ADDENDA

ANSI/ASHRAE Addendum k to
ANSI/ASHRAE Standard 135.1-2011

Method of Test for Conformance to BACnet®

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[This foreword and the "rationale" on the following page are not part of this standard. They are merely informative and do not contain requirements necessary for conformance to the standard.]

FOREWORD

Addendum *k* to ANSI/ASHRAE Standard 135.1-2011 contains a number of changes to the current standard. These modifications are the result of change proposals made pursuant to the ASHRAE continuous maintenance procedures and of deliberations within Standing Standard Project Committee 135. The proposed changes are summarized below.

135.1-2011*k*-1. Manual MS/TP Tests, p. 1.

In the following document, language to be added to existing clauses of ANSI/ASHRAE 135.1-2011 and Addenda is indicated through the use of *italics*, while deletions are indicated by ~~strikethrough~~. Where entirely new subclauses are proposed to be added, plain type is used throughout.

135.1-2011*k*-1. Manual MS/TP Tests.

Rationale

The existing MS/TP tests are not usable without a test tool that implements them. This addendum adds in a set of MS/TP tests that can be applied without such a custom test tool.

[Add new **Clause 12.1.X**, p. 464]

12.1.X MS/TP Data Link Layer Tests

This clause defines tests that can be applied without a specialized MS/TP testing tool.

12.1.X.1 Test Environment

12.1.X.1.1 Test Setup

In these tests the TD is installed on the non-MS/TP side of a router and therefore the tests do not cover strict conformance to the MS/TP data link layer.

These tests require the use of an MS/TP router and an MS/TP master device.

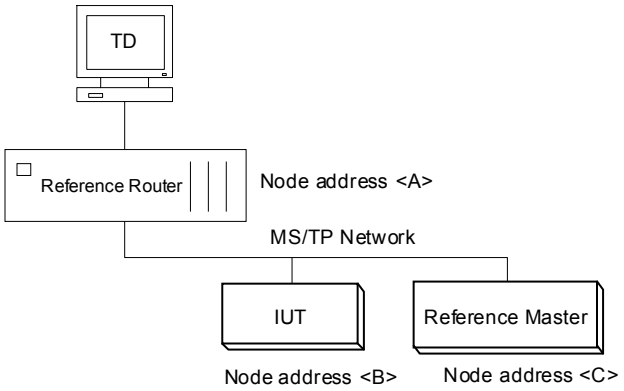


Figure 12-X. General MS/TP Test Network Setup.

The MS/TP node addresses are not critical, but must meet these requirements:

<A> = 0
<B> = <A> + 2 or higher (this address changes during testing)
<C> = <B> + 2 or higher

12.1.X.1.2 Serial Analyzer

Some of the tests specify the use of a serial analyzer for measuring characteristics of communication signals on the MS/TP cabling.

When measuring the silence time between MS/TP frames, the desired measurement is the elapsed time from the last bit transmitted of the first frame to the first bit transmitted in the following frame. When using a serial analyzer that applies a time stamp to each octet, taking the difference between the time stamps introduces an error equal to the transmission time of one octet because the difference between the time stamps is actually the elapsed time from the last bit of the last octet of the first frame to the last bit (not the first bit) of the first octet in the following frame.

The tests require that the serial analyzer used is accurate to the nearest millisecond and thus the tests assume that all measurements are ± 1 millisecond. As a result of these measurement inaccuracies, all measurements of silence time between frames where the silence time is required to be less than a specified amount are allowed to be as much as 2 milliseconds greater than the specified limit, and all measurements of silence time between frames that must be greater than a specified amount are allowed to be as much as 1 millisecond less than the specified limit. The following terms are defined to represent these measurement tolerances:

$\mathbf{T}_{pos\_err}$ = 2 milliseconds
$\mathbf{T}_{neg\_err}$ = 1 millisecond

12.1.X.1.3 Other Test Equipment

Some of the tests require the verification of inter-bit timings that are not normally available from serial analyzers. The tester is responsible for choosing appropriate testing equipment for these measurement tasks (logic analyzer, oscilloscope, etc.).

12.1.X.2 Verify $\mathbf{T}_{postdrive}$

Purpose: Verify that the time between the transmission of the last bit in a frame and the time that the IUT stops driving its EIA-485 transmitter is 15 bit times or less.

