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Standard Practice for Determining the Effects of Temperature Cycling on Fenestration Products[1]

This standard is issued under the fixed designation E2264; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the testing of any fenestration products that are installed with the exterior surface exposed to weathering conditions. It is intended to measure the response of the fenestration product to temperature cycles with the temperature changes being induced by controlling the air temperature on the exterior (weather side) or by exposing the product to infrared radiation, or both. When tested using this practice, fenestration products are exposed to standard cycles of elevated and depressed ambient air and surface temperatures. Test methods are specified for evaluating changes in performance that may occur as a result of temperature cycling. With this practice, seasonal and diurnal temperature conditions are simulated in a controlled laboratory apparatus.

1.2 In this practice, two test methods, Test Method A and Test Method B, are described for exposing the exterior surface of fenestration products to the elevated portion of a standardized temperature cycle. The purpose for providing two test methods of exposure is to address two distinct needs of the fenestration industry.

1.2.1 Test Method A uses infrared radiation to increase the surface temperature of the fenestration product and uses a black panel temperature sensor placed in front of the specimen's exterior surface to sense the temperature. The surface temperature of the black panel temperature sensor is raised to a preset level above the exterior ambient air temperature. This provides a more realistic test for temperature exposure based on atmospheric solar radiation and its effect on the temperature increase of exterior building materials. This method should be used when the number of cycles can be large and the outcome is critical for field correlation. Test Method A is intended for comparative product evaluations.

1.2.2 Test Method B uses elevated temperature produced by convective hot air to achieve the exterior air temperature set-point. It provides a more sever test because it elevates the exterior air temperature to levels that are not obtainable under in-service conditions. This provides a more rapid degradation cycle for accelerating the effects of the temperature exposure cycling on some materials and fastening methods used in fenestration products. This method is intended to be used when the number of temperature cycles must be minimized or the outcome is not critical for field correlation. Test Method B is intended for research and development purposes and not for comparative product evaluations.

1.3 In this practice, three temperature exposure levels are suggested for each method: Level 1 is a low temperature exposure, Level 2 is a moderate temperature exposure, and Level 3 is a high temperature exposure. The purpose of providing three levels of temperature exposure is to accommodate different grades of fenestration products based on their designs and their potential geographic installation locations. Other temperature levels may be selected by the specifier.

1.3.1 Performance characteristic measurements are used to evaluate the effects on the fenestration product caused by temperature cycling. They are measured by the following tests:

1.3.1.1 Air leakage rates shall be measured in accordance with Test Method E283.

1.3.1.2 Water penetration resistance shall be measured in accordance with Test Method E331 or Test Method E547.

1.3.1.3 Structural strength shall be measured in accordance with Test Method E330. This test shall only be performed when specified and only after temperature cycling is completed.

1.3.2 The test specifier may also choose additional tests to characterize fenestration product performance. (See Note 3 for suggested additional tests.)

1.3.3 For the purposes of product comparison, these tests are performed at or near standard laboratory conditions, but for research and development purposes, they may also be performed during an elevated or depressed portion of the temperature cycle in order to measure the effects of the temperature extreme on the performance parameter being evaluated. For the purposes of comparative evaluation, the parameters defined in 11.2 shall be used.

1.4 Values reported in SI units are to be regarded as the standard. The units reported in parentheses are for information only.

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on Performance of Windows, Doors, Skylights and Curtain Walls.

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1.5 Testing organizations using this practice shall have staff knowledgeable in heat transfer, fluid mechanics, instrumentation practice, and the specific requirements for the test methods specified. Testing personnel shall have a general knowledge of fenestration systems and components being tested.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

E330 Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference

E631 Terminology of Building Constructions

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology E631 unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *exterior temperature exposure level*—the increased exterior (weather side) specimen surface temperature above ambient temperature resulting from the amount of energy absorbed from a radiant source. The following temperature levels apply:

3.2.1.1 *Level 1*—for products that have limited exposure to direct solar radiation.

