MEETING LOG
DIRECTORATE FOR ENGINEERING SCIENCES

SUBJECT: Meeting of the Z21/83 Water Heater Subcommittee

PLACE: Hilton Hotel South, Cleveland, OH

MEETING DATE: June 20, 2001

LOG ENTRY SOURCE: Donald W. Switzer

ENTRY DATE: September 14, 2001
COMMISSION ATTENDEES:

Donald W. Switzer ES

NON-COMMISSION ATTENDEES:

See Attached Attendance Sheet

MEETING SUMMARY

The only item on the agenda for this meeting was to review and accept for review and comment a lint test to certify that Flammable Vapor Ignition Resistant (FVIR) water heaters will not be adversely by lint which may be present in the home. The Gas Appliance Manufacturer Association (GAMA) proposed a Lint test method for adoption. American Water Heater Company proposed several modifications to the GAMA test method to address what American considered to be weaknesses in the GAMA method. In order to ascertain if American's concerns are valid, the water heater subcommittee charged the Canadian Standards Association (CSA) to conduct a series of tests comparing the results of the two methods. The results for the tests would be forwarded to a working group for evaluation. The working group was charged to review the results recommend the preferable method to the subcommittee before the meeting scheduled for fall, 2001. The agenda item is attached.

Supplement #2 to ITEM 1.
Z21/CSA Joint Water Heater
Subcommittee Meeting,
June 20, 2001

PROPOSED LINT, DUST AND OIL TEST PROTOCOL FOR VOLUME I WATER HEATERS

Action Requested

Review the proposed lint, dust and oil test protocol for volume I water heaters and consider adopting revisions for distribution for review and comment.

Background

By e-mail dated June 11, 2001, Mr. Tim Shellenberger, American Water Heater Company, requested that the attached proposed revisions to the proposed test protocol to evaluate volume I water heaters for resistance to accumulations of lint, dust and oil be presented to the joint water heater subcommittee for consideration.

TEST METHOD FOR EVALUATING RESISTANCE OF FLAMMABLE VAPOR RESISTANT WATER HEATERS TO LINT, DUST AND OIL ACCUMULATION

DEVELOPED BY THE
WATER HEATER JOINT RESEARCH AND DEVELOPMENT CONSORTIUM
MAY 3, 2001

2.xx Resistance to Lint, Dust and Oil Accumulation

Water heaters shall not produce a concentration of carbon monoxide in excess of 0.04 percent in an air-free sample of the flue gases when exposed to lint, dust and oil under the following Method of Test. This requirement shall be considered met when:

a. the water heater completes the Burner Cycle Sequence and the carbon monoxide concentration reaches equilibrium, as defined in the following Method of Test, at a value less than 0.04 percent in an air-free sample of flue gases; or

b. the water heater shuts down prior to producing a carbon monoxide concentration in excess of 0.04 percent in an air free sample of the flue gases, and requires a manual restart to resume operation.

This provision does not apply to direct vent water heaters, ~~or to~~ water heaters for installation in recreational vehicles, or to water heaters intended for installation outdoors. if marked for outdoor installation – Consider agrees

RATIONALE: *A water heater intended for installation outdoors takes all of it's air for combustion outdoors like a direct vent water heater water and should not have to comply.*

Method of Test

~~Prior to beginning the test, at the manufacturer's request, the water heater may be cleaned to remove machining oils from manufacturing that may cause erroneous test results.~~

RATIONALE: Water heater should be tested in its as manufactured "out of box" condition in which the average consumer is going to receive it. No pre-test cleaning allowed, unless instructed by Product Installation Manual. This will represent realistic field installation conditions

This test shall be conducted at normal inlet test pressure and input rating.

The lint material used for this test shall be cotton second-cut linters removed from the cotton seed and ground in a revolving knife shearing type mill fitted with a 4 mm screen classifier.

The dust material used for the test shall be ISO Fine Test Dust, 12103-1, A2.

The oil used for the test shall be 100 percent corn oil.

