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ANSI/CTA-2045-A Electric Water Heater Test Procedures

Information Exchange and Demand Response

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ABSTRACT

This document defines the procedures for verifying that products meet the requirements specified in the *Demand Response-Ready Heat Pump Water Heater Specification: Preliminary Requirements for CEA-2045 Field Demonstration,* EPRI, Palo Alto, CA: 2014, 3002002719. This document is an update *to Demand Response-Ready Domestic Water Heater Test Plan: Preliminary Test Procedure for CEA-2045 Field Demonstration.* EPRI, Palo Alto, CA: 2015, 3002004702.

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Heat Pump Water Heater
Test Procedure
Functional Requirement

CONTENTS

ABSTRACT ..... **v**

***1* OVERVIEW** **1-1**

Purpose of Document 1-1

Definitions 1-1

***2* TEST SETUP** **2-1**

***3* TEST CASES** **3-1**

Mechanical, Electrical Communication and Safety Requirements 3-1

REQ.ME1 Size and Type 3-1

Cycling Capability 3-1

CTA-2045 Port Characteristics 3-1

Safety Standards 3-3

User Interface Characteristics 3-3

Information Exchange and Response Requirements 3-4

Link-Layer Requirements 3-4

Control Requirements 3-4

REQ.C1 – DR Event Timeout 3-4

REQ.C2 – Recovery after Power Cycle 3-6

REQ.C3 – Application ACK 3-8

REQ.C4 – Application NAK 3-8

REQ.C5 – Heartbeat 3-10

REQ.C6 – Return to Normal Operation 3-11

REQ.C7 – Shed Command 3-12

REQ.C8 – Critical Peak Event (CPE) 3-15

REQ.C9 – Grid Emergency (GE) 3-18

REQ.C10 – Present Relative Price (Optional) 3-21

REQ.C11 – Autonomous Cycling and Terminate Cycling 3-25

REQ.C12 – Load Up 3-29

Monitoring Requirements 3-32

REQ.M1 – Maximum Data Refresh Time 3-32

REQ.M2 – Customer Override 3-32

REQ.M3 – Operational State Query & Response 3-35

REQ.M4 – Query & Response: Info Request 3-36

REQ.M5 – Get/Set Commodity Read Request and Get/Set Commodity Read Reply 3-37

***A* WORKSHEETS** **A-1**

LIST OF FIGURES

Figure 2-1 Water Heater Test Setup 2-1
Figure 3-1 Communication Interface Mechanical Dimensions 3-2
Figure 3-2 Electrical Pin Out (Source Consumer Technologies Association, ANSI/CTA-2045-A) 3-3
Figure 3-3 REQ.C1 DR Event Timeout Test Case Sequence 3-5
Figure 3-4 REQ.C2 Recovery after Power Cycle Test Case Sequence 3-7
Figure 3-5 REQ.C4 Application NAK Test Case Sequence 3-9
Figure 3-6 REQ.C5 Heartbeat Test Case Sequence 3-10
Figure 3-7 REQ.C6 Shed Command Test Case Sequence 3-13
Figure 3-8 REQ.C8 Critical Peak Event (CPE) Test Case Sequence 3-16
Figure 3-9 REQ.C9 Grid Emergency (GE) Test Case Sequence 3-19
Figure 3-10 REQ.C10 Present Relative Price (Optional) Test Case Sequence 3-23
Figure 3-11 REQ.C11 Autonomous Cycling and Terminate Cycling Test Case Sequence 3-26
Figure 3-12 REQ.C12 Load Up Test Case Sequence 3-30
Figure 3-13 REQ.M2 Customer Override Test Case Sequence 3-33
Figure 3-14 REQ.M5 Test Case Sequence 3-36
Figure 3-15 REQ.M6 Test Case Sequence 3-38

LIST OF TABLES

Table 1-1 Referenced documents 1-1
Table 3-1 Link Layer Requirements 3-4
Table 3-2 REQ.C1 DR Event Timeout Test Case Steps 3-6
Table 3-3 REQ.C2 Recovery after Power Cycle Test Case Steps 3-8
Table 3-4 REQ.C4 Application NAK Test Case Steps 3-9
Table 3-5 REQ.C5 Heartbeat Test Case Steps 3-10
Table 3-6 REQ.C6 Shed Command Test Case Steps 3-14
Table 3-7 REQ.C8 Critical Peak Event (CPE) Test Case Steps 3-17
Table 3-8 REQ.C9 Grid Emergency (GE) Test Case Steps 3-20
Table 3-9 SGD Price Thresholds 3-22
Table 3-10 REQ.C10 Present Relative Price (Optional) Test Case Steps 3-24
Table 3-11 REQ.C11 Autonomous Cycling and Terminate Cycling Test Case Description 3-27
Table 3-12 REQ.C12 Load Up Test Case Steps 3-31
Table 3-13 REQ.M2 Customer Override Test Case Steps 3-34
Table 3-14 REQ.M5 Test Case Steps 3-37
Table 3-15 Device Info Data Table 3-37
Table 3-16 REQ.M6 Test Case Steps 3-39
Table 3-17 Commodity Code Data Table 3-39
Table A-1 Summary of Test Results A-1

1
OVERVIEW

Purpose of Document

This document includes procedures for testing the functional requirements of ANSI/CTA-2045-A heat pump water heaters. The procedures are dependent on the documents listed in Table 1-1.

Table 1-1
Referenced documents

Document Name	Version or Date
Demand Response-Ready Heat Pump Water Heater Specification: Preliminary Requirements for CEA-2045 Field Demonstration EPRI, Palo Alto, CA: 3002002719	December, 2014
Modular Communications Interface for Energy Management ANSI/CTA-2045-A	March, 2018

The procedures included herein are not designed to quantify the performance (i.e. energy efficiency) of the product. They are intended to verify that the product:

- Conforms with the AC UCM as defined in the ANSI/CTA-2045-A standard
- Acknowledges and responds to all ANSI/CTA-2045-A commands as defined in the *Functional Requirements for ANSI/CTA-2045-A Heat Pump Water Heaters Specification, Second Edition EPRI 2019*
- Supports other features and functions defined in the Functional Requirements for ANSI/CTA-2045-A Heat Pump Water Heaters Specification, Second Edition EPRI 2019

Definitions

ANSI/CTA-2045-A (March 2018), Second edition to ANSI/CTA-2045 (February 2013) Published by the Consumer Technology Association, the latest edition is available at this link.

HPWH, heat pump water heater

SGD, Smart Grid Device, interchangeable to HPWH

UCM, Universal Communication Module, device that plugs into and communicates with the HPWH through the ANSI/CTA-2045-A communication interface.

REQ, Requirement

Normal Mode of Operation, refers to the operational state in which the device would be operating independent of the information exchanged through the ANSI/CTA-2045-A port.

Grid Service Mode of Operation, refers to a state in which the device has changed its process in response to information received through the ANSI/CTA-2045-A communication interface.

CTA-2045 Simulator, Desktop application designed to send and respond to ANSI/CTA-2045-A commands.

CPE, Critical Peak Event (ANSI/CTA-2045-A basic application layer message)

GE, Grid Emergency (ANSI/CTA-2045-A basic application layer message)

2
TEST SETUP

The water heater should be connected to power and water sources as shown in Figure 2-1.

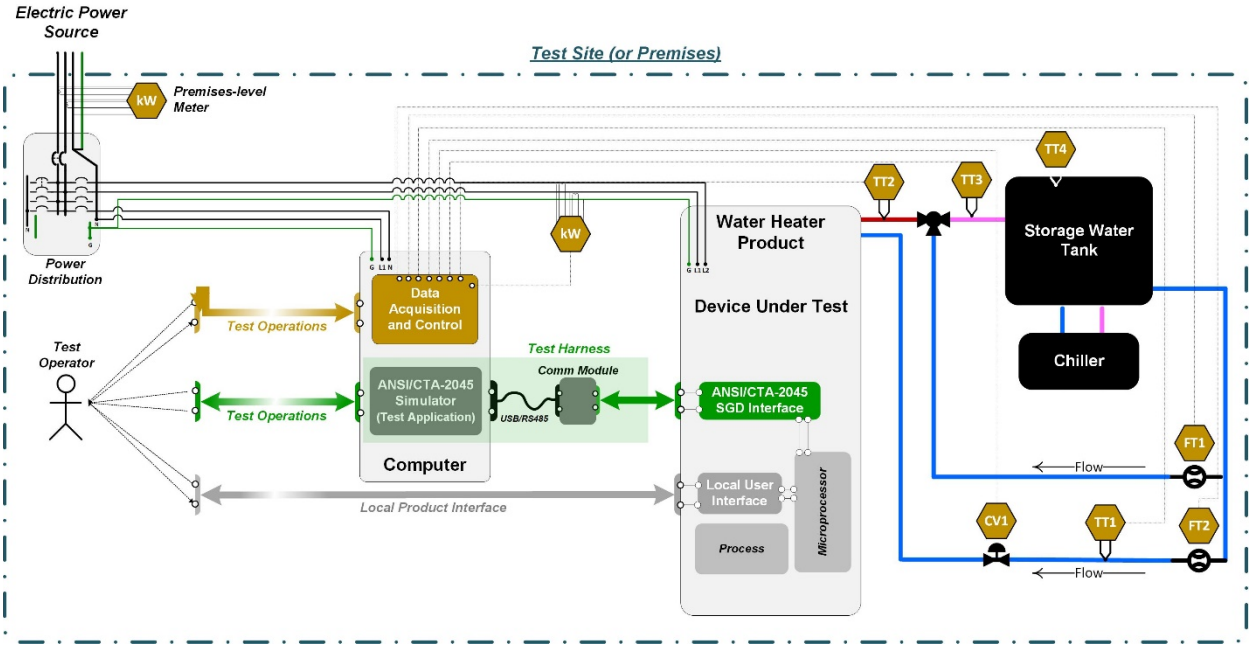


Figure 2-1
Water Heater Test Setup

3
TEST CASES

Mechanical, Electrical Communication and Safety Requirements

Review product documentation and perform visual inspections to verify REQ.ME1 through REQ.ME6 are met.

REQ.ME1 Size and Type

The water heater shall be a standard 50-gallon resistive type. Standard height/diameter. (Not a low-boy). Insulation/efficiency and other details to be manufacturer-recommended. A 50-gallon 0.93 EF model will be used.

Cycling Capability

REQ.ME2 (Warrantee Integrity – Daily Contactor Switching)

The water heater shall be capable of an average of 12 on/off cycles or more per day over its service life.

Note: Test for this feature is not included in this test plan.

REQ.ME3 (Warrantee Integrity – Total Contactor Switching)

The water heater shall track total on/off cycling and protect itself against excessive cycling based on a total cycles per 100 day period (e.g. not more than 1200 on/off cycles in a 100 day period).

Note: Test for this feature is not included in this test plan.

CTA-2045 Port Characteristics

REQ.ME4 (AC Form Factor)

The water heater shall be equipped with the AC form factor CTA-2045 port described in Appendix B of the ANSI/CTA-2045-A standard.

REQ.ME5 (Space Allocation for AC Form Factor)

The water heater will allow space for any communication module up to the maximum size specified by the CTA-2045 standard.

REQ.ME4 and REQ.ME5 Test Procedures

To enable interoperability, the communication interface is standardized at all layers, including the physical. These tests validate that the mechanical characteristics of the water heater's interface are correct per the CTA-2045 standard, enabling it to mate properly with communication modules.

This requires that the water heater mechanical mounting for the UCM adhere to the dimensions specified by the CTA-2045 standard as reflected in Figure 3-1.