3.2.1.2 *Level 2*—for products that have moderate exposure to direct solar radiation.

3.2.1.3 *Level 3*—for products that have high exposure to direct solar radiation.

NOTE 1—These levels are used only to differentiate general levels of temperature exposure on fenestration products. There are many different criteria that are cited for each level and the specifier is permitted to select other levels if appropriate to the product being tested.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4. Summary of Practice

4.1 This practice requires installing a test specimen in an apparatus that holds the interior (room-side) of the product specimen at a constant temperature and relative humidity. The exterior (weather-side) of the product specimen is subjected to specific differential infrared radiation (Test Method A) or air temperature (Test Method B) extremes (temperature cycling), or both.

4.2 The specimen(s) shall have its exterior surface exposed to elevated ambient air temperature or infrared radiation, or both, at one of the three pre-specified temperature exposure levels.

4.3 The specimen(s) shall have its interior surface exposed to ambient air temperature and relative humidity levels that are consistent with typical room conditions.

4.4 The specimen(s) shall be subjected to performance characterization tests before, during, or after temperature cycling, or combination thereof, to evaluate performance changes or structural damage that may occur as a result of exposure to the temperature extremes or cycling. Destructive testing is only done after temperature cycling and non-destructive testing are completed.

5. Significance and Use

5.1 Fenestration products, when exposed to differential temperatures (constant higher or lower temperatures on the exterior and room temperature on the interior) or temperature cycling (relatively constant room temperature on the interior and repeated cycling of higher and lower temperatures on the exterior), will have stresses induced on components that may cause failure or changes in overall system performance. Some of these changes may be temporary, with their effects on system performance lasting only during the cyclical temperature exposure. Other changes may be more permanent because of the failure of critical components or irreversible changes in those critical components that control overall system performance.

5.2 In this practice, a procedure is provided for evaluating the effects of exposure to temperature cycling at standardized conditions on fenestration products. It is useful for product evaluation and development. Interrelationships between window components can be studied under laboratory conditions simulating in-service temperature extremes.

5.3 Laboratory approximation of in-service temperature cycling and temperature extremes is a useful tool for the fenestration designer. These conditions help in evaluating designs and components for absolute and relative interactions on overall performance when these products are installed and functioning in residential and commercial buildings.

5.4 This practice is limited to temperature exposure and temperature cycling only. Temperature is only one of many environmental factors that affect field performance of fenestration products. Products made with different materials or construction methods may show specific sensitivity to different environmental factors, such as humidity, ultraviolet radiation, or airborne chemicals.

5.5 Because of the complexity and cost of a single apparatus capable of measuring window performance, providing temperature cycling, and providing infrared radiation exposure, more than one test apparatus may be required to complete this practice. If multiple test apparatus are used, care shall be taken when moving the specimen from one apparatus to another to protect them from damage by racking, twisting, dropping, or other causes of distortion.

5.6 In this practice, specimens are subjected to one of a variety of possible variations of ambient air temperature or surface temperature cycling conditions by using either convective hot air or exposure to infrared radiation. Therefore, the results are valid only for the test method and conditions used.

5.7 At present, no correlation data exists that relates this practice to field performance.

6. Safety Precautions

6.1 Extreme elevated and depressed temperatures will be encountered when using this practice. Operator access to variable temperature weather-side chambers shall be restricted during the exposure cycles.

7. Apparatus

7.1 The description of the apparatus in this section is general. Any suitable arrangement capable of maintaining the required test conditions and tolerances is permitted.

7.1.1 The test chamber is an apparatus in which the specimen can be mounted so that a differential temperature can be applied between the ambient room-side air temperature and the exterior weather-side surface temperature of the specimen(s) for extended periods.

7.1.1.1 In the apparatus, the temperature and relative humidity of the room-side of the chamber and ambient air temperature on the weather side shall be controllable. Temperature-controlling equipment shall be capable of maintaining the specified temperature set-point ±3°C (±5°F).