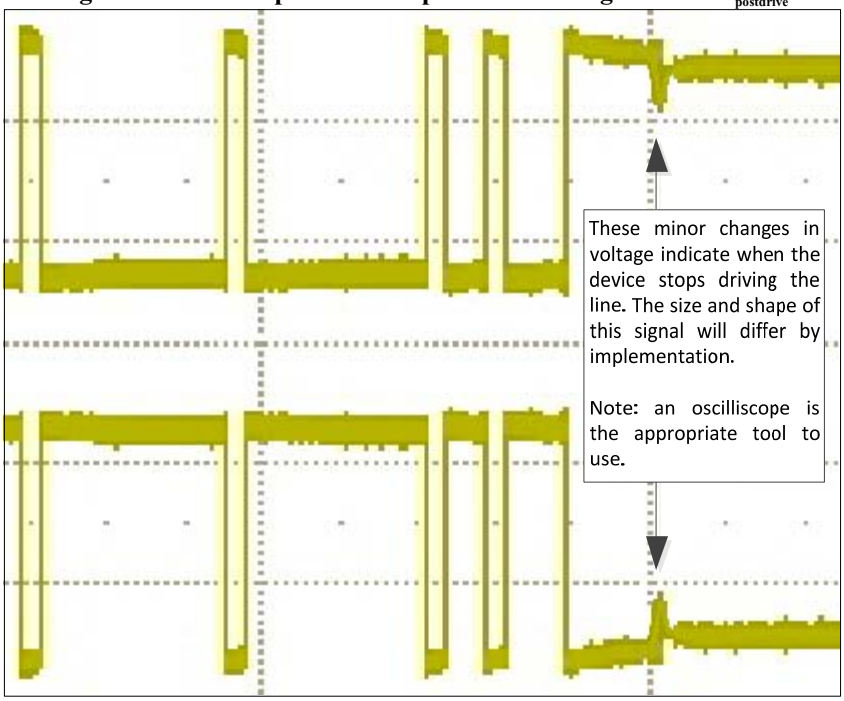
Configuration Requirements: Connect an oscilloscope to the MS/TP network.

Test Steps:

1. Elicit the transmission of any frame type from the IUT. For IUTs that are master nodes, any Token frame or Poll For Master frame is satisfactory. For IUTs that are slave nodes, send any request to the slave node that elicits a response frame from the slave.
2. Measure the time interval from the trailing edge of the last stop bit transmitted by the IUT to the time that the EIA-EIA-485 voltage levels returns to idle. If the IUT employs a "padding" octet of X'FF' as the last octet of every frame, then the time shall be measured from the trailing edge of the stop bit of the octet that precedes the X'FF' "pad" octet.
3. Fail the IUT if the time interval measured in step 2 is greater than the time intervals shown below for each baud rate.

9600 baud:	fail if interval is greater than 1,562 microseconds
19200 baud:	fail if interval is greater than 781 microseconds
38400 baud:	fail if interval is greater than 391 microseconds
57600 baud:	fail if interval is greater than 260 microseconds
76800 baud:	fail if interval is greater than 195 microseconds
115200 baud:	fail if interval is greater than 130 microseconds
x baud:	fail if interval is greater than (15/x) seconds

Figure 12-X: Example oscilloscope trace showing effect of $T_{postdrive}$



Notes to Tester: Note that temporarily using non-standard termination or bias can exaggerate the "minor changes in voltage" indicated in Figure 12-X.

12.1.X.3 Verify T_{frame_gap}

Purpose: Verify that the maximum idle time between data octets when transmitting a frame is 20 bit times or less.

Test Steps:

1. Elicit the transmission of any data frame from the IUT.
2. Measure the longest EIA-485 idle time that appears between octets within the data frame transmitted by the IUT. If there is no idle time between octets, pass the IUT.
3. Fail the IUT if the time measured in step 2 is greater than the time intervals shown below for each baud rate.

9600 baud:	fail if interval is greater than 2,083 microseconds
19200 baud:	fail if interval is greater than 1,042 microseconds
38400 baud:	fail if interval is greater than 521 microseconds
57600 baud:	fail if interval is greater than 347 microseconds
76800 baud:	fail if interval is greater than 261 microseconds
115200 baud:	fail if interval is greater than 173 microseconds
x baud:	fail if interval is greater than (20/x) seconds

12.1.X.4 Verify $T_{turnaround}$

Purpose: Verify that the IUT waits at least 40 bit times before enabling its EIA-485 transmitter after the reception of the last octet of a frame.

