 **1. ETP #: 725B011 ETP Title: Heat-up Test**

**ETP Type:**

**Revision # 1 Revision Date 2/17/2014** **Revision Author Vikrant Patel**

*(See section 13 for revision history*

**Superseded ETP # (***if applicable)* N/A

**Applicable Product Line(s):**  **and/or** (enter other here)

**Platform: Hybrid Electric/Standard Electric Water Heater**

**Subsystem:**

**Component:**

**Keywords: Water Heater**

**Recovery time Accuracy**

**Flow Event HEWH**

**Hybrid Electric Water Heater Water Heater**

**Heat Pump**

**2. ETP Objective**

**Purpose:** (*Overview of parameter(s) to be measured as well as scope of conclusions test is expected to facilitate)*

Broad test to determine proper function of standard and hybrid electric water heaters, including: Water temperature accuracy to set point, Water temp Overshoot from upper element function, Final water temperature gradient in tank. Test also verifies proper function of sealed system including: Discharge temperature, Evaporator temperatures and superheat. This test can also provide an estimate of water heater efficiency. For Hybrid water heaters, this procedure will verify proper function in all available modes of operation.

Some of the tests in this ETP may be run during development of product only, while others may be run during development AND as ongoing audit tests of production product.

**Limitations:** *(Any qualifications that apply to this test procedure or its results)*

* Water heater efficiency results recorded in this test are ESTIMATES only. Must follow official DOE procedure to determine actual energy factor of product.
* Certain portions of this procedure may be used to test standard electric water heater performance, and it is the engineer’s responsibility to determine which portions to use, and which to omit.

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**3. Key Parameters & Requirement Inputs**

**The test variables which impact product performance can either be classified as Key Noise Parameters or Key Control Parameters as described below. They may be set as test inputs, recorded for analysis or both as specified for this ETP in the following charts.**

**Key Noise Parameters -** *A key noise parameter (KNP) is any product usage or interaction variable which cannot be controlled by design (i.e. voltage, ambient temperature, water quality, etc.). Note that for the purposes of this test, the parameter may be controlled (i.e. specified as an input below) in order to understand the impact of the KNP upon product performance.*

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Key Noise Parameter**  *(KNP as defined by P-diagram)* | **Set as Test Input**  *(Set to this level for test)* | **Record as Test Output**  *(Measure results and record)* |
| **A.** | Ambient Temperature | 67.5F +/- 1F | Yes (not req’d for Std Elec test) |
| **B.** | Humidity | 50%+/-1% | Yes (not req’d for Std Elec test) |
| **C.** | Voltage | 208/240 VAC +/- 2.5VAC | Yes |
| **D.** | Frequency | 60 Hz +/- 1Hz | No |
| **E.** | Incoming water temperature | Between 58 +/- 2F | Yes |
| **F.** |  |  |  |
| **G.** |  |  |  |
| **H.** |  |  |  |
| **I.** |  |  |  |
| **J.** |  |  |  |
| **K.** |  |  |  |
| **L.** |  |  |  |
| **M.** |  |  |  |
| **N.** |  |  |  |
| **O.** |  |  |  |

**Key Control Parameters-** *A key control parameter (KCP) is any product usage or interaction variable which can be controlled by design (dimensions, operating range, material, etc.).*

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Key Control Parameter**  *(KCP as defined by P-diagram)* | **Set as Test Input**  *(Set to this level for test)* | **Record as Test Output**  *(Measure results and record)* |
| **A.** | Element wattage (Upper & Lower) | No (# watts) | Yes, upper and lower |
| **B.** | Fan wattage | No (# watts each) | Yes, from fan label, including brand/model # |
| **C.** | Compressor wattage | No | Yes, from supplier rating, including brand/model# |
| **D.** | Compressor output | No (# BTU/hr) | No – just record supplier rating at ASHRAE conditions |
| **E.** | Charge size | No (# lbs) | Yes, from production data |
| **F.** | Condenser Tube dia | No (.25 or .312 dia, inches) | Yes |
| **G.** | Condenser Configuration | No | Yes (where condenser is wrapped… eg “around tank below upper element, including bottom”) Obtain info from production |
| **H.** | Expansion Device | No | Yes – record label information including brand/model# |
| **I.** |  |  |  |
| **J.** |  |  |  |
| **K.** |  |  |  |
| **L.** |  |  |  |
| **M.** |  |  |  |
| **N.** |  |  |  |
| **O.** |  |  |  |