Set-Up

The water heater shall be installed according to the manufacturer's instructions in a room with an internal volume of 864 ± 25 cubic feet (24.5 ± 0.71 m^3). The nominal dimensions of the room shall be 12 feet ± 6 inches wide x 9 feet ± 6 inches long x 8 feet ± 6 inches high (3.66 ± 0.15 m x 2.74 ± 0.15 m x 2.44 ± 0.15 m). A diagram of the test room is shown in Figure XX. The test room shall have:

a. Means to maintain neutral internal pressure with respect to the pressure external to the test room to within a tolerance of ± 0.005 inches water column (± 1.24 Pa). Pressure transients that occur when the injection apparatus operates are allowable provided that the magnitude of the transient does not fall outside of the range of + 0.00 inches water column to – 0.02 inches water column (+0.00 Pa to –4.98 Pa), and the duration of the transient does not exceed 3 seconds.

b. Two air openings, each with an area of 100 square inches (484 cm^2) at the locations specified in Figure XX.

c. Means to inject lint and dust entrained in an air flow of ~~200 ± 25~~ 80 ± 10 cubic feet per minute (0.0~~94~~38 ± 0.0~~1~~05 m^3/s) into the test room. The discharge of the lint and dust injection apparatus shall be a 4-inch (10.16 cm) diameter duct, installed perpendicular to the wall of the test room at the location specified in Figure XX.

(Rationale: Covered below in the rationale for lint, dust and oil injection sequence.

d. An atomizer spray gun, capable of producing oil droplets less than 10 micrometer in diameter, to introduce the oil into the test room. The axis of the atomizer nozzle shall be installed perpendicular to the wall of the test chamber at the location specified in Figure XX.

e. Instruments to continuously measure and record the following:

Test room pressure
Ambient air temperature
Water heater flue carbon monoxide concentrations*
Water heater flue carbon dioxide concentrations*
Water heater inlet supply water temperature
Water heater outlet water temperature
Manifold pressure
Pilot millivoltage

* Measurement of CO and CO2 shall be made using a sample tube of a size and configuration that will minimize resistance to the flow of flue gases.

f. Means to remotely operate the water heater thermostat to enable cycling of the main burner.

g. Means to cause water flow through the heater, as specified under "Operation" in this Method of Test.

The water heater shall be installed at the location specified in Figure XX. The water heater shall be tested with all access doors in their normal position. If the lighting instructions call for the opening or removal of any door(s) to light the pilot and if the main burner(s) will operate with those door(s) removed or opened, the test shall be repeated with removable door(s) removed, and sliding or hinged door(s) left in a fully open position unless self-closing.

The water heater shall be supplied with water at a temperature of 70 ± 2°F (21 ± 1°C). A flow restricting device shall be installed in the inlet water supply line to maintain the outlet water temperature at 135 ± 5°F (57 ± 3°C).

A suitable temperature measurement device shall be placed in the outlet flow stream at the outlet connection of the storage vessel.

The water heater shall be connected to an uninsulated vent pipe the same size as the draft hood outlet or flue collar (on water heaters not equipped with a draft hood), unless otherwise specified. The vent pipe shall be arranged as follows:

a. For Water Heaters with Vertical Flue Outlets
A sufficient length of vertical pipe to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or flue collar to the top of the vertical vent pipe. If 5 feet is not sufficient to vent combustion products out of the test room the pipe length can be extended to ensure that flue products are vented out of the test room, or

(RATIONALE: With a ceiling height of up to 8 feet 6 inches it is possible that some water heater designs would not be tall enough to vent combustion products outside of the test room if only five feet of vent is allowed.)

Comment agrees

b. For Water Heaters with Horizontal Flue Outlets
An elbow and a sufficient length of vertical pipe to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or flue collar to the top of the vertical vent pipe. If 5 feet is not sufficient to vent combustion products out of the test room the pipe length can be extended to ensure that flue products are vented out of the test room -Sheet metal elbows shall be 90 degrees (1.57 rad), four piece, sheet metal elbows.

(RATIONALE: With a ceiling height of up to 8 feet 6 inches it is possible that some water heater designs would not be tall enough to vent combustion products outside of the test room if only five feet of vent is allowed.)

Comment agrees

Operation

The water heater shall be filled with water at 70 ± 2°F (21 ± 1°C). The thermostat shall be set to its highest setting and the water heater operated at the manufacturer's specified input rate (± 2 percent) and manifold pressure. The water flow rate through the heater shall be adjusted until the outlet water temperature attains equilibrium at 135 ± 5°F (57 ± 3°C). Equilibrium is defined as an outlet water temperature that does not vary more than 5°F (3°C) for one hour. ~~The outlet water temperature shall be maintained at 135 ± 5°F (57 ± 3°C) throughout the test.~~

Once equilibrium conditions have been established, the thermostat shall be adjusted to turn off the main burner and the water supply to the water heater shall be turned off. ~~While operating at the input rate and water flow rate established above With the water heater in standby, t~~The water heater shall then be exposed to a thirty minute pre-conditioning period during which the water heater shall be subjected to oil spray at a rate of 1.1 cc/min for 10 minutes, followed by 20 minutes with no additional oil spray.