Test Steps:

1. Elicit the transmission of any frame type from the IUT. For IUTs that are master nodes, any frame sent after the IUT receives a Token frame or a Poll For Master frame shall be satisfactory. For IUTs that are slave nodes, send any request to the slave node that elicits a response frame from the slave.
2. Measure the time interval from the trailing edge of the last stop bit in the frame transmitted by the reference master, to the point where the EIA-485 voltage becomes driven by the IUT at the beginning of the frame transmitted by the

IUT. If the reference master employs a "padding" octet of X'FF' as the last octet of every frame, then the time shall be measured starting from the trailing edge of the stop bit of the octet that precedes the X'FF' "pad" octet in the frame transmitted by the reference master.

3. Fail the IUT if the time measured in step 2 is less than the time intervals shown below for each baud rate.

9600 baud:	fail if interval is less than 4,167 microseconds
19200 baud:	fail if interval is less than 2,083 microseconds
38400 baud:	fail if interval is less than 1,042 microseconds
57600 baud:	fail if interval is less than 694 microseconds
76800 baud:	fail if interval is less than 521 microseconds
115200 baud:	fail if interval is less than 347 microseconds
x baud:	fail if interval is less than (40/x) seconds

12.1.X.5 Verify T_{reply_delay}

Purpose: Verify that the time between a DER frame sent to the IUT and the first octet of a reply frame or Reply Postponed frame from the IUT is no longer than 250 milliseconds.

Note to Tester: The 250 millisecond time limit can be stressed by making a DER request which requires a large packet (a packet size approaching the maximum length supported by the device) to be sent in response. For example, a ReadPropertyMultiple request, if supported, for several properties or for "all" from the device object could require the IUT to construct and issue a large packet in response.

Test Steps:

1. MAKE (IUT turned on or otherwise started)
2. VERIFY (any supported property) = (any valid value)
3. CHECK (Did the IUT transmit a type 6 or type 7 frame immediately after the type 5 frame?)
4. CHECK (Is the time difference between the last octet of the type 5 frame and the first octet of the type 6 or 7 frame sent by the IUT less than 250 milliseconds?)

12.1.X.6 Verify T_{usage_delay} After a Token w/ Serial Analyzer

Purpose: This test verifies that the IUT begins using the Token within 15 millseconds of receiving the last octet of a Token frame.

Procedure for Token tests:

1. MAKE (IUT turned on or otherwise started)
2. MAKE (MS/TP master device turned on or otherwise started)
3. CHECK (Is the time difference between the last octet of any type 0 frame (Token) sent by the master device and the first octet transmitted by the IUT less than 15 millseconds?)

12.1.X.7 Verify T_{usage_delay} After a Poll For Master w/ Serial Analyzer

Purpose: This test verifies that the IUT begins using the Token within 15 millseconds of receiving the last octet of a Poll For Master frame.

Test Steps:

1. MAKE (IUT turned on or otherwise started)
2. CHECK (Is the IUT transmitting type 1 frames (Poll For Master)?)
3. MAKE (second MS/TP master device turned on or otherwise started)
4. WAIT (until the second MS/TP master device sends a type 1 frame (Poll For Master) to the IUT)
5. CHECK (Did the IUT respond with a type 2 frame (Reply To Poll For Master)?)
6. CHECK (Is the time difference between the last octet of any type 1 frame sent to the IUT and the first octet transmitted by the IUT less than 15 millseconds?)

12.1.X.8 Verify N_{poll} w/ Serial Analyzer

Purpose: Verify that the number of Token frames that the IUT sends between Poll For Master cycles is between 50 and 52.

Configuration Requirements: Separate the addresses of the master devices enough so that both devices shall transmit Poll For Master frames. The reason for this is that the MS/TP master nodes shall not begin a Poll For Master cycle if the next device is the device + 1.

Test Steps:

1. MAKE (IUT turned on)
2. WAIT (several seconds)
3. MAKE (serial analyzer turned on to capture traffic)
4. WAIT (10 seconds)
5. MAKE (Pause the serial analyzer.)
6. CHECK (The number of Token frames that the IUT sends between Poll For Master cycles is between 50 and 52.)