7.1.1.2 An infrared radiation source shall be positioned in the weather-side of the chamber so that the specimen surface can be exposed to radiation if directed by the specifier.

7.1.1.3 The duration of any portion of the test cycle shall be controllable to the specified length of time ±5 min.

7.1.1.4 All temperature measuring systems are required to be accurate to ±1°C (±1.8°F).

7.1.1.5 Air circulation equipment shall be used in both the room-side and weather-side compartments to prevent still air stratification on either side of the test specimen.

7.1.2 Measurement of specified performance characteristics is best accomplished by incorporating the appropriate test apparatus or equipment into the temperature cycling apparatus. The elements of the test equipment shall not interfere with the test specimen(s) or the ability of the apparatus to maintain the specified temperature between the room-side ambient air temperature and the exterior surface of the specimen(s) during the test.

7.1.3 Alternately, the specimen(s) may be removed from the temperature cycling apparatus and installed in the appropriate equipment, such as an air/water test chamber for the testing.

8. Test Specimen(s)

8.1 The type, size, and installation method of the test specimen(s) shall be determined by the test specifier.

8.2 The specimen(s) surface finish shall be consistent with normal manufacturing practice or manufacturers suggested finishing instructions.

8.2.1 Disassembly of anchorage or other elements of the test assembly is not allowed during any portion of the procedures required by this practice.

NOTE 2—It is important to include full size members, expansion joints, and other control elements in multiple product installations to obtain results representative of installed product conditions.

9. Calibration

9.1 Calibration of a performance characteristic measurement test apparatus shall be according to the applicable test method chosen by the test specifier.

9.2 Calibration shall be performed on each performance characteristic measuring system at least once every 6 months or as required by the applicable test method.

9.3 *Calibration of the Infrared (IR) Source:*

9.3.1 See Practice G151 and Appendix X1 for descriptions of and information on black panel temperature sensors. There are two types of black panel temperature sensors: insulated and uninsulated. The temperatures measured by the two types differ, being somewhat higher for the insulated type. Unless otherwise specified, the uninsulated type shall be used for measurements using this standard practice.

9.3.2 Place a black panel temperature sensor on the exterior surface of the test specimen(s) 75 mm (3 in.) from the outer horizontal and vertical edges of the frame in each corner of each specimen in the test chamber. Also locate one sensor at the intersection of the horizontal and vertical centerline of each specimen. Adjust the ambient air temperature in the weather-side compartment to 52°C (125°F). Turn on the IR radiation device and adjust the energy input level to achieve the specified black panel temperature. Record the temperature of each black panel temperature sensor at 5 min intervals for 60 min. The IR irradiance to the weather-side of the specimen(s) shall be considered uniform if the 13 temperature readings for each black panel temperature sensor are within ±3°C (±5°F) of the average reading for all the panels for the 60 min period.

9.3.3 Repeat 9.3.2 at all air temperature levels and black panel sensor temperature levels specified for the test.

10. Required Operating Information

10.1 The test specifier shall choose the method of temperature cycling: Test Method A or Test Method B.

10.1.1 *Test Method A—Exposure to Elevated Temperatures Using Infrared Radiation (IR)* (Use this method for comparative testing.)

10.1.1.1 *Room-side Compartment Air Temperature Level*—If not specified, 23 ± 3°C (73 ± 5°F) shall be used throughout the test.

10.1.1.2 *Room-side Relative Humidity*—If not specified, 40% relative humidity shall be used.

10.1.1.3 *Exterior Temperature Exposure Level*—If not specified, Level 2, as shown below, shall be used.

Level 1	49 ± 3°C (120 ± 5°F)
Level 2	66 ± 3°C (150 ± 5°F)
Level 3	82 ± 3°C (180 ± 5°F)

10.1.1.4 *Exterior Low Ambient Air Temperature Level*—If not specified, –30 ± 3°C (–22 ± 5°F) shall be used during the low temperature portion of the test cycle.