**4. Test Equipment and Supplies**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Equipment/Test Device**  *(Most generic title & description including any input specs)* | **Measurement**  *(Device output requirements, include units )* | **Range**  *(Min/max measurement capability)* | **Resolution**  *(Maximum measurement increments)* | **Expected Gage Error**  *(Variability of gage, σe)* |
| **A.** | Data logger | TC’s and meter output vs time |  |  |  |
| **B.** | Wattmeter | Volts & Watts outputs to be sent to data logger. |  |  |  |
| **C.** | PC cable with communication to water heater controls. | Hybrid control to output thermistor values and relay states in .csv format in 10-second time intervals. |  |  |  |
| **D.** | Flow Meter with digital display, and analog output to data logger. | GPM & accumulative gallons. Latter must be sent to data logger. | .1 to 12 gpm, | .1 gpm |  |
| **E.** | Water temperature Flow rate Valve |  |  |  | May need flow restrictor if required to achieve 3+/-.25gpm flow through valve. |
| **F.** | Conditioned power supply - Minimum 5000 watt |  | 208VAC & 240VAC+/-2.5VAC |  |  |
| **G.** | Thermal Chamber capable of holding temperature and humidity to KNP test-condition levels indicated above. |  |  |  |  |
| **H.** | Water Chiller |  | Maintain 58+/- 2 degrees F at 3 GPM |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Supply Item**  *(Most generic title)* | **Quantity** | **Unit of Measure** | **Consumable or Reusable?** | **Comments** |
| **A.** | Thermocouples, type T | Degrees F |  |  |  |
| **B.** | \*Thermocouple Tree | Degrees F |  |  |  |

\* See Appendix A: Thermocouple Tree Construction.

**5. Expected Test Duration** *(Based on average conditions; may vary significantly depending upon lab load)*

**Set-up:** 4-hrs

**Test Procedures:** 4-hrs for each set point tested

**Post-test/Cleanup:** 2-hrs

**Documentation:** 2-hrs

**Total Expected Test Duration:** 2-Days

**6. Test Samples**

**Sample Size** *(Number of samples and/or rationale for sample size selection)*

3 for production auditing. More samples may be tested for initial product qualification per PTS.

**Qualification/Preconditioning/Setup** *(Any test sample preparation, stabilization, preconditioning or certification required before testing)*

Test Setup for Hybrid Electric Water Heater:

* Place unit in thermal chamber and set chamber ambient temperature to 67.5F +/- 1F.
* Insert Thermal couple tree in the tank.
* Connect communication cable to control, and to have shroud close and assemble. Log file must include Time, Tank thermistor, evaporator inlet thermistor, evaporator outlet thermistor, compressor discharge thermistor, ambient thermistor, and state (opened or closed) of fans, compressor, and heating element relays.
* Connect all thermocouples, flow meter and wattmeter outputs to data logger (Volts, Watts).
* Ensure data logger outputs can be synchronized (within 3 seconds) to start logging at same time, both at 10-second intervals.
* Flow meter must be plumbed in-line with cold water inlet.
* Connect cold water supply to inlet port of water heater. Inlet water temperature to be conditioned to 58F+/-2F. If incoming water supply is outside this temperature range, a water chiller must be used.
* Install valve on hot water outlet, with valve outlet directed to drain. When open, valve should allow 3 gpm +/- .25 gpm of flow.
* Connect condensate drain tube to lower condensate port located at back of unit, and direct hose to drain.
* Fill water heater with water.
* Direct wire unit to 240VAC 60 Hz single phase power supply, with meter in-line to measure voltage, power and energy (KW-hr)
* Set water temperature to 140F.
* Set unit to desired mode in which heat up test is to be run. (in other words, unit must stabilized in same mode that unit will be tested in) Allow unit to stabilize at desired water temperature set point per test procedure. (Stabilization defined as when power to all heating sources is off)
* Start data logger within 5 minutes after unit stabilizes.

The test procedure below must be started 30+/-5 minutes after stabilization).

**7. Test Procedure** *(Detailed, step-by-step directions for running test including photos/diagrams as appropriate)*

Test Procedure for Hybrid Electric Water Heater:

This ETP may be used for both product development testing, and audit Testing. Quantity of units and testing set points to be determined from PTS or per Engineer’s discretion. This procedure can be used to evaluate the Hybrid water heater in any modes of operation(couple of words were deleted) per the Engineer’s discretion.

For development test only, run test procedure below in Std electric and hybrid modes at 240 volts and record results.

1. After unit has been stable for 30+/-5 minutes, Open valve, and draw 10.75 +/- .25 gallons of water at a rate of 3+/-.25 gpm.
2. 80 Gallon Only. Wait for 1 hour after draw start.
3. Draw another 10.75 gallons.
4. If lower heat source energizes (Hybrid Mode/Heat Pump Mode = FAN ON follow by Compressor, Standard Electric Mode = Lower Element ON) before 10.75 gallons, then continue drawing water until Upper element engages as shown in step 5 (skip to step 5).
5. If lower heat source does not energize during 10.75 gallon draw, then wait a maximum of 10 minutes to see if lower heat source will energize (If it does not energize, it is considered a failure). If it does, then allow the water heater to recover to set point.
6. Allow unit to sit 5 to 10 minutes in stabilized conditions, then:
7. Open valve and draw water at 3+/-.25 gpm until the Upper Element energizes. Water draw must stop within 5 seconds after Upper Element energizes. NOTE: when running the unit in e-Heat mode, (no upper element) draw 40+/-0.25 gallons of water.
8. In Hybrid Mode: when the Upper Element stops and switches to Lower Element, switch the unit to Heat Pump Mode. This will switch the lower heating source to Compressor.
9. Allow water heater to stabilize this second time. (Recover water temperature back to set point).
10. Allow unit to sit a minimum of 30 minutes in stabilized conditions, then;
11. Stop Data Logger session.
12. Capture all data into format shown in attached spreadsheet.