12.1.X.9 Verify $T_{usage\_timeout}$ w/ Serial Analyzer

Purpose: Verify that the IUT waits at least 20 milliseconds but no longer than 100 milliseconds for another master node to begin using the Token or reply to a Poll For Master frame.

Configuration Requirements: Set up the devices such that the IUT is addressed at 1 greater than the address of the other master device.

Test Steps:

1. MAKE (Power on both devices.)
2. WAIT (several seconds)
3. VERIFY (Has Token passing been established between the devices?)
4. MAKE (Power off the other master device, but not the IUT.)
5. WAIT (10 seconds)
6. MAKE (Stop the data capture.)
7. CHECK (Did the IUT send a type 0 frame to the other master, and, when the other master did not use the Token (because it was powered off), did the IUT follow the type 0 frame with one type 0 frame (Token retry) followed by a series of type 1 frames?)
8. CHECK (Is the time difference between the last octet of the type 0 frame sent by the IUT and the first octet of the immediately following type 1 frame transmitted by the IUT greater than 20 millseconds - T_{neg_err} and less than 100 millseconds + T_{pos_err}?)
9. CHECK (Is the time gap (last character to first character) between any two type 1 frames (Poll For Master) sent by the IUT greater than 20 millseconds - T_{neg_err}, but less than 100 millseconds + T_{pos_err}?)

12.1.X.10 Max_Master Test

Purpose: Verify that Max_Master is writable, or that it is 127.

Configuration Requirements: The IUT shall be configured with an MS/TP MAC address less than 127.

Test Steps:

1. VERIFY Max_Master = (any valid value, V1)
2. IF Max_Master is writable THEN
   WRITE Max_Master = (any other valid value, with V2 greater than or equal to the IUT's address)
3. ELSE
   VERIFY Max_Master = 127

12.1.X.11 Max_Info_Frames Test

Purpose: Verify that Max_Info_Frames is configurable, or that it is 1.

Test Steps:

1. VERIFY Max_Info_Frames = (any valid value)

2. IF Max_Info_Frames is writable THEN
   WRITE Max_Info_Frames = (any valid value, V)
   VERIFY Max_Info_Frames = V
   ELSE IF Max_Info_Frames is configurable THEN
   MAKE (Max_Info_Frames equal any valid value, V)
   VERIFY Max_Info_Frames = V
   ELSE
   VERIFY Max_Info_Frames = 1

12.1.X.12 Master Node Data Frame Test

Purpose: Verify that the IUT can properly receive and transmit simple MS/TP data frames.

Test Steps:

1. If the IUT supports DM-DDB-B, perform test 135.1, Clause 9.33.2.2 (Who-Is, General Inquiry, Remote Broadcast) on the IUT and verify the I-Am response. (This tests for proper reception of MS/TP broadcasts and transmission of MS/TP broadcasts.)
2. Perform a ReadProperty of any property (135.1, Clause 9.18.1) to verify correct reception and transmission of unicast messages.

12.1.X.13 Poll For Master w/ Serial Analyzer

Purpose: This tests that a master node performs the Poll For Master sequence properly.

Configuration Requirements: Configure the reference router at address <A>, the reference master at address <C>, and the IUT at address <B> where <A> is not zero, <B> is equal to <A>+2, and <B> is less than <C>-1. Start with the IUT powered off.

Test Steps:

1. MAKE (Power on the IUT.)
2. CHECK (Verify that the IUT responds to Poll For Master requests from <A>.)
3. CHECK (Verify that the IUT periodically transmits Poll For Master frames to nodes <B> + 1 through <C> -1 and that it only transmits one Poll For Master request to node <C>.).
4. MAKE (Change the IUT's address to <C> - 1 and power cycle the device.)
5. CHECK (Verify that the IUT sends one Poll For Master frame to node <C> and then ceases to transmit any Poll For Master frames.)
6. MAKE (Power off the reference master at address <C>.)
7. MAKE (Power off the IUT.)
8. MAKE (Power on the IUT so that the IUT and reference router are the only nodes on the network.)
9. CHECK (Verify that the IUT periodically transmits Poll For Master frames to nodes <B> + 1 through its own Max_Master setting and nodes zero through <A> -1 and that it only sends one Poll For Master to node <A>.)
10. MAKE (Power off the IUT. Set its address <B> equal to its own Max_Master setting. Power on the IUT.)
11. CHECK (Verify that the IUT periodically transmits Poll For Master frames to nodes zero through node <A> - 1 and that it only sends one Poll For Master to node <A>.)

