



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

TO: Dr. Rafael Sanchez, Ph.D.
Wood Heater Program Lead -Air Branch
Monitoring, Assistance, and Media Programs Division
Office of Compliance
U.S. Environmental Protection Agency (EPA)
1200 Pennsylvania Ave., NW
Washington, DC 20460

FROM: Steffan Johnson
Measurement Technology Group Leader
Air Quality Assessment Division
Office of Air Quality Planning and Standards
109 TW Alexander Dr.
Research Triangle Park, NC 27710

03/25/2020

RE: Inquiry into Hy-C SF-1000E and FC-1000E Forced Air Furnace Certification Test and Re-Test

What follows is a discussion that MTG conducted with Mr. Danny Haynes at Hy-C manufacturing, and Mr. Brian Zigler of Intertek Laboratories with respect to a test report submitted to your office in October of 2019. Our review of the re-test report left questions that we asked the manufacturer and/or laboratory to respond to, and to aid us in resolving our understanding of the validity of the testing that was conducted and submitted to you for compliance with subpart QQQQ.

Note that this testing was done under the auspices of an Alternate Test Method that was included in the test report, and that the Alternate Test Method, as well as the specific test methods and procedures it refers to, are the specific means through which the appliance is to be tested and compliance with the standard thereby demonstrated.

For clarity, the discussion has been color-highlighted; original questions are in black, responses from the manufacturer and laboratory are in blue, and our findings based on their responses are in red. Nothing but salutations and closings from the e-mails in the copied text below have been removed.

These findings are submitted to you with the intent that they will be useful in deliberating your determination of compliance for the affected appliance models.

Stef Johnson
Group Leader – Measurement Technology Group

REVIEW OF INTERTEK/HY-C RESPONSES TO EPA'S QUESTIONS – MTG FINDINGS

This document contains Intertek's and HY-C's response to Steffan Johnson's email sent on March 10, 2020. The following includes the items of concern in black, Hy-C's response in blue, and our findings to each item in red. The OAQPS Measurement Technology Group has reviewed the EPA Emissions test report for the SF1000E, dated October 24, 2019. During our review we noted six issues, listed below.

1. The Maximum output (Category 4 test) determined in your August-September testing was 25% higher than previous Max capacity (Category 4) test on same unit conducted in October 2018. Hy-C has stated that they made no changes to the unit between these two testing efforts. By what calculations does this manufacturer determine the max fire rate? Please explain, with example calculations, how these calculations arrived at maximum output rates 25% apart from each other (test series 1 vs test series 2) without modifying the appliance.

HY-C states that:

Through In-house R&D, HY-C learned that during the first 5 minutes at beginning of 2018 test, while performing allowable air/door open adjustments, that the door was actually open too far, which diluted the combustion characteristics in the firebox and heat exchanger, thus limiting the flue and heat exchanger temperatures. The result was an insufficient delivered BTU output (duct temperature).

The 2019 Cat. 4 test used a revised first 5 minute procedure that improved BTU output considerably. A notable improvement to flue temps at beginning of test which charged the heat exchanger deeper into entire test length.

The revision to the start-up procedure resulted in the flue gas temperatures increasing from 656°F (2018 Cat 4 test) to 1166°F (2019 Cat 4 test) and the average heat output increasing from 48,727 Btu/hr. (2018 Cat 4 test) to 69,105 Btu/hr. (2019 Cat 4 test) at the 5-minute point of each test.

Because of the increase in combustion efficiency and temperature, the heat exchanger was able to produce more heat for a longer period, thus increasing the output rate.

The maximum output rate was determined by significant R&D testing at HY-C's facility with a similar test sample and the calculations used to determine the output energy is based on Annex E of CSA B415.1.

The unit tested at Intertek was the same unit previously used for certification testing and was unsealed in accordance with Rafael Sanchez's directions. No modifications were made to this unit.

MTG FINDING:

No example calculations are provided that support the claim that changing the airflow at the start of the test provides 25% greater BTU output from the same load of fuel. The lack of these does not invalidate the testing however, and the description is helpful. Details regarding the un-sealing, and the statement that no changes were made to the original model prior to retesting are also appreciated and appropriate. **RESOLVED.**

2. How does the manufacturer account for the 25% increase in actual max capacity testing?

As noted in #1 above, a revised start-up procedure was used to increase the maximum output for this unit.