10.1.1.5 *Exterior High Ambient Air Temperature Level*—If not specified, 52 ± 3°C (125 ± 5°F) shall be used during the high temperature portion of the test cycle.

10.1.1.6 *Number of Temperature Cycles*—If not specified, 14 cycles shall be used.

10.1.1.7 *Cycle Duration*—If not specified, 12 h shall be used. This is total cycle time. It includes the temperature ramp-up and ramp-down time along with the holding time at both the high and low temperatures. See Fig. X2.1 in Appendix X2 for a graphic illustration of the default cycle.

10.1.1.8 *Performance Characteristic Measurements*—If not specified, Test Method E283 and Test Method E331 or Test Method E547 shall be used.

10.1.1.9 *Performance Characteristics Measurement Schedule*—If not specified, measurements shall be made before the exposure period begins with the specimen(s) installed in the test chamber or a suitable mounting panel once during the exposure period and after the exposure period with the specimen(s) still installed.

10.1.1.10 *Wavelength and Intensity of IR Source*—If not specified, the IR source shall simulate near infrared portion of the solar spectrum from 1500 to 2600 nanometres.

10.1.2 *Test Method B—Exposure to Elevated Temperatures using Convective Hot Air* (Use this test method for research purposes.)

10.1.2.1 *Room-side Compartment Air Temperature*—If not specified, 23 ± 3°C (73 ± 5°F) shall be used throughout the test.

10.1.2.2 *Room-side Relative Humidity*—If not specified, 40 % relative humidity shall be used.

10.1.2.3 *Exterior Temperature Exposure Level*—If not specified, the exterior ambient air temperature level 2, as shown below, shall be used.

Level 1	49 ± 3°C (120 ± 5°F)
Level 2	66 ± 3°C (150 ± 5°F)
Level 3	82 ± 3°C (180 ± 5°F)

10.1.2.4 *Exterior Low Ambient Air Temperature Level*—If not specified, –30 ± 3°C (–22 ± 5°F) shall be used during the low temperature portion of the test cycle.

10.1.2.5 *Number of Temperature Cycles*—If not specified, 14 cycles shall be used.

10.1.2.6 *Cycle Duration*—If not specified, 12 h shall be used. This is the total cycle time. It includes the temperature ramp-up and ramp-down time along with the holding time at both the high and low temperatures. See Fig. X2.1 in Appendix X2 for a graphic illustration of the default cycle.

10.1.2.7 *Performance Characteristic Measurements*—If not specified, Test Method E283 and Test Method E331 or Test Method E547 shall be used.

10.1.2.8 *Measurement Schedule*—If not specified, measurements shall be made before the exposure period begins with the specimen(s) installed in the test chamber or a suitable mounting panel once during the exposure period and after the exposure period with the specimen(s) still installed.

NOTE 3—examples of additional tests that may provide useful information to characterize deterioration of performance of fenestration products during temperature cycling are: thermal transmittance (u-factor), sound transmission rating, PVC sash, and frame corner-weld tests. Additional tests are not required for this standard practice and should be specified only to address specific issues relevant to the purpose of the testing. Qualitative assessments may also be used to evaluate any changes resulting from the temperature cycling.

11. Procedure (Select Test Method A or Test Method B)

11.1 *Test Method A—Exposure to IR Radiation* (Shall be used for comparative purposes)

11.1.1 Characterize the specimen(s) before exposure by making the measurements described in Test Method E283, Test Method E331 or Test Method E547. Make any other measurements identified by the test specifier. Characterization measurements may be performed in other specialized apparatus when required. Whenever possible, it is desirable to conduct characterization measurements in the temperature cycling apparatus to prevent damage to the specimen(s) resulting from excessive handling.

11.1.2 Calibrate the IR radiation source for the specified black panel temperature sensor according to 9.3.

11.1.3 Install the specimen(s), including the specimen mounting frame (mounting buck) in the temperature cycling apparatus (chamber) with the exterior surface facing the weather side.