RATIONALE: All of the initial testing to evaluate the lint test was performed with the water heater in standby for this portion of the test.

Immediately following the 30 minute preconditioning period, the thermostat shall be set to its highest setting and the water flow to the water heater shall be reestablished at the rate to maintain an outlet water temperature of 135 ± 5°F (57 ± 3°C). The outlet water temperature shall be maintained at 135 ± 5°F (57 ± 3°C) throughout the test. ~~T~~the water heater shall then be operated in accordance with the following burner cycle sequence and water flow cycle sequence, and the apparatus for injecting (1) lint and dust, and (2) atomizer oil spray shall be operated according to the following injection cycle sequences:

Burner cycle sequence

Burner Cycle #	Duty cycle
1 through 10	55 min. ON / 5 min OFF
11 through 12	3 hour-55 min. ON / 5 min OFF
13 through end	55 min. ON / 5 min. OFF

Water flow cycle sequence

During conduct of this test, water flow through the heater shall be cycled simultaneously with the burner in accordance with the Burner Cycle Sequence described above. The water flow rate shall be adjusted as necessary to maintain an equilibrium outlet water temperature of 135 ± 5°F (57 ± 3°C) throughout the "on" times of the Burner Cycle Sequence.

Lint, dust and oil injection sequence

The lint, dust and oil injection sequence shall consist of the ~~three~~ one injection cycles noted below performed in succession for the duration of the test:

Rationale: In the originally proposed three-injection cycles lint, dust, and oil loading per hour is constant. The only difference is the amount of time the blower (clothes dryer) and oil injection is operated each cycle. If a constant lint and dust introduction rate is used, as explained below, in conjunction with a continuously operating blower the number of cycles can be reduced to one. Cycle 1 is used repeatedly throughout the test with the only difference being the oil injection time, not amount, being different for the first cycle.

Injection Cycle	LDO composition
1 (60 min.)	Air: ~~27 cycles @ 15 sec. ON / 118.3 sec. OFF~~ Continuous Operation ON 60 Minutes* Lint: ~~91 ± 8~~ 10.15 ± 1mg/sec~~**~~ Dust: ~~247 ± 12~~ 28 ± 2 mg/sec ~~**~~ Oil: 1st sequence: 30 min. no oil, followed by 5 min @ 0.8 cc/min, followed by 25 min. no oil. All subsequent sequences: 30 min. no oil, followed by 3 min @ 1.33 cc/min, followed by 27 min. no oil.
~~2 (60 min.)~~	~~Air: 40 cycles @ 30 sec. ON / 60 sec. OFF*~~ ~~Lint: 31 ± 3 mg/sec **~~ ~~Dust: 83 ± 4 mg/sec **~~ ~~Oil: 30 min. no oil, followed by 3 min @ 1.33 cc/min, followed by 27 min. no oil.~~
~~3 (60 min.)~~	~~Air: 40 cycles @ 60 sec. ON / 30 sec. OFF*~~ ~~Lint: 15.5 ± 1.5 mg/sec **~~ ~~Dust: 42 ± 2 mg/sec **~~ ~~Oil: 30 min. no oil, followed by 3 min @ 1.33 cc/min, followed by 27 min. no oil.~~
*	An air flow rate of ~~200 ± 25~~ 80 ± 10 cubic feet per minute shall be maintained during air ON times.
**	~~Injection rates apply only to air ON times. The injection rates shall be equal to zero at all other times.~~

RATIONALE:

A fixed (or constant) lint and dust introduction rate better represents (models, mimics) conceivable real life conditions of gradual lint and dust accumulation.

All initial testing conducted to develop this lint test was performed utilizing a clothes dryer to introduce lint and dust. A dryer was used in the Japanese test (LDO test – 1986) as well. In an attempt to deliver lint and dust over a period of thirty minutes several short cycles were used. To determine the amount of material being introduced lint and dust

containers were weighed prior to being loaded into the dryer and then weighed again at the completion of the thirty-minute period. The difference in mass was used to calculate the lint and dust loading. Airflow of the dryer was measured and determined to be around 200 CFM. The original lint test room at CSA International did not have any openings in the room to provide combustion air and instead relied upon the dryer to provide air for combustion. With no openings in the room for combustion air or pressure relief a balancing fan was used to offset the air introduction of the dryer. American Water Heater Company observed that it was difficult to balance these two fans and maintain a neutral pressure in the test room. The balancing fan had an inlet filter and its performance would degrade as lint accumulated on the filter causing the room pressure to become positive during dryer "On" times. If an over adjustment was made on the variable speed controller for the balancing fan a negative pressure was seen in the room potentially causing a down draft situation.