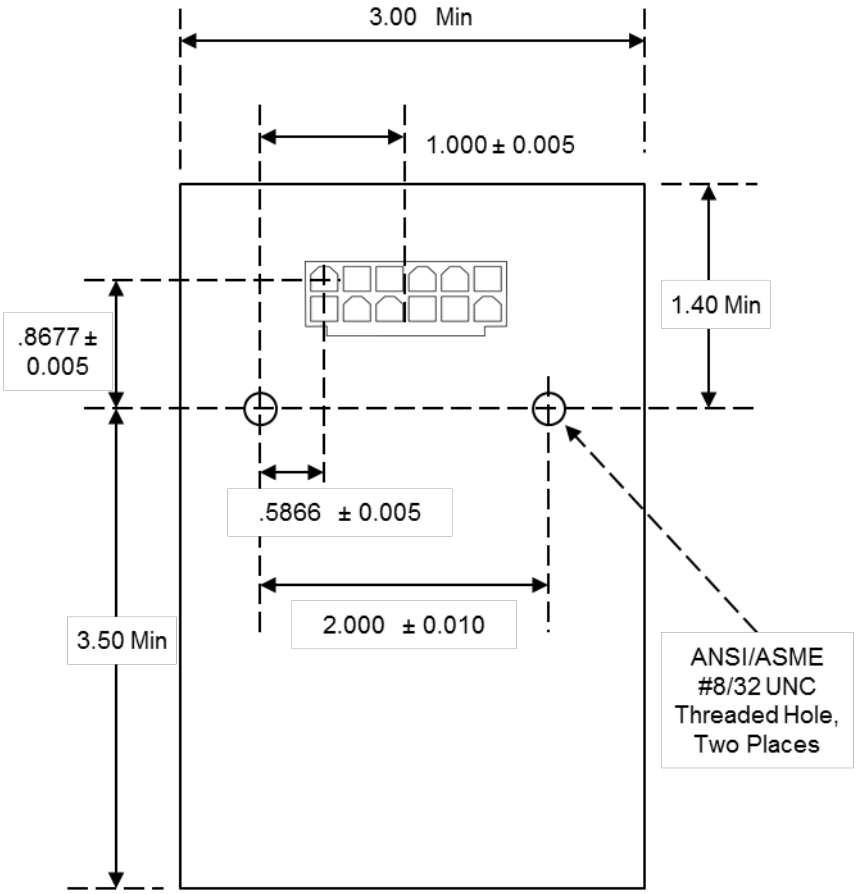
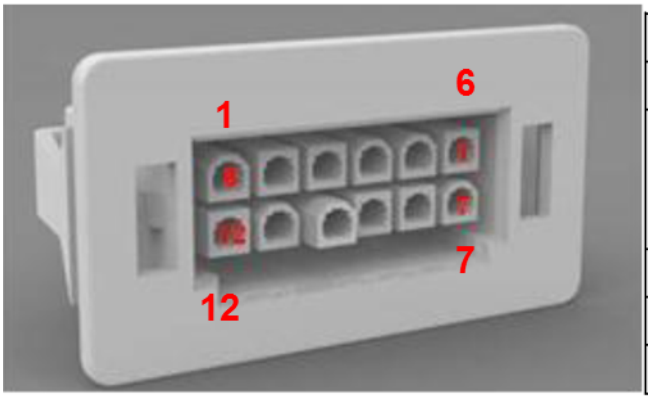


Figure 3-1
Communication Interface Mechanical Dimensions

Use a caliper and measurement tools, or a reference UCM block.

If UCM does not fit, note in test report.

The communication interface is required to provide AC line voltage to power the communication module and to communicate using an RS-485 interface. The pin out on the inverter interface is as shown in Figure 3-2.



1	Data- (RS-485)	7	Data+ (RS-485)
2	No connection	8	Signal Ground
3	Reserved for vendor-specific use	9	No connection
4	No connection	10	Earth Ground
5	120VAC Line 2	11	No connection
6	No connection	12	120VAC Line 1

Figure 3-2
Electrical Pin Out (Source Consumer Technologies Association, ANSI/CTA-2045-A)

The following tests are required:

1. Verify between 96 and 277VAC between pins 5 and 12 (Note: Full voltage AC powering the product should be measured across these pins.)
2. Verify that by default (no UCM connected) Data+ (pin 7) is pulled to a logic high (2.5 to 5.5V) and Data- (pin 1) is logic low (<1.5V).
3. Using an Oscilloscope, verify that the logic levels on Data+ and Data- toggle between these logic high and logic low states during data transmission and that they tri-state when not transmitting.

Safety Standards

REQ.ME6 (UL 174 and Equivalent CSA)

The water heater shall meet the rating criteria of a standard electric water heater, UL 174, and/or the Canadian equivalent.

Note: Verify through proof of certification

User Interface Characteristics

The water heater shall include a user interface that supports the following features:

REQ.UI1 (Successful Communication)

An indicator of successful communication connectedness (based on the CTA “comm status” message)

REQ.UI2 (Curtailment in Effect)

An indicator of curtailment when there is one in effect.

REQ.UI3 (Customer Event Override)

An override button the customer can override any current curtailment and prevent future curtailments for a 24-hour period. (Note also monitoring requirement REQ.M2)

REQ.UI4 Two User-adjustable Temperature Set Points(Optional)

Two user adjustable set points, 1) normal operations and 2) maximum temperature for temporary absorption of energy.

Note: Optional requirement, tests not included.

Information Exchange and Response Requirements

The communication requirements are described in three groups: Link-Layer, Control, and Monitoring; as detailed in the following sub-sections.

Link-Layer Requirements

Table 3-1 lists the link layer commands that the product is required to support. Since the commands listed in the Control Requirements and Monitoring sections depend on the link layer commands, tests within these sections can be used to verify that the product conforms to the link layer requirements.

Table 3-1
Link Layer Requirements

Requirement	CTA-2045 Message	Water Heater Implementation
REQ.LL1	Link ACK	Required per the standard.
REQ.LL2	Link NAK	Required per the standard. Water heater shall detect and report all the standard NAK codes.
REQ.LL3	Query & Response: Maximum Payload Length	In order to support the messages identified herein (Get_Information is the longest), the unit must support negotiation up to 64 bytes message length.
REQ.LL4	Message Type Supported Query & Response	Required per the standard.

Control Requirements

REQ.C1 – DR Event Timeout

The water heater logic shall be such that all curtailment requests expire and the water heater returns to the previous customer-chosen mode of operation after 12 hours, unless another curtailment request is received within that time.

The test sequence is shown in Figure 3-3 and detailed in Table 3-2.

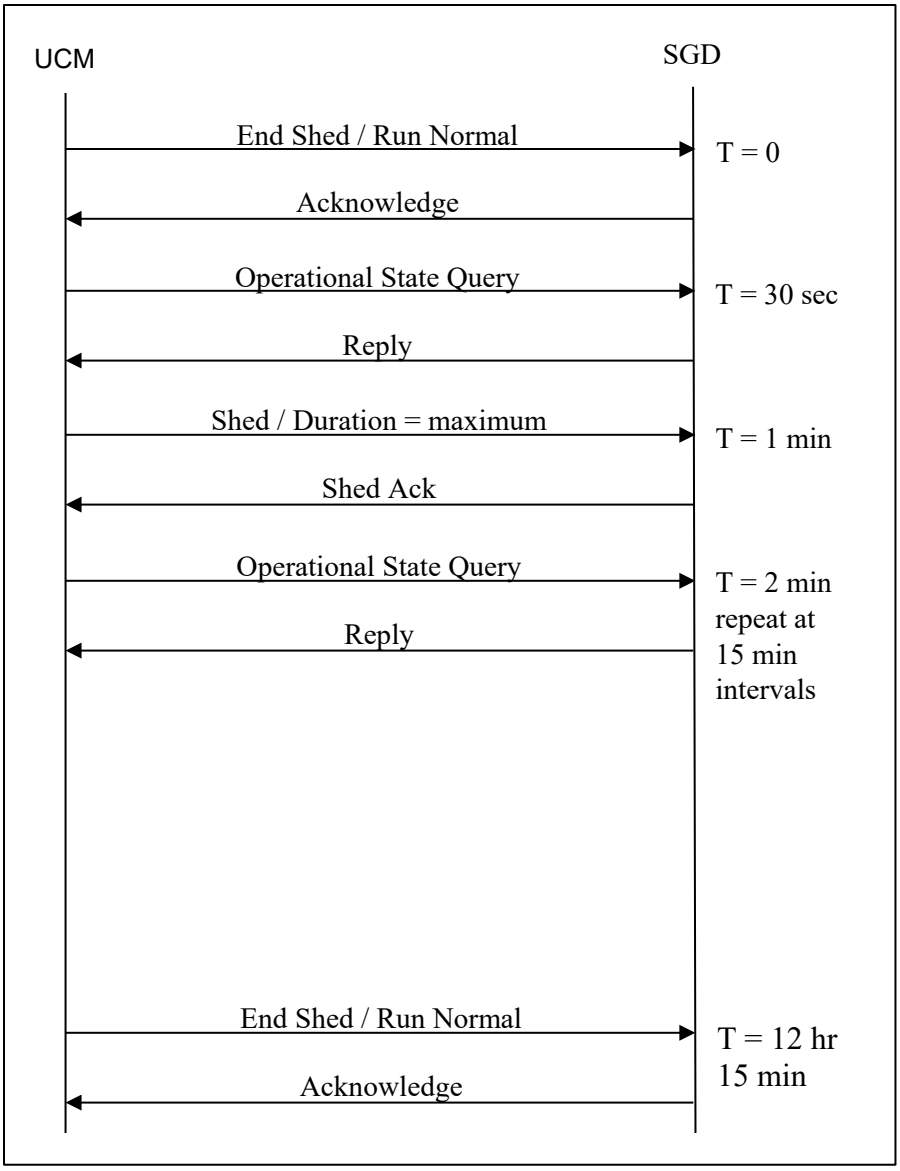


Figure 3-3
REQ.C1 DR Event Timeout Test Case Sequence

Table 3-2
REQ.C1 DR Event Timeout Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: "Idle Normal" /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or "Running Normal" /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a shed command to the SGD with a duration of "0" infinite duration: (Include opcodes and values) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x1/0x4/0x42
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: "Running Curtailed Grid": /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or "Idle Grid" /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Repeat step 4 every 15-minutes until four hours has elapsed.	Verify that the SGD continues to process the curtailment request.
6	At 12-hours and 15-mintes after step 3 has elapsed repeat step 2.	Verify that the SGD is NOT processing the last curtailment request and that it's operating in its normal operating mode.
7	Repeat steps 1 thru 6, with the following modifications Step 3, send a "Critical Peak Event" then repeat for "Grid Emergency" and "Shed"	The SGD should process the Critical Peak Event curtailment for twelve hours then revert to its normal operating mode.

All communications between the UCM and SGD should be logged.

REQ.C2 – Recovery after Power Cycle

The water heater logic shall be such that upon power cycle, all operational settings shall return to user-assigned settings. Any state other than the user-assigned settings must be renegotiated.

The test sequence is shown in Figure 3-4 and detailed in Table 3-3.

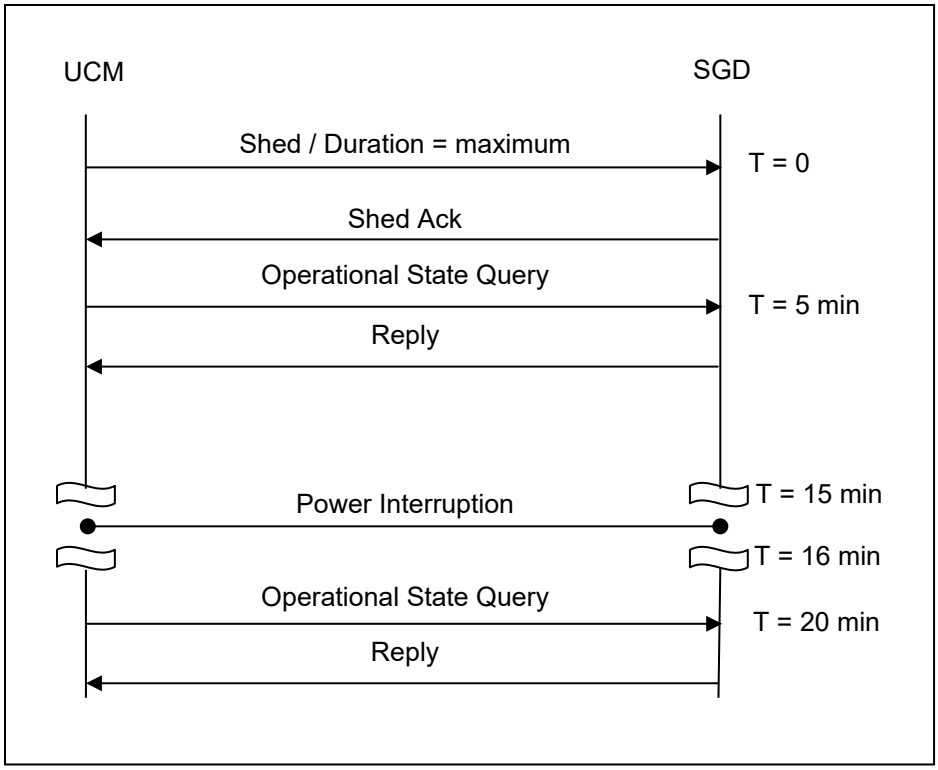


Figure 3-4
REQ.C2 Recovery after Power Cycle Test Case Sequence

Table 3-3
REQ.C2 Recovery after Power Cycle Test Case Steps

Step	Test Case Description	Required Result
1	Send a “Shed” command to the SGD: Duration = 0 (Maximum) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	SGD Response 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x1/0x4/0x42
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
3	Interrupt power to the SGD for a duration of at least 1 minute	Power to the SGD can be cycled either through automated or manual means. Either are acceptable.
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is running normal Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
5	Repeat steps 1 thru 5 with the following modifications: Step 1, send a “Critical Peak Event”, “Grid Emergency”, and “Load Up” instead of a “Shed” command in step 1	The SGD should revert back to its normal operating mode after power is cycled or the UCM is removed.