Here is the Cat 4 operation procedure described by HY-C:

Basic instructions for operating the SF1000E/FC1000E FORCED AIR FURNACE Testing to B415.1-10 Category IV

Pretest Load and operating procedures.

- Place approximately 24 lbs. of split red oak cordwood north/south directly on floor of firebox.
- Then place approximately 7 lbs. of kindling on top of split cordwood east/west.
- Then 1 lbs. small kindling.
- Light Top of small kindling to start pretest load.
- Leave Fuel and Ash doors open ½" for approximately 5 minutes at pretest start then close.
- Draft inducer engaged (switch "on").
- Stir pretest load at approximately 19 lbs. remaining.
- Stir pretest load again at approximately 15 lbs. remaining.
- Stir pretest load again at approximately 11 lbs. remaining.
- Tare scale to start test with approximately 7 lbs. remaining.

Test Load and operating procedures.

- Test Load: approximately 31 lbs. Red Oak Cordwood.
- Place test load North/South.
- Place test load to the rear of firebox.
- Draft inducer engaged at start of test.
- Position both Fuel and Ash doors open approximately ½" for 5 minutes then close both.
- Leave draft inducer engaged ("on") entire length of test.

MTG FINDING:

These procedures are different from those used in the first test, and it appears that they did result in higher measured BTU content. Likewise, the delivered efficiency for these test runs supports this information and indicates that the modifications made to start up did impact the ability of the unit to reach a substantially higher actual maximum firing rate. **RESOLVED.**

3. Was the October 2018 testing, Category 4, not conducted at actual maximum capacity? Please explain.

October 2018 Category 4 testing was performed and resulted in the maximum output based on the provided instructions from HY-C. Intertek followed the operating procedures HY-C provided, which required the fueling door to be opened fully to try and ignite the fresh test fuel. As noted in #1 and #2, this procedure was later found to dilute the firebox and combustion chamber with too much air and the fire did not fully engulf during start-up.

MTG FINDING:

Responses to Question 2 are reasonable and borne out by the data, which likewise validates this response. **RESOLVED.**

4. The manufacturer's instructions for conducting the Category 3 test are not consistent with CCSA B415.1-10, Section 7.2.2.2, nor are the results consistent with that test requirement. Please explain why the unit was explicitly operated outside the requirement of the test method. Note: Section 7.2.2.2 is designed to simulate an on/off heat demand mode from the home. Heat demand during the test run did not cycle on/off/on per the test method. The Alternate Test Method explicitly states that section 7.2.2.2 must be followed, and MTG did not receive any requests from the laboratory or manufacturer to further modify the Alternate Test Method.

As a reminder of how forced air furnaces operate, the remote switch only controls the combustion inducer fan for HY-C's model SF1000E. The limit switch is a separate and independent component of the system and this controls the distribution blower for the output measurement. The limit switch has high and low set-points that when the plenum temperature of the unit heats to the upper set-point, the distribution blower will turn on until the lower limit temperature is met and the distribution blower turns off. Each time the distribution blower is on, we are measuring the output energy, which accumulates to a total measured output. This is then divided by the total accumulated operation time to provide a Btu/hr. rate.

To meet each designated output category per 7.2.2.2, the applicable test data is measured, recorded, and monitored every minute. When the output reaches a point slightly above the target rate, the remote switch is turned off. This turns off the combustion inducer fan, which puts the combustion chamber into an idle mode. This, however, does not prevent the distribution blower from operating and removing heat from the heat exchanger. When the data shows that the output is slightly below the target rate, the remote switch is turned back on to either maintain or increase the output energy average.

When the unit is in an idle mode, there is still some combustion occurring in the firebox in order to make sure the fire can be maintained. This in turn continues to heat the plenum and requires the distribution blower to operate to remove the heat, which results in a measured output, even in an idle mode.

With the fact that a forced air furnace is almost always generating heat, it may take a long time to remove enough heat to get the output low enough to turn the remote switch on.

This is the case for the SF1000E Category 3 test. Intertek followed HY-C's operating procedure and the remote switch wasn't turned off until late in the test. There was enough stored energy in the heat exchanger that the test load was consumed before the target output was low enough to require turning it back on.