A study was performed on each lint and dust load for the various dryer cycles (1,2,3) to determine the lint and dust introduction rate. This study showed that the lint introduction rate was very high during the first few dryer cycles and rapidly decreased to zero for the last few dryer cycles. The dust introduction rate dynamics were similar.

The blower (or airflow) is only to provide a means to inject the lint and dust into the room. Even if we were to consider that all air for combustion was provided by the blower (which it is not) the originally proposed 200-CFM seems extremely excessive. The ANSI Z21.10.-1998 CSA 4.1-M98 Volume I standard covers all storage water heaters with input ratings of 75,000 Btu per hour or less. The theoretical air necessary for combustion on a 75,000 BTU/hr unit is only about 13 CFM. However, assuming some excess air, and adding the necessary dilution air to cool Power Vent products that use PVC pipe for venting. Approximately 80-CFM total of air should be enough. This is less than half of the currently proposed 200 CFM. If a more reasonable airflow is used and combustion air openings are provided in the test room there is no need to provide a balancing fan to compensate the air introduced by the blower. A balancing fan only introduces potential problems with maintaining neutral test room pressure and affecting water heater performance and is not needed nor desired. In other words as the dryer turns "On and Off" spikes in CO2 and CO were observed. By using a continuously operating 80-CFM blower that introduces the lint and dust the combustion spikes are eliminated.

In the original testing, utilizing the dryer for lint and dust introduction, it was necessary to cycle the dryer to distribute the lint and dust over time. American Water Heater Company and CSA have since looked at systems that can control the lint and dust introduction without cycling of the blower by replacing it with a conventional blower and using a conveyor system to feed the lint and dust. By varying the speed of the conveyor system and lint and dust loading on the conveyor belt any introduction

rate can be achieved without cycling the blower. Lint test results at CSA (and AWHC) have indicated a direct correlation between elevated unstable combustion emission rates, as noted above, and transient pressure conditions inside the test room attributed to the dryer (blower) switching "On/ Off". These transient pressure conditions are eliminated if a smaller 80-CFM blower is operated continuously throughout the test.

Cycling the blower and lint and dust introduction causes a pulsing of lint and dust to the appliance being tested. American Water Heater Company does not believe this represents the gradual lint and dust loading that would be seen in the field. Using the new systems that are being developed to control this test (both at American Water Heater Company and CSA) a constant lint and dust introduction rate can be achieved. It is the opinion of American Water Heater Company that this test was designed to simulate how the potential gradual continuous lint and dust accumulation on water heaters affect new water heater designs intended to deal with flammable vapors. If the blower is operated continuously a constant injection rate can be easily implemented. This will also simplify the test and improve the test repeatability.

The test shall be allowed to continue until the first of the following conditions are met:

a. The water heater emits carbon monoxide concentrations in excess of 0.04 percent on an air free basis, for a period of 10 minutes,

b. Carbon monoxide and carbon dioxide concentrations have reached equilibrium, as evidenced by readings taken during or after burner cycle #14. For the purposes of this test, equilibrium shall be considered as having been achieved when carbon monoxide concentrations do not vary by more than 0.001%, and CO2 concentrations do not vary by more than 0.1%, between the beginning and last thirty minutes of the burner operating cycle, or

c. The water heater shuts down by design, and requires a manual restart to resume operation.

Rationale: Reports on flammable vapor ignition incidents involving gas water heaters led to the development and subsequent adoption for inclusion in the volume I water heater standard (ANSI Z21.10.1•CSA 4.1) of a method of test to evaluate a water heater design's ability to resist the ignition of flammable vapors outside the confines of the water heater.

One common approach to make the water heater resistant to ignition of flammable vapors is to modify the combustion air intake with a device that has been designed to act as a flame arrestor. Research has shown that this device may accumulate lint, dust and oil over the life of the water heater. The accumulation of lint dust and oil may affect the performance of the water heater in other areas (e.g., carbon monoxide (CO) emissions). Consequently,

a test for resistance to accumulations of lint, dust and oil, (LDO) has been developed, and it is intended that this test should be required as part of the certification of flammable vapor-resistant water heaters.