All communications between the UCM and SGD should be logged.

REQ.C3 – Application ACK

The water heater shall support the application ACK as described in the ANSI/CTA-2045-A specification.

To verify this requirement, review the log files that were recorded for REQ.C1 and REQ.C2 testing. If the water heater is incapable of returning an application ACK it has failed this requirement.

REQ.C4 – Application NAK

The water heater will support the application NAK as described in the ANSI/CTA-2045-A specification.

The test sequence is shown in Figure 3-5 and detailed in Table 3-4.

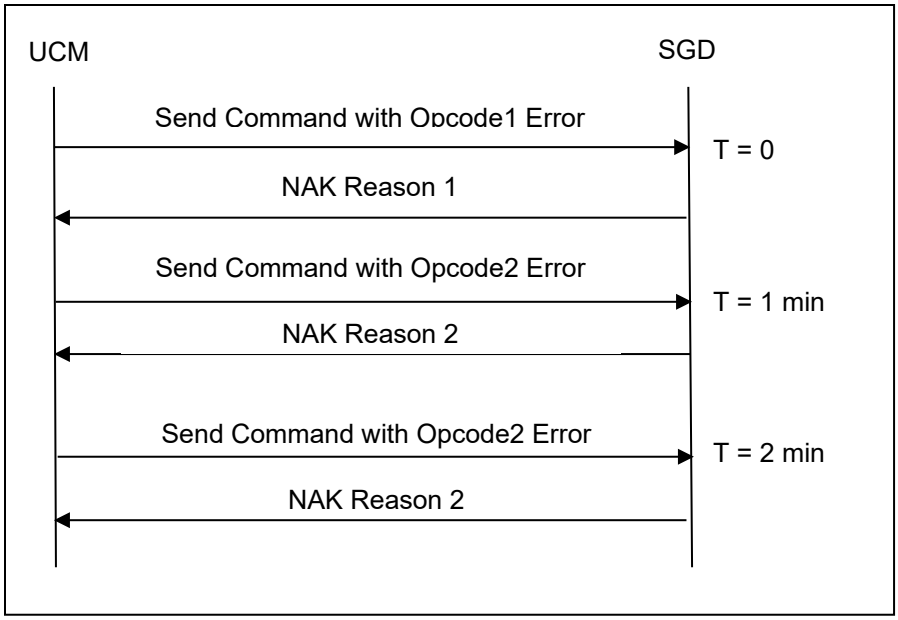


Figure 3-5
REQ.C4 Application NAK Test Case Sequence

Table 3-4
REQ.C4 Application NAK Test Case Steps

Step	Test Case Description	Required Result
1	In the simulator, go to “Common Commands > Simulate Errors” and check the box beside “Opcode 1” (leave the value beside it alone). Send a “Shed” command to the SGD: Duration = 0 (Maximum) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The SGD will respond: NAK Reason 1 0x8/0x1/0x0/0x2/0x4/0x1/0xXX/0xXX
2	In the simulator, go to “Common Commands > Simulate Errors” and check the box beside “Opcode 2” (leave the value beside it alone). Send a “Shed” command to the SGD: Duration = 0 (Maximum) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The SGD will respond: NAK Reason 2 0x8/0x1/0x0/0x2/0x4/0x2/0xXX/0xXX
3	Put the SGD in vacations mode. Send a “Shed” command to the SGD: Duration = 0 (Maximum) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The SGD will respond: NAK Reason 3 0x8/0x1/0x0/0x2/0x4/0x3/0xXX/0xXX

All communications between the UCM and SGD must be logged.

REQ.C5 – Heartbeat

The water heater must monitor for this "heartbeat" signal. If not received within 15 minutes, the water heater will return to the previous customer-chosen mode of operation.

The test sequence is shown in Figure 3-6 and detailed in Table 3-5.

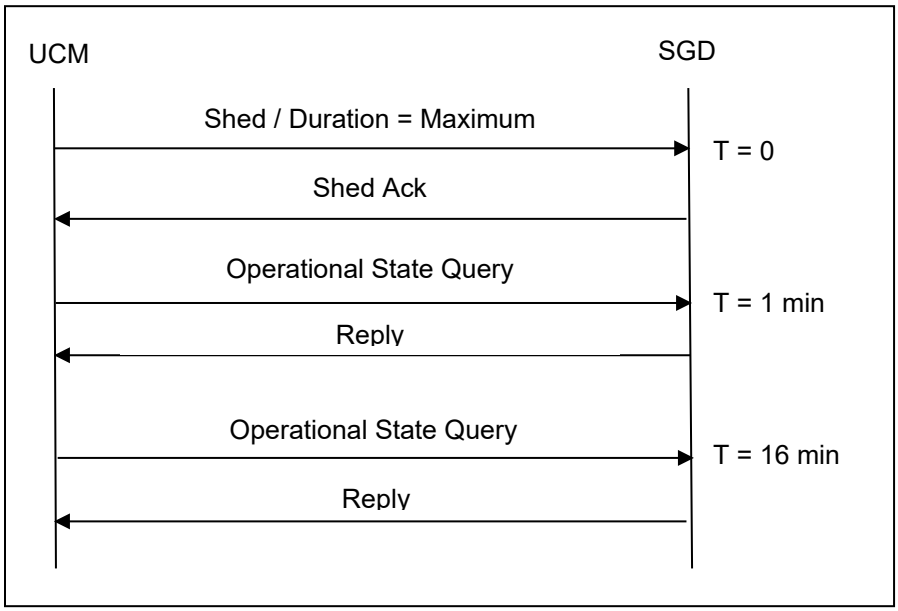


Figure 3-6
REQ.C5 Heartbeat Test Case Sequence

Table 3-5
REQ.C5 Heartbeat Test Case Steps

Step	Test Case Description	Required Result
1	The box for "Real Device Simulation Mode" should be unchecked and the Comm Status should be set to "No / Lost Connection"	This will disable the "heartbeat" signal to the SGD.
2	Send a "Shed" command to the SGD: Duration = 0 (Maximum) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The SGD will respond "Running Curtailed Grid": 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or "Idle Grid" /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65 depending on the temperature of the water in the tank
3	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: "Running Curtailed Grid": 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or "Idle Grid" /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65

Step	Test Case Description	Required Result
	The UCM simulator will respond: 0x6/0x00	
4	Wait for 15 minutes.	
5	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is running normal Acceptable responses include: "Idle Normal" /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or "Running Normal" /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
6	Repeat steps 1 thru 5 with the following modifications: Step 1, send a "Critical Peak Event" instead of a "Shed" command step 4	The SGD should revert back to its normal operating mode after no "heartbeat" is detected for 15 minutes.
7	Repeat steps 1 thru 5 with the following modifications: Step 1, send a "Grid Emergency" instead of a "Shed" command step 4	The SGD should revert back to its normal operating mode after no "heartbeat" is detected for 15 minutes.
8	Repeat steps 1 thru 5 with the following modifications: Step 1, send a "Load Up" instead of a "Shed" command step 4	The SGD should revert back to its normal operating mode after no "heartbeat" is detected for 15 minutes.

All communications between the UCM and SGD must be logged.

REQ.C6 – Return to Normal Operation

End Shed/Run Normal: Maintain normal water heater operation, sequences and customer designated set points. Use 120 degrees F as factory default.

To verify this requirement, review the log files that were recorded for REQ.C1 and REQ.C2 testing and ensure that this command ended all shed, load up, critical peak event (CPE), or grid emergency events. If the water heater is incapable of returning an application ACK it has failed this requirement.

REQ.C7 – Shed Command

Shed events are used as part of fixed-incentive based programs and require a predictable response:

- Water heater shall allow the stored thermal energy in the tank to reach a "Minimum, limited by consumer comfort" level. This could be accomplished, for example, by not operating the lower element and adjusting the upper temperature set-point to a reduced level.
- An end effect of this command (if held in-effect for a long duration) would be to minimize the stored energy in the tank, maximizing the opportunity to dispatch the device with minimal impact to customers.

The test sequence is shown in Figure 3-7 and detailed in Table 3-6.

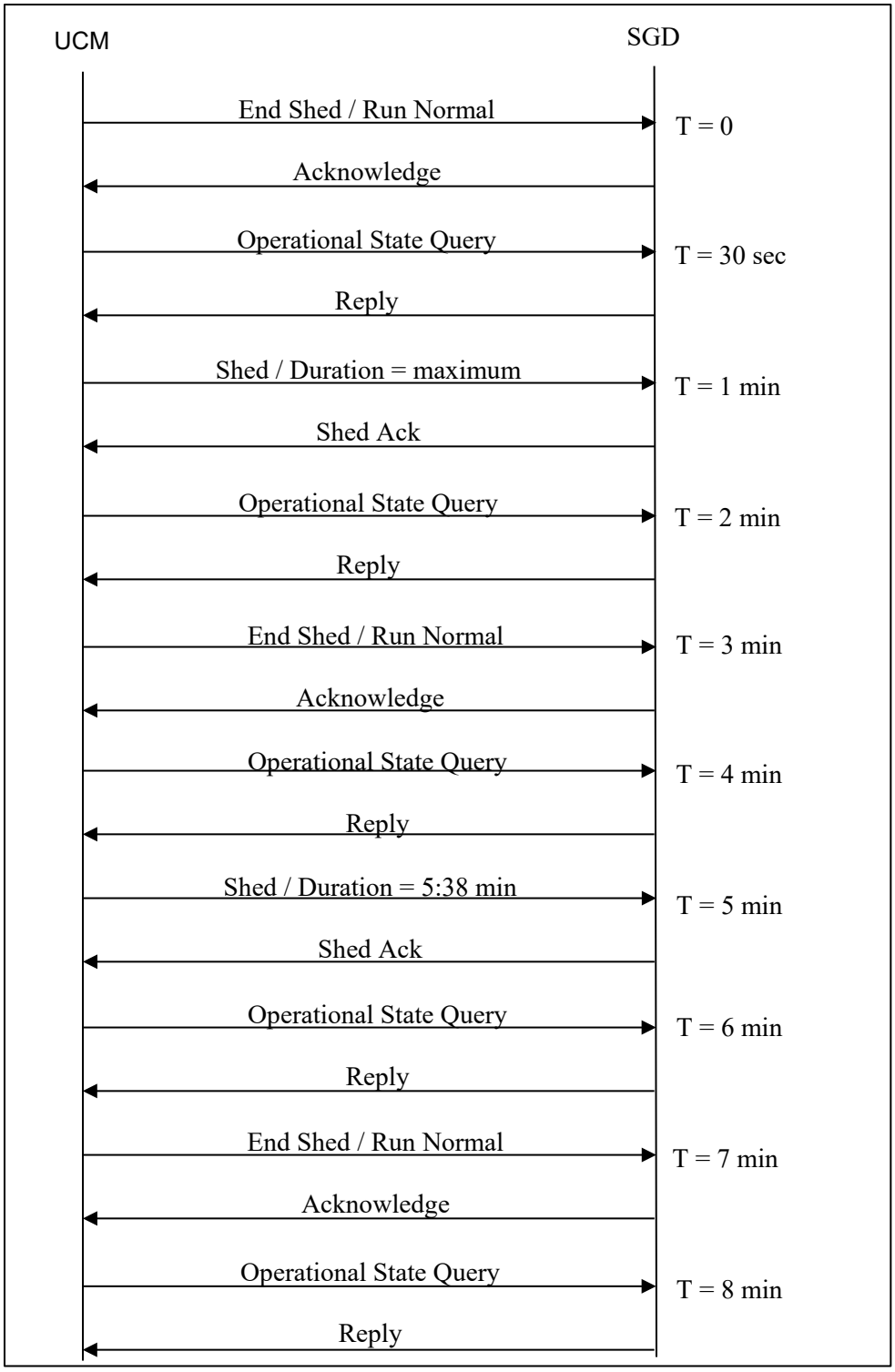


Figure 3-7
REQ.C6 Shed Command Test Case Sequence

Table 3-6
REQ.C6 Shed Command Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a shed command to the SG SGD: Duration = maximum (Include opcodes and values) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x1/0x4/0x42
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
7	Send a shed command to the SG SGD:	The command will inform the SGD that the curtailment event has begun.