11.1.4 Locate the weather-side compartment and room-side compartment ambient air temperature sensing devices near the horizontal centerline of the specimen(s). The sensors shall be at least 150 mm but no more than 300 mm (at least 6 in. but no more than 12 in.) away from the black panel temperature sensor and 75 mm (3 in.) away from the outermost weather-side and room-side planes of the specimen(s). Temperature sensing device(s) shall be shielded to minimize the effects of radiation.

11.1.5 Install weather-side and room-side surface temperature measuring devices on the specimen in all areas where temperature increases are anticipated and other areas of interest.

11.1.6 Install a black panel temperature sensor 75 mm (3 in.) away from the outermost weather-side plane at the horizontal and vertical centerline of each specimen.

11.1.7 Turn on all room-side compartment ambient air temperature and humidity controlling equipment using set points specified or use the default value listed in Section 10.

11.1.8 Activate the weather-side compartment temperature control equipment and set control parameters to provide the specified temperature cycle for the test. See Appendix X2 for information on a typical temperature cycling program.

11.1.9 Turn on the air circulating equipment in both the room-side and weather-side compartments.

11.1.10 Repeat the temperature cycle as chosen by the specifier.

11.1.11 Conduct performance characterization measurements specified according to the performance characteristic measurement schedule specified or use the default schedule in 10.1.2.8. Unless otherwise specified, allow the test specimen(s) to stabilize at room temperature for at least 2 h before conducting these measurements and examinations.

11.2 *Test Method B—Exposure to Convective Hot Air* (Shall be used for research purposes.)

11.2.1 Characterize the specimen(s) before exposure by making the measurements described in Test Method E283, Test Method E331 or Test Method E547. Make any other measurements identified by the test specifier. Characterization measurements may be performed in other specialized apparatus when required. Whenever possible, it is desirable to conduct characterization measurements in the temperature cycling apparatus to prevent damage to the specimen(s) resulting from excessive handling.

11.2.2 Install the specimen(s), including the specimen mounting frame (mounting buck) in the temperature cycling apparatus (chamber) with the exterior surface facing the weather side.

11.2.3 Locate the weather-side compartment and room-side compartment ambient air temperature sensing devices near the horizontal and vertical centerline of the specimen(s). The sensors shall be at least 150 mm but no more than 300 mm (at least 6 in. but no more than 12 in.) away from the interior and exterior planes of the specimen(s). Temperature sensing device(s) shall be shielded to minimize the effects of radiation.

11.2.4 Install weather-side and room-side surface temperature measuring devices on the specimen in all areas of interest.

11.2.5 Turn on all room-side compartment ambient air temperature and humidity controlling equipment using setpoints specified or use the default vale listed in Section 10.

11.2.6 Activate the weather-side compartment temperature control equipment and set control parameters to provide the specified temperature cycle for the test. See Appendix X2 for information on a typical temperature cycling program.

11.2.7 Turn on the air circulating equipment in both the room-side and weather-side compartments.

11.2.8 Repeat the temperature cycle as chosen by the specifier.

11.2.9 Conduct performance characterization measurements specified according to the performance characteristic measurement specified or use the default schedule in 10.1.2.8. Unless otherwise specified, allow the test specimen(s) to stabilize at room temperature for at least 2 h before conducting these measurements and examinations.

12. Report

12.1 The following information shall be reported to the test specifier by the test organization.

12.1.1 Date of the test and of the report,

12.1.2 Identification of the specimen(s), manufacturer, source of supply, dimensions, model number, product type, materials of construction, color, and any other pertinent information,

12.1.3 Detailed drawings of the specimen tested,

12.1.4 Description of locking, balance, and operating hardware,

12.1.5 Glass type and method of glazing,

12.1.6 Type, material, and location of sealing systems and devices,

12.1.7 Tabulation of all performance characterization measurements specified,

12.1.8 Exposure Test Method A or Exposure Test Method B and all specific conditions utilized, where variable conditions are allowed by the exposure levels (Level 1, Level 2, or Level 3).