In development of the proposed test method, independent research was conducted in the following areas:

1. A global document search for relevant lint, dust and/or oil tests on appliances,
2. A review of existing standards and reports on indoor particulates,
3. A review of studies on domestic water heater usage patterns,
4. A collection and evaluation of samples of indoor particulates gathered from homes across the country,
5. A development of a draft test protocol, and
6. Verification of the test protocol with actual testing.

The results of the work in steps 1 through 4 concluded that an existing Japanese test (LDO test-1986) protocol most closely represented environmental conditions found in North America. However, the Japanese test did not address the issue in the context of water heaters equipped with flame arrestor technology. An independent research organization was contracted to develop a lint, dust and oil test protocol for inclusion in the ANSI/CSA volume I water heater standard (Z21.10.1•CSA 4.1). A proposed test method was developed using the Japanese LDO test protocol as a baseline LDO-protocol. Technical modifications were made to provide a standardized, calibrated, realistic, reproducible and discriminating evaluation of LDO-safety in residential flammable vapor resistant water heaters.

Intensive verification work has been conducted using the proposed test method. The proposed LDO test protocol has been found to be both discriminating and reproducible.

Supplement ITEM 1.
Z21/CSA Joint Water Heater
Subcommittee Meeting,
June 20, 2001

PROPOSED LINT, DUST AND OIL TEST PROTOCOL FOR VOLUME I WATER HEATERS

Action Requested

Review the proposed lint, dust and oil test protocol for volume I water heaters and consider adopting revisions for distribution for review and comment.

Background

Attached is Figure XX which is referenced in the proposed lint, dust and oil test protocol for volume I water heaters.

All Dimensions are inside dimensions
Tolerance is +/- 6" on building dimensions only
All other tolerances are +/- 1/2"