Step	Test Case Description	Required Result
	Duration = 5:38 minutes (Include opcodes and values) /0x8/0x1/0x0/0x1/0xD/0xC/0x3D	The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x1/0x4/0x42
	The UCM simulator will respond: 0x6/0x00	
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: "Running Curtailed Grid": 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or "Idle Grid" /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
9	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
10	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: "Idle Normal" /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or "Running Normal" /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62

All communications between the UCM and SGD must be logged.

REQ.C8 – Critical Peak Event (CPE)

Critical Peak Events are typically used as part of fixed-incentive based programs and require a predictable response. These Events are typically infrequent (only a few times a year) so responses are more aggressive.

Water heater will act to reduce the stored thermal energy in the tank to the Minimum storage level, limited by consumer comfort.

Because this message is used for infrequent events, and usually associated with very high prices or incentives, the manufacturer may elect to be more aggressive in response.

The test sequence is shown in Figure 3-8, procedures in Table 3-7.

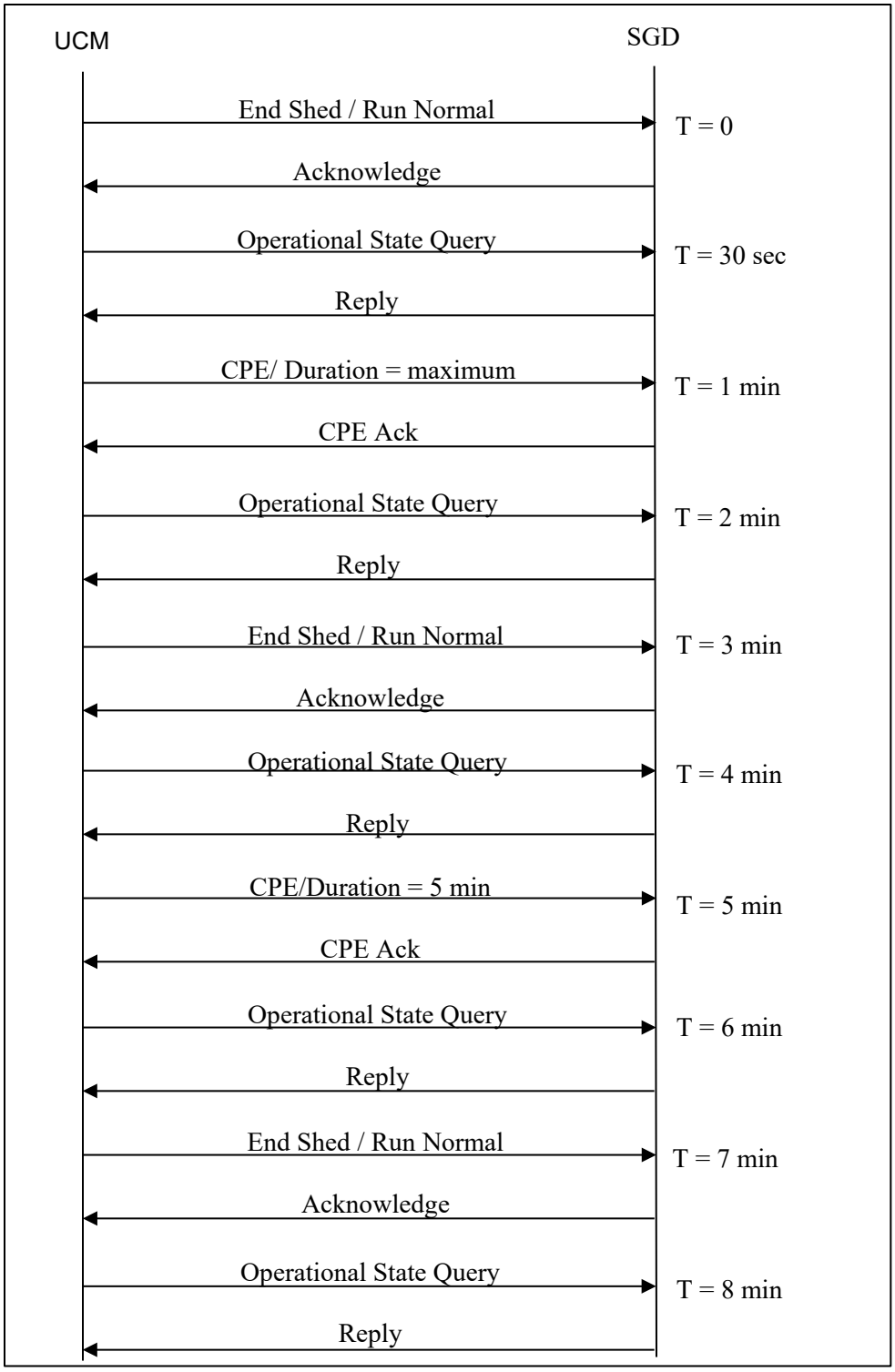


Figure 3-8
REQ.C8 Critical Peak Event (CPE) Test Case Sequence

Table 3-7
REQ.C8 Critical Peak Event (CPE) Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a CPE command to the SG SGD: Duration = maximum (Include opcodes and values) /0x8/0x1/0x0/0x2/0xA/0xF0/0x4F	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0xA/0xF1/0x4B
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
	The UCM simulator will respond: 0x06/0x00	
7	Send a CPE command to the SG SGD:	The command will inform the SGD that the curtailment event has begun.

Step	Test Case Description	Required Result
	Duration = 5:38 minutes (Include opcodes and values) /0x8/0x1/0x0/0x2/0xD/0xF0/0x4F	The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0xA/0xF1/0x4B
	The UCM simulator will respond: 0x6/0x00	
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
9	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
10	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62

All communications between the UCM and SGD must be logged.

REQ.C9 – Grid Emergency (GE)

During an emergency event, the water heater shall immediately shutdown, not heating water until the event has ended. For Grid Emergencies, the water heater may time out and resume operation after one hour.

The test sequence is shown in Figure 3-9 followed by procedures in Table 3-8.

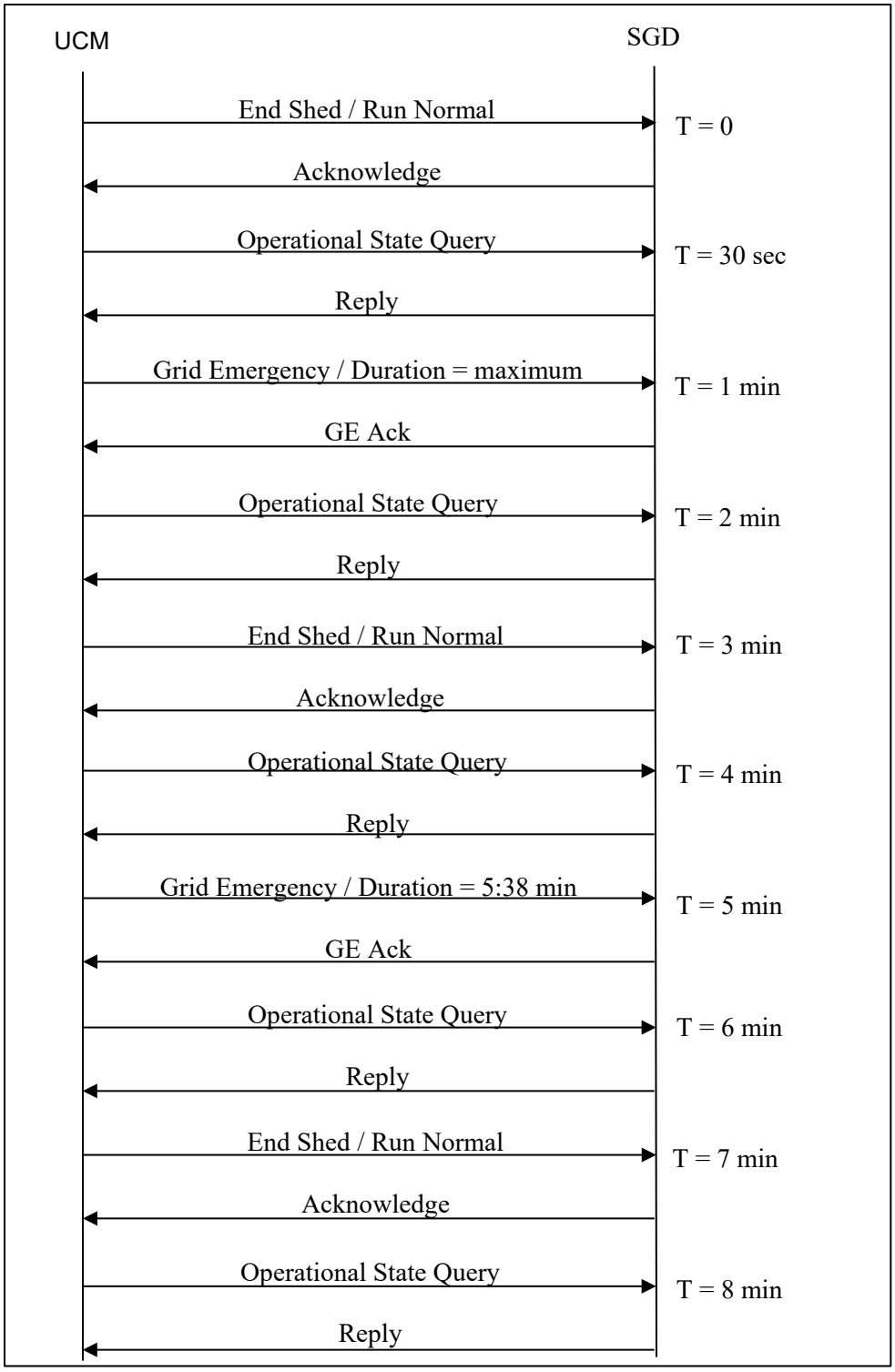


Figure 3-9
REQ.C9 Grid Emergency (GE) Test Case Sequence

Table 3-8
REQ.C9 Grid Emergency (GE) Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a Grid Emergency command to the SG SGD: Duration = maximum (Include opcodes and values) /0x8/0x1/0x0/0x2/0xB/0xED/0x51	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0xB/0xEF/0x4C
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
	The UCM simulator will respond: 0x06/0x00	

Step	Test Case Description	Required Result
7	Send a Grid Emergency command to the SG SGD: Duration = 5:38 minutes (Include opcodes and values) /0x8/0x1/0x0/0x2/0xD/0xED/0x51	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0xB/0xEF/0x4C
	The UCM simulator will respond: 0x6/0x00	
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: "Running Curtailed Grid": 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or "Idle Grid" /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
9	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
10	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: "Idle Normal" /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or "Running Normal" /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62

All communications between the UCM and SGD must be logged.

REQ.C10 – Present Relative Price (Optional)

The Relative Price command is used in association with a range of price-based programs and lends strongly to consumer-configurability of response (i.e. no particular response is mandatory from a utility perspective).

- The simplest of products could have responses that are selected by the manufacturer and fixed (nonadjustable).
- For this demonstration project, the water heater must offer consumers configurability of a "Low Price Threshold" and a "High Price Threshold".
- If Present Relative Price is < "Low Price Threshold":
  - Water heater will act to maximize the stored thermal energy in the tank. For example, maintaining near the upper temperature limit throughout the tank.

- If Present Relative Price is between “Low Price Threshold” and “High Price Threshold”:
  - Water heater will behave normally, the same as when a “Run Normal” message has been received.
- If Present Relative Price is above “High Price Threshold”:
  - Water heater will act to reduce the stored thermal energy in the tank to the Minimum, limited by consumer comfort. This could be accomplished, for example, by not operating the lower element and adjusting the temperature set-point to a reduced level.

This test will usually require some knowledge of the expected response, so communication with the manufacturer of the SGD may be necessary. Use Table 3-9 to record the thresholds for the particular water heater that is being evaluated.