12.1.X.14 Slave Node Data Frame Test

Purpose: This test verifies that the IUT can properly receive and transmit simple MS/TP data frames.

Test Steps:

1. If the IUT supports DM-TS-B, send a Remote Broadcast TimeSynchronization service and verify the time change in the IUT Device Object. (This tests for proper reception of MS/TP broadcasts in a slave device.)
2. Perform a ReadProperty of any property (135.1, Clause 9.15.1) to verify correct reception and transmission of unicast messages.

12.1.X.15 Sole Master Test

Purpose: This test verifies that the IUT properly initiates Poll For Master frames when it is the only node installed on the network.

Configuration Requirements: Power off all of the nodes on the MS/TP network, including the IUT. The node address of the IUT can be set to any address 0 through 127, but it shall be less than or equal to its own Max_Master property. The IUT node address shall be referred to as address <B>.

Test Steps:

1. MAKE (Power on the IUT.)
2. WAIT (until the IUT finishes initializing)
3. CHECK (that the IUT starts transmitting Poll For Master frames, starting with address <B>+1, continues through address Max_Master, and then addresses 0 through <B>-1)
4. CHECK (that the Poll For Master cycle repeats)
5. CHECK (that the IUT sends no more than 50 * Max_Info_Frames between successive Poll For Master cycles)

Notes to Tester: This test shall be skipped if the device requires that there be MS/TP activity from which it will determine the baud rate to use.

In step 5, it is acceptable for devices claiming a Protocol_Revision less than 5 to send 52 sets of Max_Info_Frames between Poll For Master cycles.

12.1.X.16 MS/TP Network Startup Tests (IUT power on Variation)

Purpose: Verify that the IUT can join a preexisting MS/TP network when the IUT is introduced into the MS/TP network from a power-on scenario.

Test Concept: A network of reference masters is constructed and is turned on with the IUT remaining off. Once the network achieves normal network operation, the IUT is connected to the network and powered on. The network is monitored to verify that the IUT successfully joins the network within a reasonable time period.

This test shall be performed both with a single reference master and with multiple reference masters.

Configuration Requirements: The test starts with an MS/TP network comprised of one or more reference master devices that has achieved normal network operation. If the IUT does not autobaud, then it shall be configured with the same baud rate of the operating network. The IUT shall be configured with a valid MAC address (0-127) which is not in use by any of the other devices on the network and is less than the Max_Master value in use by the reference masters. The IUT shall be configured with the same Max_Master in use by the other master devices.

Test Steps:

1. MAKE (Power on or otherwise start the IUT.)
2. CHECK (the IUT does not generate any packets until it receives a Poll For Master frame)
3. CHECK (Verify that the IUT correctly joins the MS/TP network by answering a Poll For Master destined for its MAC address, accepting a Token, and generating Poll For Master frames and subsequently passing the Token.)

Passing Result: Note that the IUT may take a considerable amount of time before accepting Poll For Master frames. The duration of the CHECK in step 3 shall be a sufficient duration for the IUT as defined by the vendor.

12.1.X.17 MS/TP Network Startup Tests (IUT's wire connected)

Purpose: To verify that the IUT can, after powering on and declaring Sole Master, successfully join an established MS/TP network.

Test Concept: A network of reference masters is constructed and is turned on with the IUT disconnected. Once the network achieves normal network operation, the IUT is powered on. Once the IUT reaches the Sole Master state, the IUT is connected to the network. The network is monitored to verify that the IUT successfully joins the network within a reasonable time period.

This test shall be performed both with a single other master device and with multiple master devices.

Configuration Requirements: The test starts with an MS/TP network comprised of one or more reference master devices that has achieved normal network operation. If the IUT does not autobaud, then it shall be configured with the baud rate of the operating network. The IUT shall be configured with a valid MAC address (0-127) which is not in use by any of the other devices on the network and is less than the Max_Master value in use by the other masters. The IUT shall be configured with the same Max_Master as is used by the other master devices.

If the IUT lurks until it detects traffic after power on, then this test shall be skipped. For this test, Time_to_join in step 5 is 60 Seconds. The exact time for a device to join is dependent on implementation and the sequence of events that follow the joining of two live networks. The time shall be the sum of the time duration of collisions, the time to start a Poll For Master cycle, and the time to poll and receive a response from the other master. (This total time cannot be calculated because the standard does not specify how often the master node state machine must be run—only that timers must have a 5ms resolution. Moreover, it is possible that the master node could be sending out data frames in between each Poll For Master.)