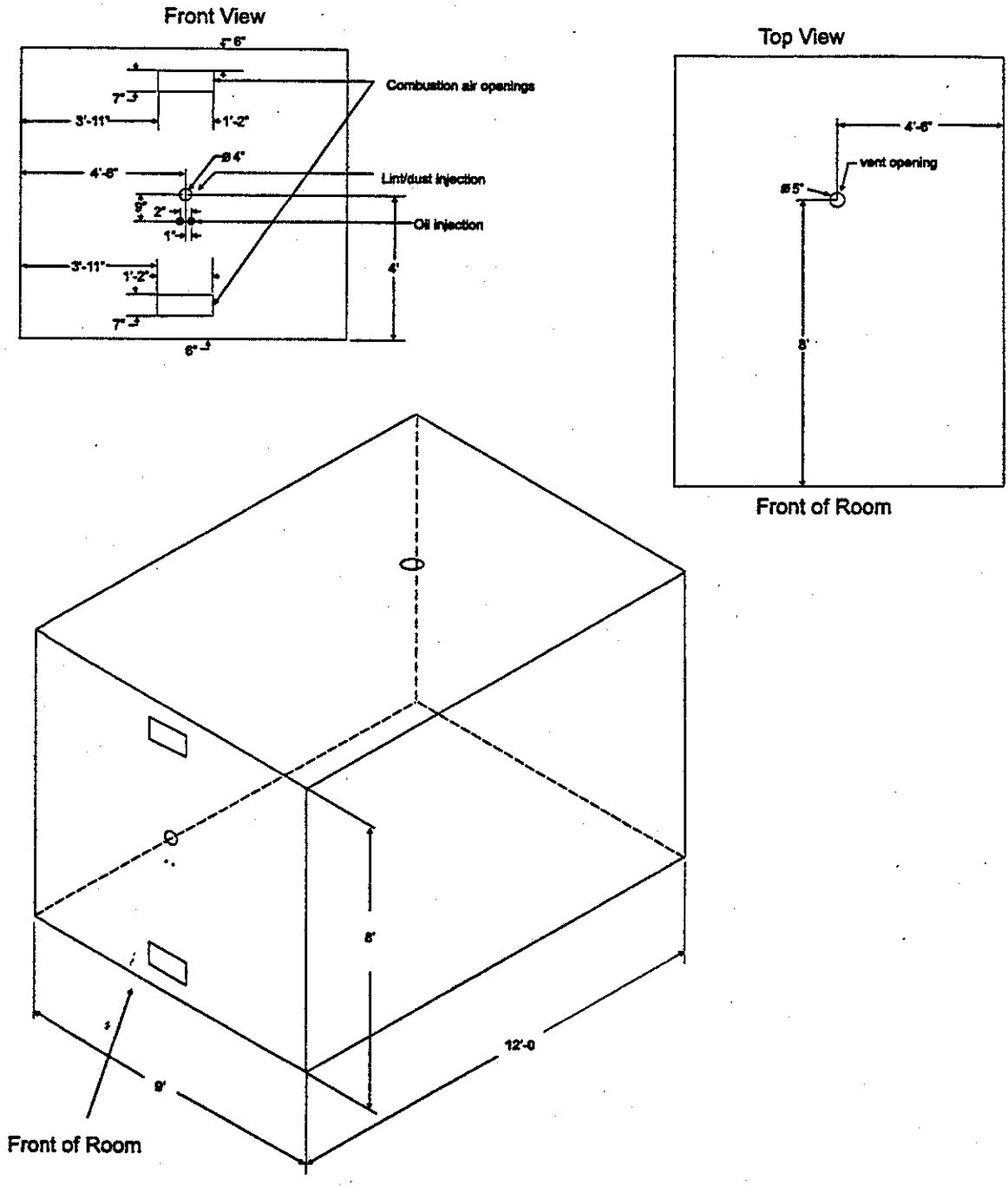

Figure XX.

ITEM 1.
Z21/CSA Joint Water Heater
Subcommittee Meeting,
June 20, 2001

PROPOSED LINT, DUST AND OIL TEST PROTOCOL FOR VOLUME I WATER HEATERS

Action Requested

Review the proposed lint, dust and oil test protocol for volume I water heaters and consider adopting revisions for distribution for review and comment.

Background

The "a" addenda to the volume I water heater standard, Z21.10.1a•CSA 4.1a, was approved by the American National Standards Institute (ANSI) on February 25, 2000, and by the Interprovincial Gas Advisory Council (IGAC) on *June 12, 2000*. The "a" addenda contains a method of test to evaluate a water heater designs ability to resist the ignition of flammable vapors outside the confines of the water heater (2.35, Figure 10, Figure 11, Figure 12 and Figure 13).

One method used to make the water heater resistant to ignition of flammable vapors is flame arrestor technology. Independent research observed that water heater designs using this technology may accumulate lint, dust and oil over the life of the water heater and may affect the performance of the water heater in other areas (e.g., carbon monoxide (CO) emissions).

By letter dated February 12, 2001 and e-mail dated May 3, 2001, the Water Heater Industry Joint Research and Development Consortium requested that the attached proposed test protocol to evaluate volume I water heaters for resistance to accumulations of lint, dust and oil be presented to the joint water heater subcommittee for consideration.

TEST METHOD FOR EVALUATING RESISTANCE OF FLAMMABLE VAPOR RESISTANT WATER HEATERS TO LINT, DUST AND OIL ACCUMULATION

DEVELOPED BY THE
WATER HEATER JOINT RESEARCH AND DEVELOPMENT CONSORTIUM
MAY 3, 2001

2.xx Resistance to Lint, Dust and Oil Accumulation

Water heaters shall not produce a concentration of carbon monoxide in excess of 0.04 percent in an air-free sample of the flue gases when exposed to lint, dust and oil under the following Method of Test. This requirement shall be considered met when:

a. **the water heater completes the Burner Cycle Sequence and the carbon monoxide concentration reaches equilibrium, as defined in the following Method of Test, at a value less than 0.04 percent in an air-free sample of flue gases; or**

b. **the water heater shuts down prior to producing a carbon monoxide concentration in excess of 0.04 percent in an air free sample of the flue gases, and requires a manual restart to resume operation.**

This provision does not apply to direct vent water heaters, or to water heaters for installation in recreational vehicles.

Method of Test

Prior to beginning the test, at the manufacturer's request, the water heater may be cleaned to remove machining oils from manufacturing that may cause erroneous test results.

This test shall be conducted at normal inlet test pressure and input rating.

The lint material used for this test shall be cotton second-cut linters removed from the cotton seed and ground in a revolving knife shearing type mill fitted with a 4 mm screen classifier.

The dust material used for the test shall be ISO Fine Test Dust, 12103-1, A2.

The oil used for the test shall be 100 percent corn oil.