Table 3-9
SGD Price Thresholds

Threshold	Price
Low Price Threshold	
High Price Threshold	

The test sequence is shown in Figure 3-10 and detailed in Table 3-10.

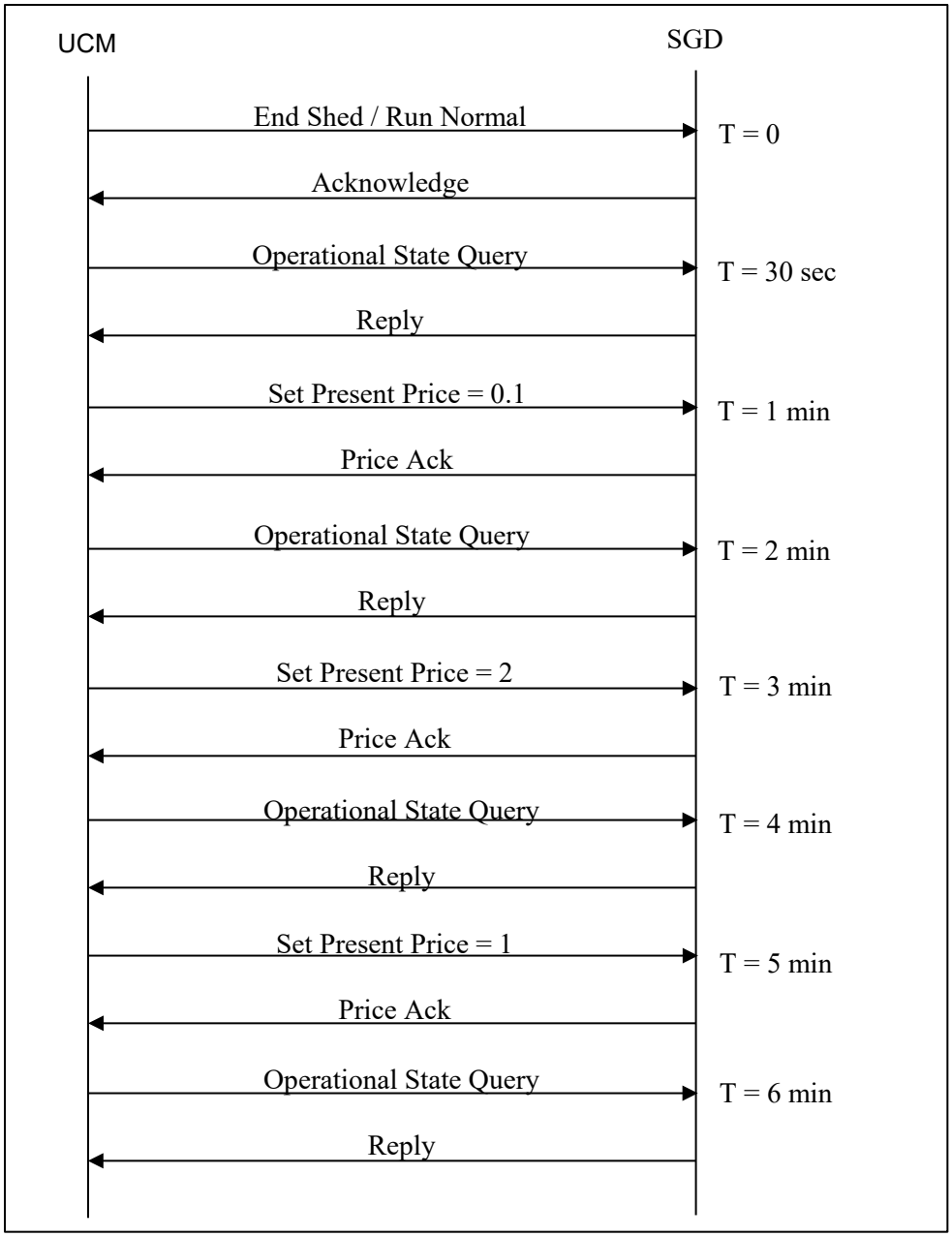


Figure 3-10
REQ.C10 Present Relative Price (Optional) Test Case Sequence

Table 3-10
REQ.C10 Present Relative Price (Optional) Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a Present Relative Price command to the SG SGD: Price = 0.1 (Include opcodes and values) /0x8/0x1/0x0/0x2/0x7/0xC/0xF7/0x48	The command will inform the SGD that the price of energy is 1 % of the threshold. The elements should turn on. If not, draw water from the tank until they do. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Heightened Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x3/0xCF/0x64 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send a Present Relative Price command to the SG SGD: Price = 2 (Include opcodes and values) /0x8/0x1/0x0/0x2/0x7/0x65/0xF7/0x48	The command will inform the SGD that the price of energy is 2 times the threshold. The elements should turn off. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65

Step	Test Case Description	Required Result
	The UCM simulator will respond: 0x06/0x00	
7	Send a Present Relative Price command to the SG SGD: Price = 1 (Include opcodes and values) /0x8/0x1/0x0/0x2/0x7/0x41/0xF7/0x48	The command will inform the SGD that the price of energy is the threshold. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F
	The UCM simulator will respond: 0x6/0x00	
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is now in normal mode.
	The UCM simulator will respond: 0x06/0x00	

All communications between the UCM and SGD must be logged.

REQ.C11 – Autonomous Cycling and Terminate Cycling

This message passes the water heater a request for operation at a particular duty cycle (note that the "off"-time percentage is passed, not the "on"-time). The water heater acts to carry out this duty-cycle of operation, to the extent possible, given total cycle-count limits and remaining within the bounds of upper and lower temperature limits and Maximum and minimum stored energy.

The period of the cycling (i.e. one cycle) shall be one-hour for the water heater.

The water heater may be designed such that it has no real-time clock and can only support a cycling "start-time" of 0 (start now). If a command is received with a start-time that is not equal to zero, the water heater may respond with an Intermediate DR Message response code byte = 0x02 (bad value) and ignore the command.

When the start-time = 0, then the "on"-time of the event shall start immediately (after the start randomization, if used).

Example: the water heater is passed an Autonomous Cycling command of 90% with start-time = 0 and start-randomization not used. The water heater will turn on immediately for 6 minutes, then remain off for the next 54 minutes, then repeat in each successive hour until another control request is received.

Note: This request may be preceded by other requests that result in reducing or minimizing the stored energy in the tank such that there is available storage capacity to allow responding to this duty-cycle request.

The test sequence is shown in Figure 3-11 and detailed in Table 3-11.

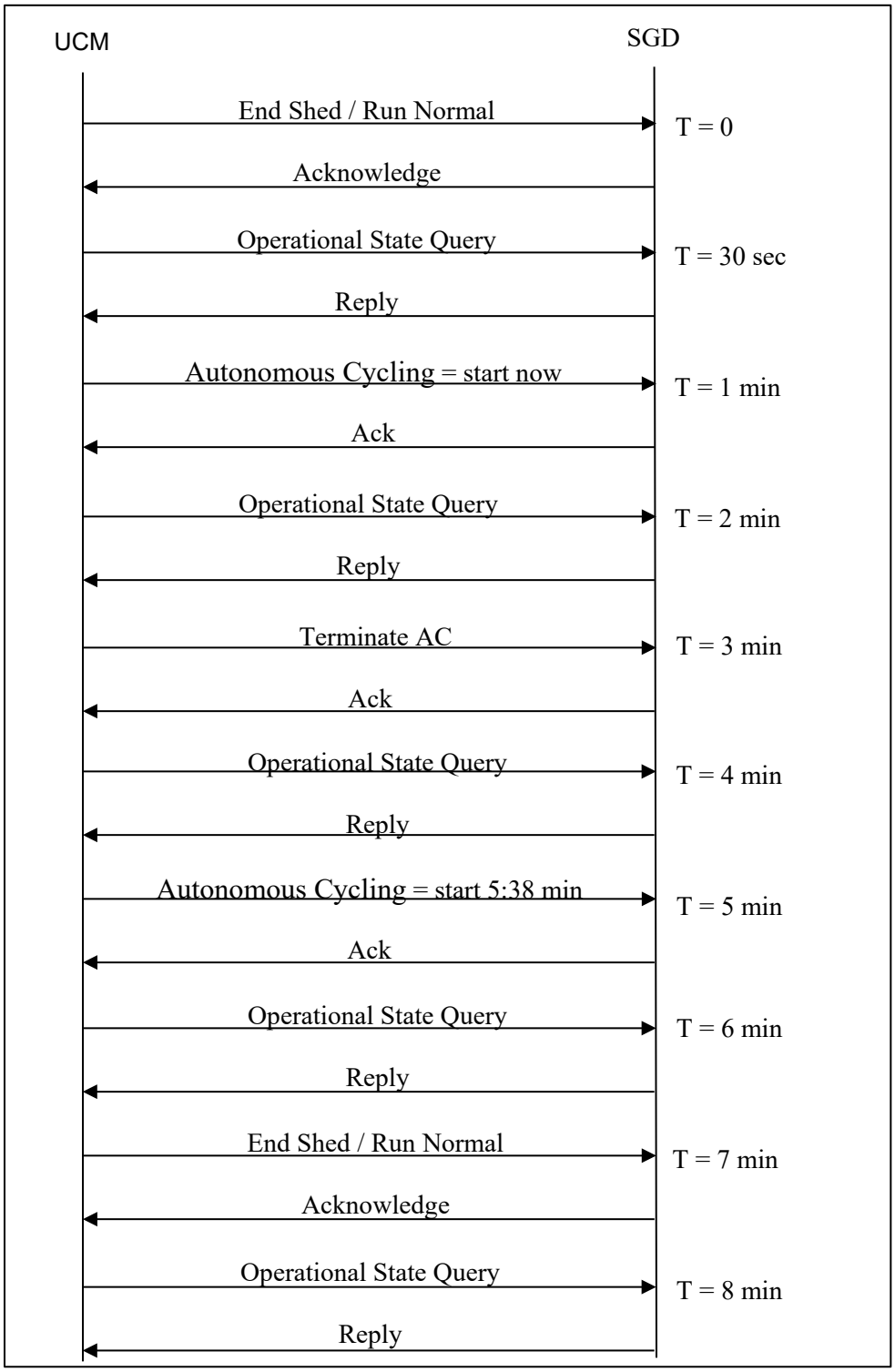


Figure 3-11
REQ.C11 Autonomous Cycling and Terminate Cycling Test Case Sequence

Table 3-11
REQ.C11 Autonomous Cycling and Terminate Cycling Test Case Description

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send the Autonomous Cycle Command: Start Time = start now Duty Cycle = 50% Duration = Maximum (Include opcodes and values) /0x8/0x2/0x0/0xD/0x4/0x0/0x0/0x0/0x0/0x0/0x0/0x1B/0x58/ 0x33/0x22/0xFF/0xFF/0x32/0xCB/0x73	The command will inform the SGD to begin cycling right away with a duty cycle of 50% until the Stop Cycling command is given for that event. The SGD must respond: 0x06/0x00 /0x8/0x2/0x0/0x3/0x4/0x80/ 0x0/0xBB/0x8
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Heightened Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/ 0x3/0xCF/0x64 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send the Stop Cycling command: (Include opcodes and values) 0x8/0x2/0x0/0x6/0x4/0x1/0x0/0x0/0x0/0x0/0x0/0xEB/0x54	The cycling should CTAse. The SGD must respond: 0x06/0x00 0x8/0x2/0x0/0x3/0x4/0x81/0x0/0xB8/0xA

Step	Test Case Description	Required Result
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
	The UCM simulator will respond: 0x06/0x00	
7	Send the Autonomous Cycle Command: Start Time = start now Duty Cycle = 50% Duration = 5 minutes (Include opcodes and values) /0x8/0x2/0x0/0xD/0x4/0x0/0x0/0x0/0x0/0x0/0x0/0x1B/0x58/0x33/0x22/0x5/0x32/0x20/0xC7	The command will inform the SGD to begin cycling right away with a duty cycle of 50% for 5 minutes or until the Stop Cycling command is given for that event. The SGD must respond: 0x06/0x00 /0x8/0x2/0x0/0x3/0x4/0x80/0x0/0xBB/0x8
	The UCM simulator will respond: 0x6/0x00	
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Heightened Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x3/0xCF/0x64 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send the Stop Cycling command: (Include opcodes and values) 0x8/0x2/0x0/0x6/0x4/0x1/0x0/0x0/0x0/0x0/0xEB/0x54	The cycling should CTAse. The SGD must respond: 0x06/0x00 0x8/0x2/0x0/0x3/0x4/0x81/0x0/0xB8/0xA
10	Send an Operational State Query to the SGD	Verify that the SGD is in its normal operational mode

Step	Test Case Description	Required Result
	/0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62

REQ.C12 – Load Up

Loud Up is sent from the UCM to SGD to request that the SGD go to the Maximum level.

