phase of the study. In that instance, water heaters installed in

attics were shutting down when high attic temperatures were reached, and the builder was stating that he would switch to electric water heaters in attic installations to avoid these problems.

Based on information contained in the memo, the cause of the nuisance shutoffs was not apparent to the utility personnel. Discussions with the manufacturer identified from the memo confirmed that high attic temperatures could be a cause of nuisance shutoff's with their products due to the temperature setting of the LDO switch. A second water heater manufacturer whose products were claimed to have been installed in the same attics to replace the first manufacturers units stated that they had investigated the report and they confirmed that thier products were never installed at that location. It is unknown at the writing of this report which manufacturers products were ultimately installed in the attics (and whether they were gas or electric) or what the long term reliability of those replacement units is.

In addition to the initial temperature setting of LDO switches, venting configurations, ambient temperatures, and lack of combustion air were all identified as potential contributors to nuisance shut off problems for FVIR designs. In an attic installation for example, if the vent left the draft hood with a minimum amount of rise and the maximum lateral run, the configuration could cause the pilot flame to flatten out in the sealed combustion chamber and result in the incorrect impingement on the thermocouple. This could occur even though the venting system met minimum code requirements, especially during periods of hot weather.

Restricted combustion air, either from incorrectly sized openings in closets or attics or restrictions caused by excessive lint, dust, or oil, could also lead to nuisance shutoffs due to incorrect pilot flame impingement or excessive combustion chamber temperatures and the shutoff of LDO switches. Because manufacturers utilized different methods or devices for applying the temperature related LDO device, it can be expected that over the long term, some manufacturers will experience a difference in reliability for units installed in marginal situations.

A Freedom Of Information Act (FOIA) request was made to the Consumer Product Safety Commission (CPSC) in May, 2005, to see if they had any reports of problems or incidents associated with FVIR water heaters. CPSC provided 11 reports involving water heaters dating back to May of 2003. The reports were reviewed and none of them involved a FVIR water heater, based on the information available in the reports. One incident involved the ignition of gasoline saturated clothing, and the rest involved fires, CO incidents, and miscellaneous performance complaints such as sooting and disintegrating plastic dip tubes. No reports were found that involved linting or blockage of combustion air openings.

A report of excessive linting of FVIR water heaters in British Columbia, Canada was followed up by e-mail requesting details of the incident. No additional information was received despite follow up. A review of manufacturers FVIR water heater installation instructions and field bulletins did not identify and other major design or installation issues with FVIR water heaters. It is expected that each manufacturer will continue to improve their products as they gain more field experience or develop new ways to prevent the ignition of flammable vapors. This is a normal situation as manufacturers strive to have the most cost effective and reliable product possible, in order to retain or gain market share.

DISCUSSION

The initial field deployment of FVIR water heaters appears to have been successful despite rumors of potential problems. It appears that whenever a problem surfaced, competitive manufacturers attempted to make the most of it in order to promote their own products. In some cases, a lack of knowledge of the fundamental design features of these new water heaters led to concerns that bigger problems would occur, and that people were just witnessing the “tip of the iceberg”. It appears that water heater manufacturers closely watched the deployment of their products and thoroughly investigated reports of problems. The information obtained shows that manufacturers

made corrections to manufacturing problems as they became apparent. Installation problems, where the water heater was installed in a marginal situation such as an attic space, closets with improperly sized combustion air openings, or marginal venting system configurations were a little more difficult to address since the manufacturer of the water heater had little control over that aspect of the issue. In some cases, pre-FVIR water heaters had operated in these marginal locations, but FVIR type water heaters would not. Manufacturers addressed this issue either in their service manuals or through additional field service bulletins.

Because of their design, FVIR water heaters may not operate normally in marginal installations, but they will operate as designed when installed as recommended by the manufacturer. They have retained serviceable components, although servicing is more difficult due to the sealed combustion chamber design. In addition, it is unknown at the time this report is being written whether or not lint, dust, or oil accumulation on the combustion air openings or the integral flame arrestor will cause significant operational problems and the need for non-routine cleaning of these parts, which may or may not require disassembly of the sealed combustion chamber. Manufacturers are fully aware of the issues involving blockage of combustion air openings, and all have attempted to design their products in a manner that significantly reduces the need for non-routine service.