<u>Set-Up</u>

The water heater shall be installed according to the manufacturer's instructions in a room with an internal volume of 864 ± 25 cubic feet (24.5 ± 0.71 m^3). The nominal dimensions of the room shall be 12 feet ± 6 inches wide x 9 feet ± 6 inches long x 8 feet

± 6 inches high (3.66 ± 0.15 m x 2.74 ± 0.15 m x 2.44 ± 0.15 m). A diagram of the test room is shown in Figure XX. The test room shall have:

a. Means to maintain neutral internal pressure with respect to the pressure external to the test room to within a tolerance of ± 0.005 inches water column (± 1.24 Pa). Pressure transients that occur when the injection apparatus operates are allowable provided that the magnitude of the transient does not fall outside of the range of + 0.00 inches water column to – 0.02 inches water column (+0.00 Pa to –4.98 Pa), and the duration of the transient does not exceed 3 seconds.

b. Two air openings, each with an area of 100 square inches (484 cm^2).

c. Means to inject lint and dust entrained in an air flow of 200 ± 25 cubic feet per minute (0.094 ± 0.01 m^3/s) into the test room. The discharge of the lint and dust injection apparatus shall be a 4-inch (10.16 cm) diameter duct, installed perpendicular to the wall of the test room at the location specified in Figure XX.

d. An atomizer spray gun, capable of producing oil droplets less than 10 micrometer in diameter, to introduce the oil into the test room. The axis of the atomizer nozzle shall be installed perpendicular to the wall of the test chamber at the location specified in Figure XX.

e. Instruments to continuously measure and record the following:

Test room pressure
Ambient air temperature
Water heater flue carbon monoxide concentrations*
Water heater flue carbon dioxide concentrations*
Water heater inlet supply water temperature
Water heater outlet water temperature
Manifold pressure
Pilot millivoltage

* Measurement of CO and CO2 shall be made using a sample tube of a size and configuration that will minimize resistance to the flow of flue gases.

f. Means to remotely operate the water heater thermostat to enable cycling of the main burner.

g. Means to cause water flow through the heater, as specified under "Operation" in this Method of Test.

The water heater shall be installed at the location specified in Figure XX. The water heater shall be tested with all access doors in their normal position. If the lighting instructions call for the opening or removal of any door(s) to light the pilot and if the main burner(s) will operate with those door(s) removed or opened, the test shall be repeated with removable door(s) removed, and sliding or hinged door(s) left in a fully open position unless self-closing.

The water heater shall be supplied with water at a temperature of 70 ± 2°F (21 ± 1°C). A flow restricting device shall be installed in the inlet water supply line to maintain the outlet water temperature at 135 ± 5°F (57 ± 3°C).

A suitable temperature measurement device shall be placed in the outlet flow stream at the outlet connection of the storage vessel.

The water heater shall be connected to an uninsulated vent pipe the same size as the draft hood outlet or flue collar (on water heaters not equipped with a draft hood), unless otherwise specified. The vent pipe shall be arranged as follows:

a. For Water Heaters with Vertical Flue Outlets
A sufficient length of vertical pipe to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or flue collar to the top of the vertical vent pipe, or

b. For Water Heaters with Horizontal Flue Outlets
An elbow and a sufficient length of vertical pipe to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or flue collar to the top of the vertical vent pipe. Sheet metal elbows shall be 90 degrees (1.57 rad), four piece, sheet metal elbows.

Operation

The water heater shall be filled with water at 70 ± 2°F (21 ± 1°C). The thermostat shall be set to its highest setting and the water heater operated at the manufacturer's specified input rate (± 2 percent) and manifold pressure. The water flow rate through the heater shall be adjusted until the outlet water temperature attains equilibrium at 135 ± 5°F (57 ± 3°C). Equilibrium is defined as an outlet water temperature that does not vary more than 5°F (3°C) for one hour. The outlet water temperature shall be maintained at 135 ± 5°F (57 ± 3°C) throughout the test.

While operating at the input rate and water flow rate established above, the water heater shall be exposed to a thirty minute pre-conditioning period during which the water heater shall be subjected to oil spray at a rate of 1.1 cc/min for 10 minutes, followed by 20 minutes with no additional oil spray.

Immediately following the 30 minute preconditioning period, the water heater shall be operated in accordance with the following burner cycle sequence and water flow cycle sequence, and the apparatus for injecting (1) lint and dust, and (2) atomizer oil spray shall be operated according to the following injection cycle sequences:

Burner cycle sequence

Burner Cycle #	Duty cycle
1 through 10	55 min. ON / 5 min OFF
11 through 12	3 hour-55 min. ON / 5 min OFF
13 through end	55 min. ON / 5 min. OFF

Water flow cycle sequence

During conduct of this test, water flow through the heater shall be cycled simultaneously with the burner in accordance with the Burner Cycle Sequence described above. The water flow rate shall be adjusted as necessary to maintain an equilibrium outlet water temperature of 135 ± 5°F (57 ± 3°C) throughout the "on" times of the Burner Cycle Sequence.