This message can be used in conjunction with other curtailment messages such as Shed. The Shed command can be used to maximize the energy storage level of the water heater.

The test sequence is shown in Figure 3-12 and detailed in Table 3-12.

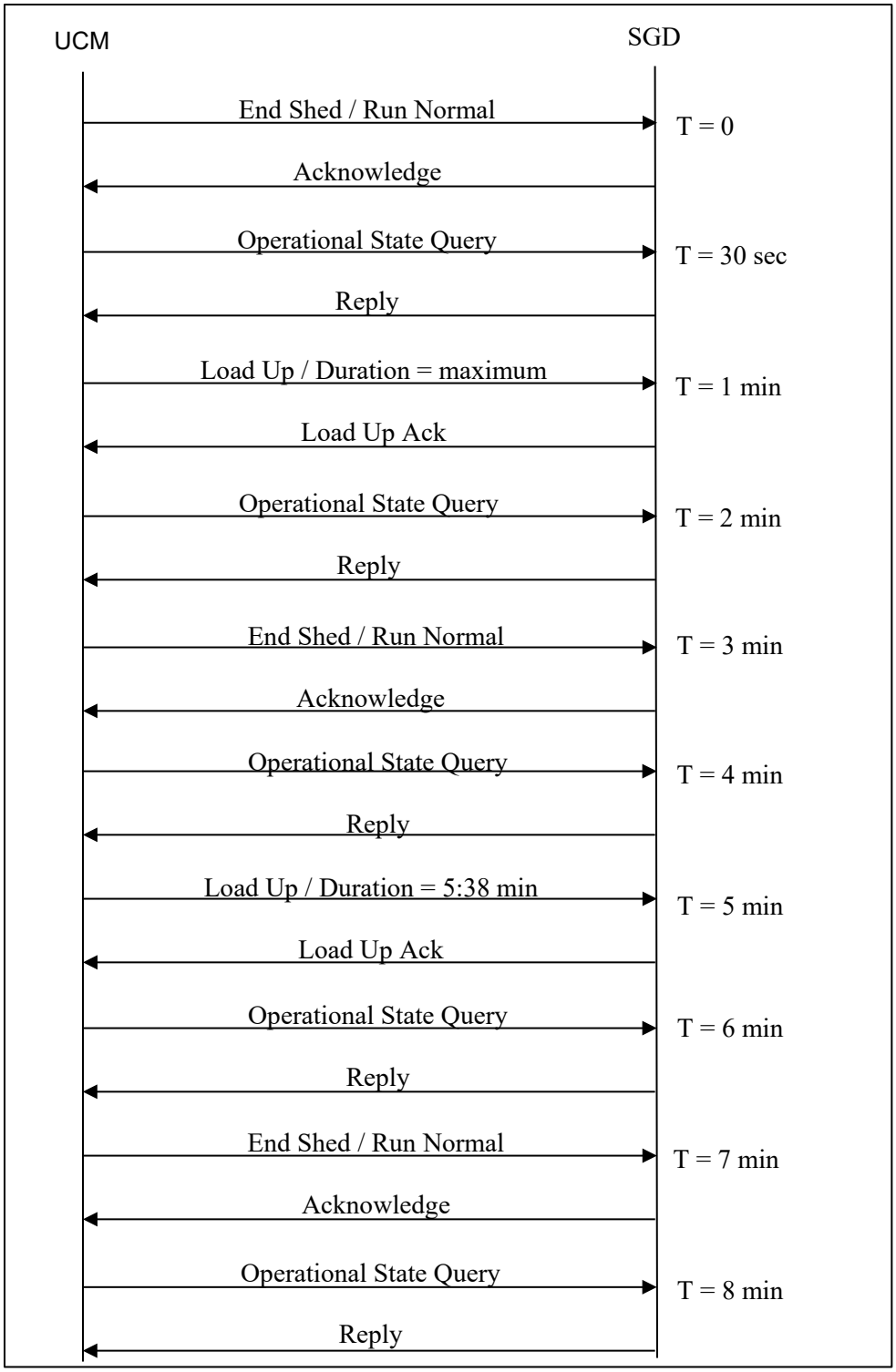


Figure 3-12
REQ.C12 Load Up Test Case Sequence

Table 3-12
REQ.C12 Load Up Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a Load Up command to the SG SGD: Duration = maximum (Include opcodes and values) /0x8/0x1/0x0/0x2/0x17/0xC9/0x69	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x17/0xD7/0x58
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Heightened Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x3/0xCF/0x64 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
	The UCM simulator will respond: 0x06/0x00	
7	Send a Load Up command to the SG SGD:	The command will inform the SGD that the curtailment event has begun.

Step	Test Case Description	Required Result
	Duration = 5:38 (Include opcodes and values) /0x8/0x1/0x0/0x2/0xD/0xC9/0x69	The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x17/0xD7/0x58
	The UCM simulator will respond: 0x6/0x00	
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: "Running Heightened Grid": 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x3/0xCF/0x64 or "Idle Grid" /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
9	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
10	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: "Idle Normal" /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or "Running Normal" /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62

All communications between the UCM and SGD must be logged.

Monitoring Requirements

This section identifies the CTA-2045 monitoring messages that must be supported and the associated water heater usage.

REQ.M1 – Maximum Data Refresh Time

The data update time of the following messages (REQ.M2 – REQ.M6) must be less than 1-second.

REQ.M2 – Customer Override

The water heater must provide consumers with an event override option. If pressed, the water heater must report the override to the UCM using this message. If an override occurs, the water heater shall return to normal operation and ignore any new curtailment messages for the next four hours. The SGD shall also provide a simple mechanism for an override of 24 hours. This could be pressed prior to the receipt of an event (proactively).

The test sequence is shown in Figure 3-13 and detailed in Table 3-13.

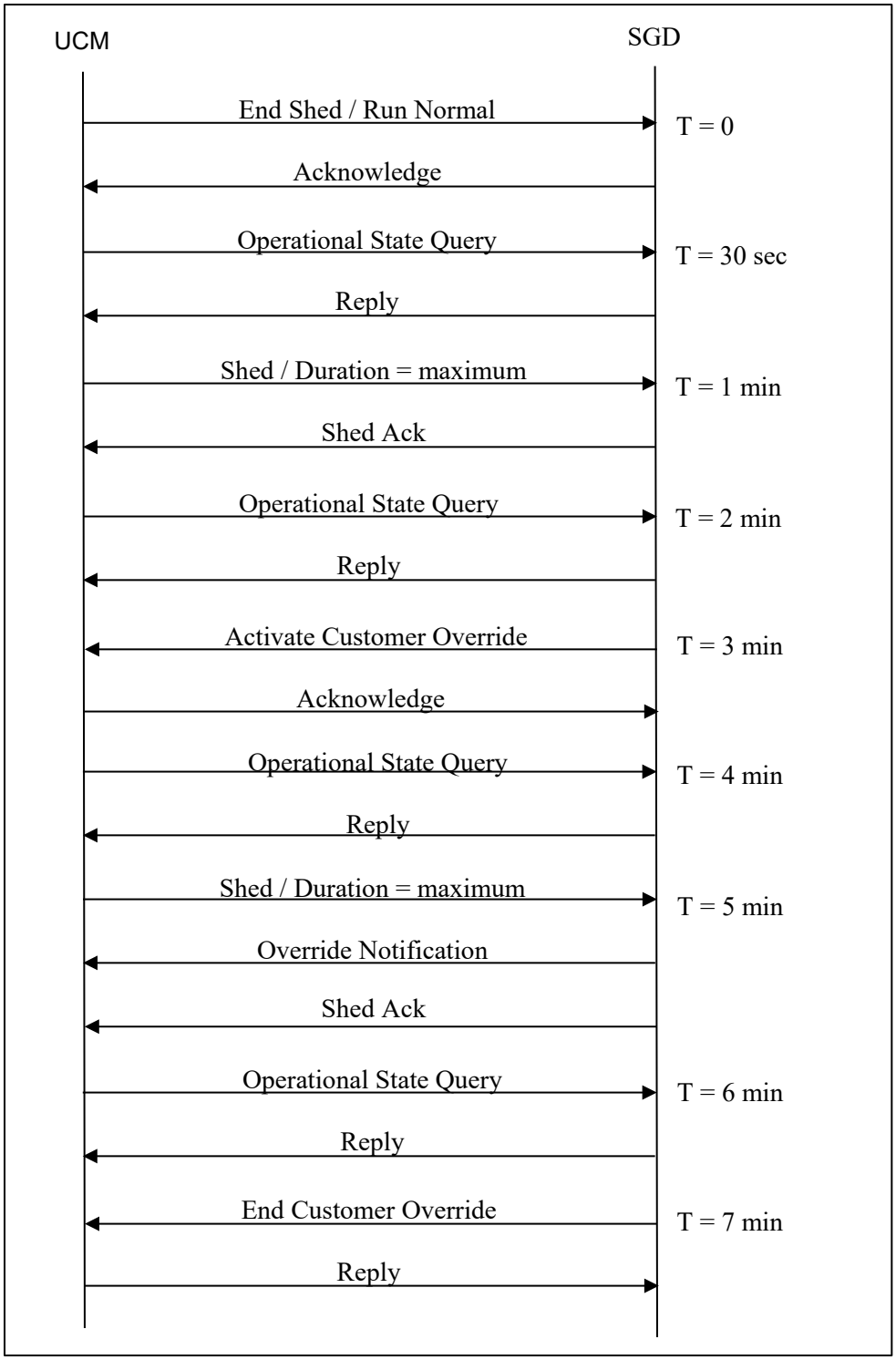


Figure 3-13
REQ.M2 Customer Override Test Case Sequence

Table 3-13
REQ.M2 Customer Override Test Case Steps

Step	Test Case Description	Required Result
1	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
2	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is in its normal operational mode Acceptable responses include: “Idle Normal” /0x8/0x1/0x0/0x2/0x13/0x0/0xD5/0x61 or “Running Normal” /0x8/0x1/0x0/0x2/0x13/0x1/0xD3/0x62
3	Send a shed command to the SG SGD: Duration = maximum (Include opcodes and values) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The command will inform the SGD that the curtailment event has begun. The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x1/0x4/0x42
	The UCM simulator will respond: 0x6/0x00	
4	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is processing the request. Acceptable responses include: “Running Curtailed Grid”: 0x06/0x00 /0x08/0x01/0x00/0x02/0x13/0x02/0xD1/0x63 or “Idle Grid” /0x8/0x1/0x0/0x2/0x13/0x4/0xCD/0x65
	The UCM simulator will respond: 0x06/0x00	
5	Initiate Customer Override	Receive: /0x8/0x1/0x0/0x2/0x11/0x1/0xD9/0x59
	Send: 0x8/0x1/0x0/0x2/0x3/0x11/0xE3/0x52	
6	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is running normal.
	The UCM simulator will respond: 0x06/0x00	
7	Send a shed command to the SG SGD: Duration = maximum	The command will inform the SGD that the curtailment event has begun.

Step	Test Case Description	Required Result
	(Include opcodes and values) /0x8/0x1/0x0/0x1/0xFF/0xC/0x3D	The SGD must respond: 0x06/0x00 0x8/0x1/0x0/0x2/0x3/0x1/0x4/0x42
	The UCM simulator will respond: 0x6/0x00	
	UCM should respond with a message to indicate a customer override.	Receive: /0x8/0x1/0x0/0x2/0x11/0x1/0xD9/0x59
8	Send an Operational State Query to the SGD /0x8/0x1/0x0/0x2/0x12/0x0/0xD8/0x5F	Verify that the SGD is running normal
	The UCM simulator will respond: 0x06/0x00	
9	Send an End Shed / Run Normal command to the SGD	This command is issued to ensure that the SGD is in a normal operating mode
10	End Customer Override	Receive: /0x8/0x1/0x0/0x2/0x3/0x11/0xE3/0x5D
	Send: 0x8/0x1/0x0/0x2/0x3/0x11/0xE3/0x52	

All communications between the UCM and SGD must be logged.