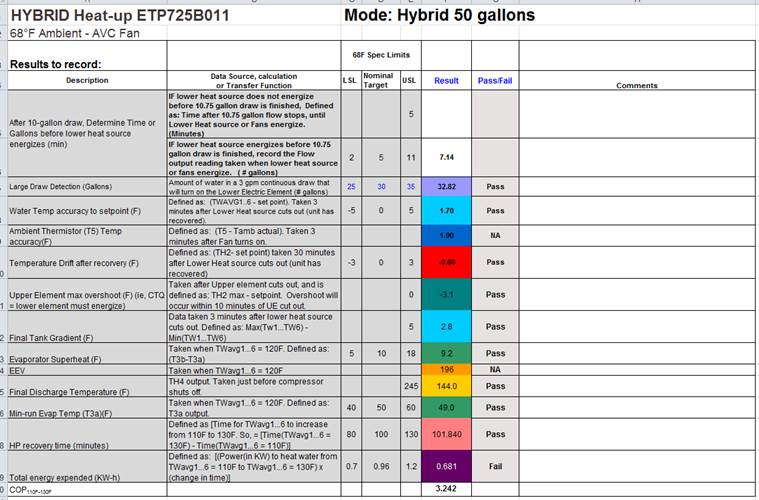
**8. Results**

**Note - All test results to include:**

* **Equipment used to generate data**
* **Calibration (accuracy) of test equipment**
* **Resolution of test**
* **Measurement error (variability, σe) of test**
* **Data from Data Logger to be imported into spreadsheet attached, and charted as shown in spreadsheet. All results listed below to be taken from that file.**
* **Upper and Lower Specification Limits may vary according with model and tank size.**

**Heat Up Summary Table**

**Link to the macro**: [\\ITNAS\technology\GlobalProducts\InProcess\Water\AP2 Hybrid Electric Water Heater\Evaluation\MACROS](file:///\\ITNAS\technology\GlobalProducts\InProcess\Water\AP2%20Hybrid%20Electric%20Water%20Heater\Evaluation\MACROS)



**9.** **Results Interpretation** *(Includes any pertinent guidelines, limitations or insights needed for interpreting results)*

The pass/fail critera are defined in the attached excel spreadsheet per the PTS requirements. All results are to be recorded in the attached spreadsheet by the supplier/technician and must be reviewed by the Engineer. The attached Excel file is an example. The Technician and Engineer need to put in the actual specification limits for the product that is being tested.

**ESTIMATE** Of Efficiency = #BTU/hr in to water = mCpΔT = (#gal) x (8lb/gal) x (Cp) x (Twaf – Twai)

#kwh energy used # kwh #kwh used

note: Cp = 1 for water

**10. Failure Modes Exercised/Acceleration Factors/Field Failure Correlation**

*(Includes both performance and reliability failure modes which test may exercise. Subjective failure levels denoted with photos for reference as appropriate. Field correlations used to set subjective failure guidelines as appropriate.)*

Pass / Fail criteria defined in attached spreadsheet.

**11. Nomenclature/Vocabulary** *(Defines all technical terms, variables and acronyms used in the background)*

PTS = Product Technical Spec

HEWH = Hybrid Electric Water Heater, GE’s name for a water heater which used a combination of a heat pump and an electric resistance heating element to heater the water in it’s storage tank.

HPWH = Heat Pump Water Heated, standard industry name for this type of water heater.

Heat Pump mode = This is the compressor only mode (or heat pump mode). It uses only the compressor and sealed system to heat the water. It is the most efficient mode for this model but it takes the longest time for the water temperature in the tank to recover.

Hybrid mode = This mode uses both the compressor (or heat pump) and upper resistance heating element. It is the default mode for the unit. It gives the user better energy savings than today’s electric water heater (not as good as Heat Pump but speeds up the recover time to heat the water in the tank

Standard Electric mode = Same as today’s electric water heaters. It uses an upper and lower resistance heating element to heat the water. Least energy efficient mode, but it has the fastest recover time.

**12.**  **Background** *(Related theory, methods and standards used to develop test procedure)*

Heat-up Test was developed during the innovation phase of the 1st Hybrid Electric Water Heater project. The test procedure takes a snapshot of one thermal cycle of a water heater. The KNP test-setup conditions essentially match those used in the DOE test procedure for Energy Factor and First-Hour-Delivery tests. Outputs of this test were needed to understand operation of existing electric water heaters, and to develop the controls/algorithm for the new HEWH.

**13. Reference** *(Technical studies, standards, articles, etc., which are related to this ETP)*

**N/A**

**14. Revision History** *(Includes reasoning for release of current revision, with date and name of person releasing revision)*

Rev 1 – 2/17/2014 – Vikrant Patel: Recent updates of this ETP.