Lint, dust and oil injection sequence

The lint, dust and oil injection sequence shall consist of the three injection cycles noted below performed in succession for the duration of the test:

Injection Cycle	LDO composition
1 (60 min.)	Air: 27 cycles @ 15 sec. ON / 118.3 sec. OFF* Lint: 91 ± 8 mg/sec** Dust: 247 ± 12 mg/sec ** Oil: <u>1st sequence:</u> 30 min. no oil, followed by 5 min @ 0.8 cc/min, followed by 25 min. no oil. <u>All subsequent sequences:</u> 30 min. no oil, followed by 3 min @ 1.33 cc/min, followed by 27 min. no oil.
2 (60 min.)	Air: 40 cycles @ 30 sec. ON / 60 sec. OFF* Lint: 31 ± 3 mg/sec ** Dust: 83 ± 4 mg/sec ** Oil: 30 min. no oil, followed by 3 min @ 1.33 cc/min, followed by 27 min. no oil.
3 (60 min.)	Air: 40 cycles @ 60 sec. ON / 30 sec. OFF* Lint: 15.5 ± 1.5 mg/sec ** Dust: 42 ± 2 mg/sec ** Oil: 30 min. no oil, followed by 3 min @ 1.33 cc/min, followed by 27 min. no oil.
* An air flow rate of 200 ± 25 cubic feet per minute shall be maintained during air ON times.	
** Injection rates apply only to air ON times. The injection rates shall be equal to zero at all other times.	

The test shall be allowed to continue until the first of the following conditions are met:

a. The water heater emits carbon monoxide concentrations in excess of 0.04 percent on an air free basis, for a period of 10 minutes,

b. Carbon monoxide and carbon dioxide concentrations have reached equilibrium, as evidenced by readings taken during or after burner cycle #14. For the purposes of this test, equilibrium shall be considered as having been achieved when carbon monoxide concentrations do not vary by more than 0.001%, and CO2 concentrations do not vary by more than 0.1%, between the beginning and last thirty minutes of the burner operating cycle, or

c. The water heater shuts down by design, and requires a manual restart to resume operation.

Rationale: Reports on flammable vapor ignition incidents involving gas water heaters led to the development and subsequent adoption for inclusion in the volume I water heater standard (ANSI Z21.10.1•CSA 4.1) of a method of test to evaluate a water heater design's ability to resist the ignition of flammable vapors outside the confines of the water heater.

One common approach to make the water heater resistant to ignition of flammable vapors is to modify the combustion air intake with a device that has been designed to act as a flame arrestor. Research has shown that this device may accumulate lint, dust and oil over the life of the water heater. The accumulation of lint dust and oil may affect the performance of the water heater in other areas (e.g., carbon monoxide (CO) emissions). Consequently, a test for resistance to accumulations of lint, dust and oil, (LDO) has been developed, and it is intended that this test should be required as part of the certification of flammable vapor-resistant water heaters.

In development of the proposed test method, independent research was conducted in the following areas:

1. A global document search for relevant lint, dust and/or oil tests on appliances,
2. A review of existing standards and reports on indoor particulates,
3. A review of studies on domestic water heater usage patterns,
4. A collection and evaluation of samples of indoor particulates gathered from homes across the country,
5. A development of a draft test protocol, and
6. Verification of the test protocol with actual testing.

The results of the work in steps 1 through 4 concluded that an existing Japanese test (LDO test-1986) protocol most closely represented environmental conditions found in North America. However, the Japanese test did not address the issue in the context of water heaters equipped with flame arrestor technology. An

independent research organization was contracted to develop a lint, dust and oil test protocol for inclusion in the ANSI/CSA volume I water heater standard (Z21.10.1•CSA 4.1). A proposed test method was developed using the Japanese LDO test protocol as a baseline LDO-protocol. Technical modifications were made to provide a standardized, calibrated, realistic, reproducible and discriminating evaluation of LDO-safety in residential flammable vapor resistant water heaters.

Intensive verification work has been conducted using the proposed test method. The proposed LDO test protocol has been found to be both discriminating and reproducible.

ATTENDANCE RECORD

Z21/(Interim CSA) JOINT WATER HEATER SUBCOMMITTEE

DAY 1 - WEDNESDAY, June 20, 2001

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January 19, 1999

Attendance Record Page :

Z21/(Interim CSA) JOINT WATER HEATER SUBCOMMITTEE

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