REQ.M3 – Operational State Query & Response

The water heater shall support the operational state query.

This message is part of tests REQ.C6 thru REQ.C12. During these tests, if the water heater responds with the appropriate response, indicate "Pass" in column 4, else indicate "Fail".

Code	Name	Operational State	Pass / Fail
0	Idle Normal	Water heater is not heating, but is in a normal mode of operation	
1	Running Normal	Water heater is in a Normal Operating Mode and the water heater is presently heating (heat pump unit, or any heating elements are energized)	
2	Running Curtailed Grid	Water heater is running in a grid service mode of operation and the water heater is presently heating (heat pump unit, or any heating elements are energized)	
3	Running Heightened Grid	Water heater is processing a Load Up request and water is being heated.	
4	Idle Grid	Water heater is in a grid service operational mode and the units is not heating water.	

Code	Name	Operational State	Pass / Fail
5	SGD Error	Device is malfunctioning. Recommended use: Failure of heat pump or element	
6	Idle Heightened,	Water heater is processing a Load Up request and water is not being heated.	
7	Cycling On	Cycling type of grid service event is in effect and water is being heated (i.e. cycled on)	
8	Cycling Off,	Cycling type of grid service event is in effect and water is NOT being heated (i.e. cycled off)	
9	Variable Following	not applicable	
10	Variable Not Following	not applicable	
11	Idle Opted Out	Water heater is overridden has no/insignificant energy consumption	
12	Running, Opted Out	Water heater is overridden has significant energy consumption	

REQ.M4 – Query & Response: Info Request

Query & Response: Info Request: Water heater shall support, at a minimum, all mandatory device information plus the model number and serial number optional fields associated with the Info Request. It is understood that these fields may be reflective of the controller module rather than being specific to the water heater.

To comply with this requirement, the SGD must support the Device Info command which can be found in the Intermediate DR Application (Message Type = 0x08, 0x02) section. The procedures and the data that should be collected during this test are included below.

The test sequence is shown in Figure 3-14 and detailed in Table 3-14.

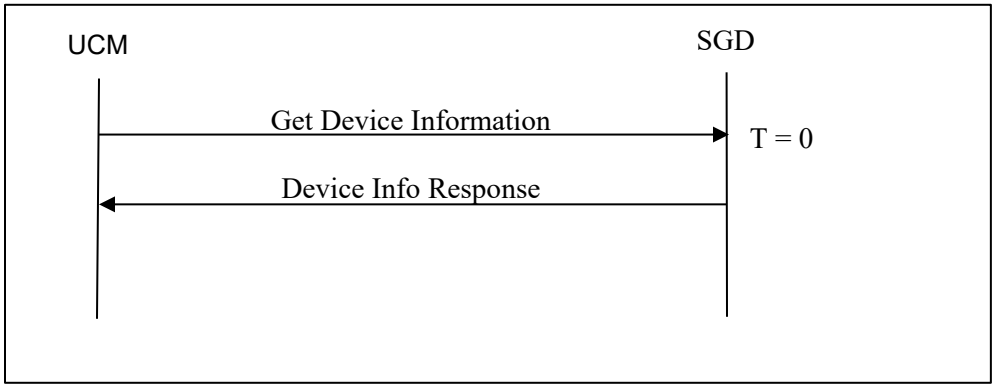


Figure 3-14
REQ.M5 Test Case Sequence

Table 3-14
REQ.M5 Test Case Steps

Step	Test Case Description	Required Result
1	Send a “Get Info Request” from the UCM to SGD	This command should result in the SGD responding with the Device Info data, listed in Table 3-15

Table 3-15
Device Info Data Table

Info Request Byte Range	Info Request Data Field Description	Mandatory / Optional
1	Opcode1	M
2	Opcode2 (Reply always has bit 7 high)	M
3	Response Code	M
4-5	CTA-2045 Version – ASCII*	M
6-7	Vendor ID	M
8-9	Device Type Should be 0x0003 Water Heater- Heat Pump	M
10-11	Device Revision	M
12-15	Capability Bitmap	M
16	Reserved	M
17-32	Model Number – ASCII	O
33-48	Serial Number – ASCII	O
49	Firmware Year – 20YY	O
50	Firmware Month	O
51	Firmware Day	O
52	Firmware Major	O
53	Firmware Minor	O

REQ.M5 – Get/Set Commodity Read Request and Get/Set Commodity Read Reply

Get/Set Commodity Read Request and Get/Set Commodity Read Reply: Water heater shall support the following requests from a UCM:

1. Electric power (present consumption rate) and cumulative lifetime energy consumed. Commodity Code = 0 “Electricity Consumed”
2. Total Energy Storage Capacity Commodity Code = 6
3. Present Energy Storage Capacity Commodity Code = 7

These values can be estimates based on operating state, metering electronics are not required.

The heating elements may vary from model to model or can be replaced after the units are deployed. For power and energy, it is acceptable for these calculations to assume that the heater elements are 4500 W elements.

To comply with this requirement, the SGD must support the Device Info command which can be found in the Intermediate DR Application (Message Type = 0x08, 0x02) section. The procedures and the data that should be collected during this test are included below.

The test sequence is shown in Figure 3-15 and detailed in Table 3-16.

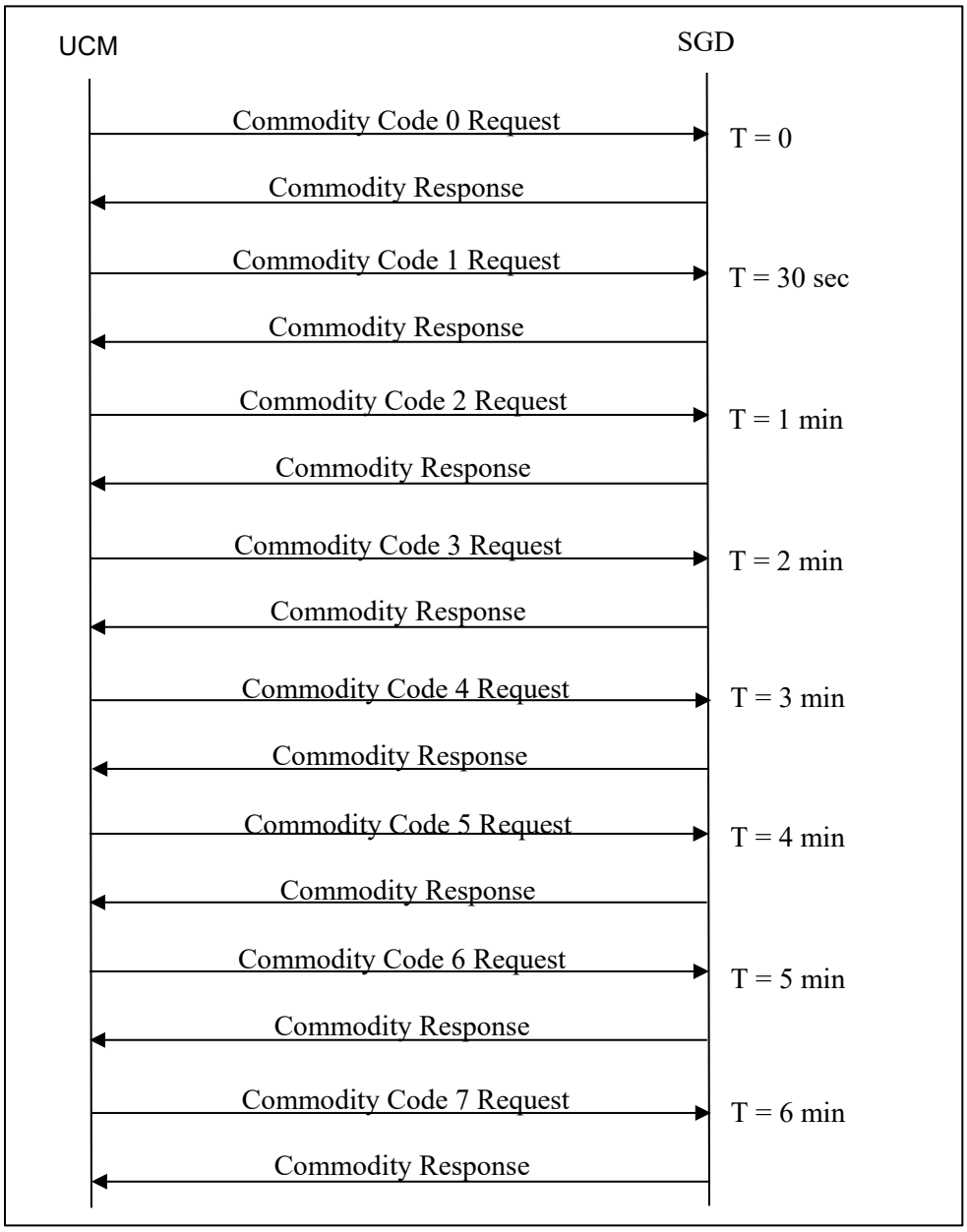


Figure 3-15
REQ.M6 Test Case Sequence

Table 3-16
REQ.M6 Test Case Steps

Step	Test Case Description	Required Result
1	Send “Get Commodity Request” from the UCM to SGD	This command should result in the SGD responding with the supported Commodity data found in Table 3-17. For the decimal data (as opposed to hex), look under the “Device Information > Commodity” tab of the simulator.

Table 3-17
Commodity Code Data Table

Commodity code	Info Request Data Field Description	Instantaneous	Cumulative
0	Electricity Consumed	W	W-hr
1	Electricity Produced	W	W-hr
2	Natural gas	cu-ft/hr	cu-ft
3	Water	Gal/hr	Gallons
4	Natural gas	cubic meters/hour (m^3)	cubic meters (m^3)
5	Water	liters/hr	liters
6	Total Energy Storage Capacity	W	W-hr
7	Present Energy Storage Capacity	W	W-hr
8-15	Reserved		

A
WORKSHEETS

This section is included to aid in the documentation and reporting of the test results.

Table A-1
Summary of Test Results

Requirement	Description	Pass/Fail	Comments
	Mechanical, Electrical Communication and Safety Requirements		
ME1	The water heater shall be a standard 50-gallon resistive type. Standard height/diameter. (Not a low-boy). Insulation/efficiency and other details to be manufacturer-recommended. A 50-gallon 0.93 EF model will be used.		
ME2	The water heater shall be capable of an average of 12 on/off cycles or more per day over its service life.		
ME3	The water heater shall track total on/off cycling and protect itself against excessive cycling based on a total cycles per 100 day period (e.g. not more than 1200 on/off cycles in a 100 day period).		
ME4	The water heater shall be equipped with the AC form factor CTA-2045 port described in Appendix B of the ANSI/CTA-2045-A standard.		
ME5	The water heater will allow space for any communication module up to the maximum size specified by the CTA-2045 standard. Step: Fasten a CTA-2045 test sample that meets all requirements of an AC UCM to the device under test **Did the UCM fit properly** Notes:		
ME6	The water heater shall meet the rating criteria of a standard electric water heater, UL 174, and/or the Canadian equivalent.		

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><td colspan="4">Mechanical, Electrical Communication and Safety Requirements</td></tr>
<tr><td>UI1</td><td>An indicator of successful communication connectedness (based on the CTA “comm status” message)

<table>
<tr><th>Steps</th><th>Notes</th></tr>
<tr><td>What type of indicator is used? (i.e. LED, Text, etc)</td><td></td></tr>
<tr><td>Is this indicator labeled?</td><td></td></tr>
<tr><td>Is there information included in the user manual that describes the purpose of this indicator?</td><td></td></tr>
<tr><td>Does the interface inform the user when the outside communication status command is received (irrelevant of Opcode 2 Lost, Poor, Good status)?

If Yes, document how the user is informed</td><td></td></tr>
<tr><td>Does the interface inform the user when the outside communication status command with Opcode 2 of Lost is received?

If Yes, document how the user is informed</td><td></td></tr>
<tr><td>Does the interface inform the user when the outside communication status command with Opcode 2 of Poor is received?

If Yes, document how the user is informed</td><td></td></tr>
</table></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><td colspan="4">Mechanical, Electrical Communication and Safety Requirements</td></tr>
<tr><td></td><td>
<table>
<tr><td>Does the interface inform the user when the outside communication status command with Opcode 2 of Good is received?

If Yes, document how the user is informed</td><td></td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>UI2</td><td>An indicator of curtailment when there is one in effect.