Test Steps:

1. MAKE (Power on or otherwise start the IUT without the MS/TP wire connected to the IUT.)
2. WAIT (a vendor specified time (for device startup and/or auto-baud completion))
3. CHECK (Verify that the IUT generates Poll For Master frames.)
4. MAKE (Connect the IUT to the MS/TP network.)
5. CHECK (Did the IUT join the MS/TP network within Time_to_join seconds?)

12.1.X.18 MS/TP Network Startup Tests (IUT's wire disconnected)

Purpose: To verify that the IUT can, after disconnecting from a network and declaring Sole Master, successfully rejoin an established MS/TP network.

Test Concept: A network of master devices is constructed and is turned on with the IUT connected. Once the network achieves normal network operation, the IUT is disconnected from the network. Once the IUT reaches the Sole Master state, the IUT is re-connected to the network. The network is monitored to verify that the IUT successfully rejoins the network within a reasonable time period.

This test shall be performed both with a single other master device and with multiple other master devices.

Configuration Requirements: The test starts with an MS/TP network comprised of one or more other master devices and the IUT that has achieved normal network operation. If the IUT does not autobaud, then it shall be configured with the baud rate of the operating network. The IUT shall be configured with a valid MAC address (0-127) which is not in use by any of the other devices on the network and is less than the Max_Master value in use by the other master devices on the network.

The time, Time_to_join, in step 6 is 60 Seconds. The exact time is dependant on implementation and the sequence of events that follow the joining of two live networks. The time shall be the sum of the time duration of collisions, the time to start a Poll For Master cycle, and the time to poll and receive a response from the other master. (This total time cannot be calculated as the standard does not specify how often the master node state machine must be run—only that timers must have a 5ms resolution. Moreover, it is possible that the master node could be sending out data frames in between each Poll For Master.)

Note that if the IUT possesses the Token before step 2, the wait time in step 3 shall be significantly less than the time indicated. The time between step 2 and step 5 shall only be long enough to perform step 4 because some devices may revert back to lurking if separated from the network for too long.

Test Steps:

1. CHECK (that the IUT is actively in the network)
2. MAKE (Disconnect the IUT from the MS/TP network.)
3. WAIT ($\mathbf{T}_{no\_token} + \mathbf{T}_{slot} * TS$)
4. CHECK (that the IUT generates Poll For Master frames and therefore declares Sole Master)
5. MAKE (Connect the IUT to the MS/TP network.)
6. CHECK (Verify that the IUT joins the MS/TP network within Time_to_join seconds.)

12.1.X.19 MS/TP Network Startup Tests (Reference device joins the MS/TP network)

Purpose: Verify that the IUT behaves correctly when devices are introduced into working MS/TP networks, both when the IUT is a Sole Master, and when multiple masters are present.

Configuration Requirements: Reference Master B shall be configured with a MAC address greater than the IUT and a Max_Master greater than the IUT's MAC address. Reference Masters A and B shall be configured with the same baud rate as the IUT.

Test Steps:

1. MAKE (Power on or otherwise start the IUT.)
2. CHECK (Did the IUT declare Sole Master as evidenced by it generating Poll For Master frames starting with TS+1?)
3. MAKE (Power on or otherwise start the master device A.)
4. CHECK (Did the IUT continue to send Poll For Master frames to successive addresses up to and including the other master (A) MAC Address?)
5. WAIT (until the master device A sends a Reply to Poll For Master to the IUT)
6. CHECK (Did the IUT send a Token frame to master device A?)
7. WAIT (until the master device A sends a Poll For Master request to all devices from its TS+1 to IUT)
8. CHECK (Did the IUT send a Reply to Poll For Master to master device A?)
9. WAIT (until the master device A sends a Token frame to the IUT)
10. CHECK(That the IUT did not send any frames, except the Reply to Poll For Master between passing the token in step 6, and receiving the token in step 9)
11. MAKE (Power on or otherwise start master device B.)
12. CHECK (Verify that the IUT sends a Poll For Master to all devices from its TS+1 to master device B.)
13. WAIT (until master device B sends a Reply to Poll For Master to the IUT)
14. CHECK (Did the IUT send a Token frame to master device B?)

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.