According to industry sources, power vent water heaters must meet FVIR requirements by January 1, 2006. All other Z21.10.1 water heaters must meet the FVIR requirements by January 1, 2007. Recreational Vehicle water heaters are not required to be FVIR compliant. Additional field issues may surface with the roll out of these products, as well as issues with the initial FVIR water heaters that may come to light after additional time in service. During the research project discussion with the water heater manufacturers, the possibility of establishing a communication vehicle, based loosely on the National Appliance Field Observation Program (also known as the Gas Appliance Improvement Network (GAIN) in the 1980's) was discussed and ultimately supported by those present.

This communication network would serve as a means for utilities to ask questions of manufacturers related to their products, which in this case would initially be limited to water heaters, and receive timely responses. A proposed method would involve having a central contact person for utility questions (AGA Staff, utility volunteer, or contractor), where the questions could be reviewed and clarified before forwarding to GAMA staff for additional review and forwarding to the appropriate manufacturer. Once an answer was received, it would be sent back through the utility contact for filing and then returned to the person or organization that initiated the question. Manufacturers would also be able to use this system to ask questions of utilities.

Having a central contact person for utilities and coordinating through GAMA staff will significantly reduce the workload associated with having multiple utilities contacting manufactures and help to ensure consistent and timely information exchanges. GAMA staff agreed to participate on behalf of their manufacturers if this type of communication vehicle was established. It is recommended as an outcome of this research project that the Natural Gas Codes and Standards Research Consortium consider initiating a project designed to achieve this communication vehicle on behalf of the Consortium members and the utility industry .

LIST OF CONTACTS

Paul E. Beach, Chief Engineer, Standards
White-Rodgers Division
Emerson Climate technologies
24650 Center Ridge Road, Suite 150
Westlake, OH 44145-5627
Phone: 440/835-1300
Paul.beach@white-rodgers.com

Charles W. Adams, Vice President, Product Engineering
A. O. Smith Water Products Company
500 Tennessee Waltz Pkwy
Ashland City, TN 37015-1299
Phone: 615/792-2166
cadams@hotwater.com

Drew Smith, Director-Residential Product Engineering
A. O. Smith Water Products Company
25731 U. S. Highway 1
McBee, SC 29101-8510
Phone: 843/335-8281 Ext. 537
dsmith@hotwater.com

Tim Shellenberger, Vice President, Rinnai America
103 International Drive
Peachtree City, GA 30269
Phone: 770/632-4316
tshellenberger@rinnai.us

Ted Poulin
GSW Water Heating, A Division of GSW Inc.
599 Hill Street west
Fergus, Ontario
CANADA N1M 2X1
Phone: 519/843-1610 Ext. 4385

Eric M. Lannes, President
Bradford-White Corporation
200 Lafayette Street
Middleville, MI 49333-0247
Phone: 269/795-3364
elannes@bradfordwhite.com

Michael W. Gordon, Vice President, Engineering
Bradford-White Corporation
200 Lafayette Street
Middleville, MI 49333-0247
Phone: 269/795-3364
mgordon@bradfordwhite.com

D. Scott Essenburgh
Manager, Engineering Support
Bradford-White Corporation
200 Lafayette Street
Middleville, MI 49333-0247
Phone: 616/795-3364
sessenburgh@bradfordwhite.com

Michael Garrabrant
American Water Heating Company
1100 E. Fairview Ave.
Johnson City, TN 37601-3504
Phone: 423/975-2409
Michael.garrabrant@awhc.com

William Harrigill
Vice President, Product Development
Rheem Manufacturing Co.
Water Heater Division
101 Bell Road
Montgomery, AL 36117
Phone: 334/260-1354
bharrigi@rheem.com

Joseph Boros, Engineering Manager
Rheem Manufacturing Company
2600 Gunter Park Drive East
Montgomery, AL 36109-1413
Phone: 334/260-1389
jboros@rheem.com