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>What type of indicator is used? (i.e. LED, Text, etc)</td><td></td></tr>
<tr><td>Is this indicator labeled?</td><td></td></tr>
<tr><td>Is there information included in the user manual that describes the purpose of this indicator?</td><td></td></tr>
<tr><td>Does the indicator inform the user when the product has altered its process state based on the receipt of any of the following commands; shed, CPE, GE, Automatous Cycling or Load Up?

Note: This can be verified when tests for REQ.C7, REQ.C8, REQ.C9, REQ.C11 and REQ.C12 are executed.</td><td></td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>UI3</td><td>An override button the customer can override any current curtailment and prevent future curtailments for a 24-hour period. (Note also monitoring requirement REQ.M2)</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><td colspan="4">Mechanical, Electrical Communication and Safety Requirements</td></tr>
<tr><td></td><td>
<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>Initiate DR Event (see REQ.M2)</td><td></td></tr>
<tr><td>Is this indicator labeled?</td><td></td></tr>
<tr><td>Is there information included in the user manual that describes the purpose of this indicator?</td><td></td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>UI4 (Optional)</td><td>Two user adjustable set points, 1) normal operations and 2) maximum temperature for temporary absorption of energy</td><td></td><td></td></tr>
<tr><td colspan="4">Information Exchange and Response Requirements

Link Layer Requirements</td></tr>
<tr><td>LL1</td><td>Link ACK</td><td></td><td></td></tr>
<tr><td>LL2</td><td>Link NAK
<table>
<tr><th>Code</th><th>Description</th><th>Supported by product (Y/N)</th><th>Notes</th></tr>
<tr><td>Code 1</td><td>Invalid Byte</td><td></td><td></td></tr>
<tr><td>Code 2</td><td>Invalid Length</td><td></td><td></td></tr>
<tr><td>Code 3</td><td>Checksum Error</td><td></td><td></td></tr>
<tr><td>Code 4</td><td>Reserved</td><td></td><td></td></tr>
<tr><td>Code 5</td><td>Message Timeout</td><td></td><td></td></tr>
<tr><td>Code 6</td><td>Unsupported Message Type</td><td></td><td></td></tr>
<tr><td>Code 7</td><td>Request Not Supported</td><td></td><td></td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>LL3</td><td>Query & Response: Maximum Payload Length, In order to support the messages identified herein (Get_Information is the longest), the unit must support negotiation up to 64 bytes message length.</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><th colspan="4">Mechanical, Electrical Communication and Safety Requirements</th></tr>
<tr><td>LL4</td><td>Message Type Supported Query & Response

Must support Basic and Intermediate message types</td><td></td><td></td></tr>
<tr><th colspan="4">Control Requirements</th></tr>
<tr><td>C1</td><td>The water heater logic shall be such that all curtailment requests expire and the water heater returns to the previous customer-chosen mode of operation after 12 hours, unless another curtailment request is received within that time.

<table><tr><th>Curtailment Event</th><th>If an end shed/run normal command is not sent, does the product return to normal operation? (Y/N)</th></tr><tr><td>Shed</td><td></td></tr><tr><td>Loud Up</td><td></td></tr><tr><td>CPE</td><td></td></tr><tr><td>Grid Emergency</td><td></td></tr></table></td><td></td><td></td></tr>
<tr><td>C2</td><td>The water heater logic shall be such that upon power cycle, all operational settings shall return to user-assigned settings. Any state other than the user-assigned settings must be renegotiated.</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><td colspan="4">Mechanical, Electrical Communication and Safety Requirements</td></tr>
<tr><td></td><td><table>
<tr><th>Curtailment Event</th><th>If power is interrupted while processing the curtailment event, did the product return to normal operation after power was restored? (Y/N)</th></tr>
<tr><td>Shed</td><td></td></tr>
<tr><td>Loud Up</td><td></td></tr>
<tr><td>CPE</td><td></td></tr>
<tr><td>Grid Emergency</td><td></td></tr>
</table></td><td></td><td></td></tr>
<tr><td>C3</td><td>The water heater shall support the application ACK as described in the ANSI/CTA-2045-A specification.</td><td></td><td></td></tr>
<tr><td>C4</td><td>The water heater will support the application NAK as described in the ANSI/CTA-2045-A specification.</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><td colspan="4">Mechanical, Electrical Communication and Safety Requirements</td></tr>
<tr><td></td><td>
<table>
<tr><th>Code</th><th>Description</th><th>Supported by product (Y/N)</th><th>Notes</th></tr>
<tr><td>Code 1 (0x00)</td><td>No reason given</td><td></td><td></td></tr>
<tr><td>Code 1 (0x01)</td><td>Opcode1 not supported</td><td></td><td></td></tr>
<tr><td>Code 2 (0x02)</td><td>Opcode2 invalid</td><td></td><td></td></tr>
<tr><td>Code 3 (0x03)</td><td>Busy</td><td></td><td></td></tr>
<tr><td>Code 4 (0x04)</td><td>Length Invalid</td><td></td><td></td></tr>
<tr><td>Code 5 (0x05)</td><td>Customer Override is in effect</td><td></td><td></td></tr>
<tr><td>Code 6 (0x06 to 0xFF)</td><td>Reserved</td><td></td><td></td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>C5</td><td>The water heater must monitor for this “heartbeat” signal. If not received within 15 minutes, the water heater will return to the previous customer-chosen mode of operation.</td><td></td><td></td></tr>
<tr><td>C6</td><td>End Shed/Run Normal: Maintain normal water heater operation, sequences and customer designated set points. Use 120 degrees F as factory default.</td><td></td><td></td></tr>
<tr><td>C7</td><td>Water heater shall allow the stored thermal energy in the tank to reach a “Minimum, limited by consumer comfort” level. This could be accomplished, for example, by not operating the lower element and adjusting the upper temperature set-point to a reduced level.

An end effect of this command (if held in-effect for a long duration) would be to minimize the stored energy in the tank, maximizing the opportunity to dispatch the device with minimal impact to customers.</td><td></td><td></td></tr>
</table>

Requirement	Description	Pass/Fail	Comments
	Mechanical, Electrical Communication and Safety Requirements		
C8	Critical Peak Events are typically used as part of fixed-incentive based programs and require a predictable response. These Events are typically infrequent (only a few times a year) so responses are more aggressive. Water heater will act to reduce the stored thermal energy in the tank to the Minimum storage level, limited by consumer comfort. Because this message is used for infrequent events, and usually associated with very high prices or incentives, the manufacturer may elect to be more aggressive in response.		
C9	During an emergency event, the water heater shall immediately shutdown, not heating water until the event has ended. For Grid Emergencies, the water heater may time out and resume operation after one hour.		
C10	Present Relative Price (Optional)		
C11	The period of the cycling (i.e. one cycle) shall be one-hour for the water heater. The water heater may be designed such that it has no real-time clock and can only support a cycling “start-time” of 0 (start now). If a command is received with a start-time that is not equal to zero, the water heater may respond with an Intermediate DR Message response code byte = 0x02 (bad value) and ignore the command. When the start-time = 0, then the “on”-time of the event shall start immediately (after the start randomization, if used).		
C12	Loud Up is sent from the UCM to SGD to request that the SGD go to the Maximum level.		
	Monitoring/Feedback		
M1	The data update time of the following messages (REQ.M2 – REQ.M6) must be less than 1-second.		

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><th colspan="4">Mechanical, Electrical Communication and Safety Requirements</th></tr>
<tr><td>M2</td><td>The water heater must provide consumers with an event override option. If pressed, the water heater must report the override to the UCM using this message. If an override occurs, the water heater shall return to normal operation and ignore any new curtailment messages for the next four hours. The SGD shall also provide a simple mechanism for an override of 24 hours. This could be pressed prior to the receipt of an event (proactively).</td><td></td><td></td></tr>
<tr><td>M3</td><td>The water heater shall support the operational state query.
<table>
<tr><th>Code</th><th>Name</th><th>Operational State</th><th>Pass / Fail</th></tr>
<tr><td>0</td><td>Idle Normal</td><td>Water heater is not heating, but is in a normal mode of operation</td><td></td></tr>
<tr><td>1</td><td>Running Normal</td><td>Water heater is in a Normal Operating Mode and the water heater is presently heating (heat pump unit, or any heating elements are energized)</td><td></td></tr>
<tr><td>2</td><td>Running Curtailed Grid</td><td>Water heater is running in a grid service mode of operation and the water heater is presently heating (heat pump unit, or any heating elements are energized)</td><td></td></tr>
<tr><td>3</td><td>Running Heightened Grid</td><td>Water heater is processing a Load Up request and water is being heated.</td><td></td></tr>
<tr><td>4</td><td>Idle Grid</td><td>Water heater is in a grid service operational mode</td><td></td></tr>
</table></td><td></td><td></td></tr>
</table>

Requirement	Description				Pass/Fail	Comments
	Mechanical, Electrical Communication and Safety Requirements					
			and the units is not heating water.			
	5	SGD Error	Device is malfunctioning. Recommended use: Failure of heat pump or element			
	6	Idle Heightened,	Water heater is processing a Load Up request and water is not being heated.			
	7	Cycling On	Cycling type of grid service event is in effect and water is being heated (i.e. cycled on)			
	8	Cycling Off,	Cycling type of grid service event is in effect and water is NOT being heated (i.e. cycled off)			
	9	Variable Following	not applicable			
	10	Variable Not Following	not applicable			
	11	Idle Opted Out	Water heater is overridden has no/insignificant energy consumption			
	12	Running, Opted Out	Water heater is overridden has significant energy consumption			
M4	Query & Response: Info Request: Water heater shall support, at a minimum, all mandatory device information plus the model number and serial number optional fields associated with the Info Request. It					

is understood that these fields may be reflective of the controller module rather than being specific to the water heater.

Info Request Byte Range	Info Request Data Field Description	Mandatory / Optional	Value / Notes
1	Opcode1	M	
2	Opcode2 (Reply always has bit 7 high)	M	
3	Response Code	M	
4-5	CTA-2045 Version – ASCII*	M	
6-7	Vendor ID	M	
8-9	Device Type Should be 0x0003 for Water Heater – Heat Pump	M	
10-11	Device Revision	M	

<table>
<tr><th>Requirement</th><th colspan="4">Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><td colspan="7">Mechanical, Electrical Communication and Safety Requirements</td></tr>
<tr><td></td><td colspan="4"><table>
<tr><td>12-15</td><td>Capability Bitmap</td><td>M</td><td></td></tr>
<tr><td>16</td><td>Reserved</td><td>M</td><td></td></tr>
<tr><td>17-32</td><td>Model Number – ASCII</td><td>O</td><td></td></tr>
<tr><td>33-48</td><td>Serial Number – ASCII</td><td>O</td><td></td></tr>
<tr><td>49</td><td>Firmware Year – 20YY</td><td>O</td><td></td></tr>
<tr><td>50</td><td>Firmware Month</td><td>O</td><td></td></tr>
<tr><td>51</td><td>Firmware Day</td><td>O</td><td></td></tr>
<tr><td>52</td><td>Firmware Major</td><td>O</td><td></td></tr>
<tr><td>53</td><td>Firmware Minor</td><td>O</td><td></td></tr>
</table></td><td></td><td></td></tr>
<tr><td>M6</td><td colspan="4">Get/Set Commodity Read Request and Get/Set Commodity Read Reply: Water heater shall support the following requests from a UCM:

1) Electric power (present consumption rate) and cumulative lifetime energy consumed. Commodity Code = 0 “Electricity Consumed”
2) Total Energy Storage Capacity Commodity Code = 6
3) Present Energy Storage Capacity Commodity Code = 7</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Requirement</th><th>Description</th><th>Pass/Fail</th><th>Comments</th></tr>
<tr><th colspan="4">Mechanical, Electrical Communication and Safety Requirements</th></tr>
<tr><td></td><td>These values can be estimates based on operating state, metering electronics are not required.

<table>
<tr><th>Commodity code</th><th>Info Request Data Field Description</th><th>Instantaneous Reading Units (W)</th><th>Cumulative Reading Units (W-h)</th></tr>
<tr><td>0</td><td>Electricity Consumed</td><td></td><td></td></tr>
<tr><td>6</td><td>Total Energy Storage Capacity</td><td>N/A</td><td></td></tr>
<tr><td>7</td><td>Present Energy Storage Capacity</td><td>N/A</td><td></td></tr>
</table>
</td><td></td><td></td></tr>
</table>

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