MTG FINDING:

The explanation of how the data were arrived is straightforward, however the manufacturer's instructions were not consistent with section 7.2.2.2 and the response offered no explanation as to why. Intertek states that they followed Hy-C's instructions, which the data confirm, yet those instructions are in direct conflict with the test method requirements as well as requirements specifically stated in the Alternate Test Method. As such, the test method was not followed during this category test run.

MTG recommends invalidating this category 3 test.

5. The manufacturer's instructions for conducting the Category 2 test are consistent with CCSA B415.1-10, Section 7.2.2.2, but the heat output results of the test are not consistent with that test requirement. Please explain why the unit was operated outside the requirement of the test method. Note: Section 7.2.2.2 is designed to simulate an on/off heat demand mode from the home. Heat demand during the test run did not cycle on/off/on per the test method. The Alternate Test Method explicitly states that

section 7.2.2.2 must be followed, and MTG did not receive any requests from the laboratory or manufacturer to further modify the Alternate Test Method.

The basic procedure is the same for Category 2 and Category 3. Intertek followed HY-C's operation procedure for Category 2, which required that the remote switch to be turned off at 30 minutes into the test. The switch remained off until 317 minutes into the test, when the output was slightly below the target rate, which was then turned on. The remote switch was on until 346 minutes into the test, which was then turned off. The switch remained off through the end of the test.

MTG FINDING:

Intertek labs may have missed that the operating instructions from the manufacturer are clearly different with respect to Category 3 and Category 2 operations, yet in this case (category 2) the operating instructions agreed with the test method and yet the operation of the unit did not comport with the test method requirements in 7.2.2.2. Either the test run started with too much heat, too large a fuel load, or this unit is simply incapable of cycling and delivering a regulated heat output to a home. MTG had a direct and specific conversation with the manufacturer regarding the need to follow CSA B415.1-10 Section 7.2.2.2, and while their operating instructions indicated that this is how the unit was to be operated during the testing, this is not borne out by examination of the data, nor is that fact explained in the response above. As such, the test method was not followed during this category test run.

MTG recommends invalidating this Category test.

6. The summary data table on page 16 of the test report clearly shows that the Actual Load % Max values (heat output category criteria) are calculated from the theoretical max heat output derived by the manufacturer, and not the actual output rate values achieved during the testing. Please correct these values and address any discrepancies.

It appears there is some confusion with this. Wood hydronic heaters and wood air furnaces have performed the Category 4 test, in part, to validate the manufacturer's specified maximum output rating.

Once the measured output has been validated to within 10% of the specified rating, all the remaining test categories have been calculated based on this rating. This procedure has been performed by all labs for all wood hydronic heaters and wood air furnaces certified to this point.

Here are a couple examples of certified wood air furnaces tested by various labs and certified by the EPA:

United States Stove Company, Models 1660E Series Models: 1660E, AF1660E, CF1660E, SF1660E, BK1660E, NM1660E, GE1660E, CH1660E, VG1660E, HC1660E, HB1660E
Report #0215WH080E – Tested by OMNI Test Laboratories

MTG FINDING:

To clarify any confusion, burn/output rates are calculated per Sections 9.3.4 and 13.4 of CSA B-415.1-10. The CSA B415.1-10 test method is the method specified by the Alternate Test Method and is the only methodology pointed to by the Alternate Test Method. CSA B415.1-10 makes no mention of using a Calculated Maximum Output rate for any calculations. The laboratory is very likely confusing the requirements of the CSA B415.1-10 method with those listed in section 12.2.10 of ASTM 2618-13. While this ASTM method does require such a validation, there is no requirement in the CSA test method to

validate the manufacturer's rating within any percentage, and the appliance being certified by this testing is not a hydronic heater. As mentioned above, all the calculations with respect to Output Rates in CSA B415.1-10 are to be performed using Actual Output rates. To the extent that other laboratories have also erred in their calculations, it is recommended by this review that the EPA investigate test reports of other Forced Air Furnace models, certified under subpart QQQQ, to see if there are corrections that need to be made. Furthermore, correcting the data to burn categories based on the Actual burn rates, per the test method, invalidates the low burn test as it falls above the 35% cut off point by 3%, creating an invalid Category 1 test.

MTG recommends invalidating this Category 1 test.

MTG further recommends review of previous Forced Air Furnace test data, submitted since May 15, 2016, with respect to Actual Burn Category calculations.

END REVIEW.