S. Ron Caudle
Southern California Gas Co.
1919 S. State College Blvd., SC 8389
Anaheim, CA 92806-6114
Phone: 714/634-5042
scaudle@semprautilities.com

Larry Whaley
Southern California Gas Co.
1919 S. State College Blvd., SC 8389
Anaheim, CA 92806-6114
Phone: 714/634-3177
lwhaley@semprautilities.com

John Krill, Manager, Technical Operations
Union Energy
539-A Collier MacMillan Dr.
Cambridge, ON N1R 7P3
Phone: 519/622-2772 Ext. 2012
jkrill@unionenergy.com

Donald W. Switzer
U. S. Consumer Product Safety Commission
4330 East West Highway, Room 611
Bethesda, MD 20814
Phone: 301/504-7534
dswitzer@cpsc.gov

Frank A. Stanonik, Chief Technical Advisor
GAMA
2107 Wilson Boulevard, Suite 600
Arlington, VA 22201
Phone: 703/525-7060
fstanonik@gamanet.org

David Sutula
Manager, Technical Services
GAMA
2107 Wilson Boulevard, Suite 600
Arlington, VA 22201
Phone: 703/525-7060 Ext. 223
dsutula@gamanet.org

Ted B. Reinhart
Manager, Utilization Engineering & Market Dev.
Laclede Gas Company
720 Olive Street, Room 1423
Saint Louis, MO 63101-2338
Phone: 314/342-0720
treinhart@lacledegas.com

Jeff Kelly, Manager, Consumer Marketing
Laclede Gas Company
720 Olive Street, Room 1411
Saint Louis, MO 63101-2338
Phone: 314/342-0874
jkelly@lacledegas.com

Martin P. Petchul
Manager, Codes and Technical Training
Piedmont Natural Gas Company
P. O. Box 33068
Charlotte, NC 28233-3068
Phone: 704/731-4457
martin.petchul@piedmontng.com

Don Ferguson
Supervisor, Codes and Standards
Piedmont Natural Gas
1915 Rexford Road
Charlotte, NC 28211
Phone: 704/731-4401
donald.ferguson@piedmontng.com

Ronnie Ray Frazier
Codes and Standards Specialist
Atmos Energy Corporation
800 E. Border Street
Arlington, TX 76010-7408
Phone: 817/303-2916
Ronnie.frazier@atmosenergy.com

Dennis Holden, Director/Customer Relations, Southern Arizona Division
Southwest Gas Corporation
P. O. Box 26500
Tucson, AZ 85726-6500
Phone: 520/794-6503
Dennis.holden@swgas.com

Edward J. Angelone, Manager
Keyspan Corporation
8424 Ditmas Ave., Bldg. #31, 1st Floor
Brooklyn, NY 11236-1502
Phone: 718/270-5840
eangelone@keyspanenergy.com

C. J. Beck, Senior Engineer
Pacific Gas and Electric Corporation
Mail Code N-7P
P. O. Box 770000
San Francisco, CA 94177-0001
Phone: 415/973-4659
Cjb4@pge.com

Mike Deegan, South Area Service Manager
Clearwater Gas System
400 N. Myrtle Avenue
Clearwater, FL 33755-4433
Phone: 727/562-4900
Mike.deegan@clearwatergas.com

Terry L. Hurst, Commercial Sales Manager
NW Natural
One Pacific Square
220 northwest Second Avenue
Portland, OR 97209-3991
Phone: 503/721-2486
tlh@nwnatural.com

Russel Iwan, Director, marketing
Metropolitan Utility District
1723 Harney Street
Omaha, NE 68102-1907
Phone: 402/504-7720
Russ_iwan@mudnebr.com

Gert P. Rudel, Marketing Programs Manager
Centerpoint Energy Southern Gas Operations
P. O. Box 2628
Houston, TX 77252-2628
Phone: 713/207-5625
Gert.rudel@centerpointenergy.com

Matthew W. Wilber, Manager, Codes and Standards
Centerpoint Energy Minnesota Gas
800 LaSalle Avenue
Minneapolis, MN 55402-0000
Phone: 612/321-4385
Matthew.wilber@centerpointenergy.com