12.1.9 Complete descriptions of test measurements and visual characterization of systems and components both prior to exposure to temperature cycles and after completion of the specified cycles,

12.1.10 Observations made by testing personnel during testing that may aid the test specifier in the evaluation of effects of temperature cycling,

12.1.11 Record of all physical measurements of all major or primary components of interest prior to and after completion of the specified test cycles,

12.1.12 Record of all shrinkage, warping, expansion, cracking, or failure of specimen components (including sealant) after completing the test cycles,

12.1.13 Record of any cracking, crazing, corrosion, surface finish failure, weld failure, adhesive failure, and so forth,

12.1.14 Record in detail, all characterization measurement results. Describe in detail all visible or measured changes in component size, distortion, separation, fracture, structural damage, warpage, color change, or failure, and

12.1.15 Supply a plot, figure, or table of the cycle that provides detail of the times and temperatures used and observations.

13. Precision and Bias

13.1 The precision and bias of Test Methods A and B have not yet been determined.

14. Keywords

14.1 accelerated aging; air leakage; convective hot air; differential air temperatures; durability; fenestration; infrared radiation; temperature cycling; window performance

APPENDIXES

(Nonmandatory Information)

X1.

X1.1 The intensity of the solar radiation reaching the earth's surface varies significantly with location, atmospheric conditions (including cloud cover, aerosol content, and concentration of the ozone layer), time of day, time of the year, and solar radiation and activity. The intensity of the solar radiation reaching window and door components and systems also depends on the latitude, declination, slope, surface azimuth angle, hour, and angle of incidence as well as additional amounts of radiation reflected from nearby objects.

X1.2 The spectral power distribution of the infrared radiation source and the spectral absorption characteristics of the black absorber plate can significantly affect the temperature of the black absorber plate.

X1.3 Maximum surface temperatures determined by adding approximately 31°C (55°F) to the ambient air temperatures can be approximated by a black panel temperature sensor. For example, a city as far north as Minneapolis, MN would be represented by a black panel sensor temperature of 33°C (92°F) plus 31°C (55°F) or 64°C (147°F). On the other hand, Phoenix, AZ would be represented by a black panel sensor temperature of 43°C (109°F) plus 31°C (55°F) or 73°C (164°F). It may be required to set the black panel sensor temperature at levels that correspond to in-service actual conditions. Since Minneapolis experiences less solar radiation than Phoenix, black panel sensor temperatures of 64°C (147°F) for Minneapolis and 73°C (164°F) for Phoenix might be selected by the specifier.

NOTE X1.1—The approximate temperature increase of 31°C (55°F) comes from AAMA TIR A8. The 1 % dry bulb temperatures come from Table 1 in the ASHRAE Handbook of Fundamentals.

X1.4 The factors in X1.1 through X1.3 must be taken into account when trying to correlate the specific black body temperatures to geographical locations in Section 10.

X2. EXAMPLE OF A TWELVE HOUR TEMPERATURE CYCLING FORMAT

X2.1 During the first 120 min (±5 min), decrease the weather-side compartment temperature from an approximate starting temperature of 23°C (73°F) to –30°C (–22°F).

X2.2 Maintain the weather-side temperature at –30°C (–22°F) for 120 min.

X2.3 Increase the weather-side temperature in the next 120 min to 23°C (73°F).

X2.4 Increase the weather-side temperature during the next 120 min to the specified elevated (high) temperature level.

X2.5 Maintain the weather-side temperature for the next 120 min at the specified elevated (high) temperature level.

X2.6 Lower the temperature of the weather-side during the next 120 min to 23°C (73°F).

X2.7 The above steps (X2.1 through X2.6) constitute one test cycle. (See Fig. X2.1 for graphic representation of the cycle.)

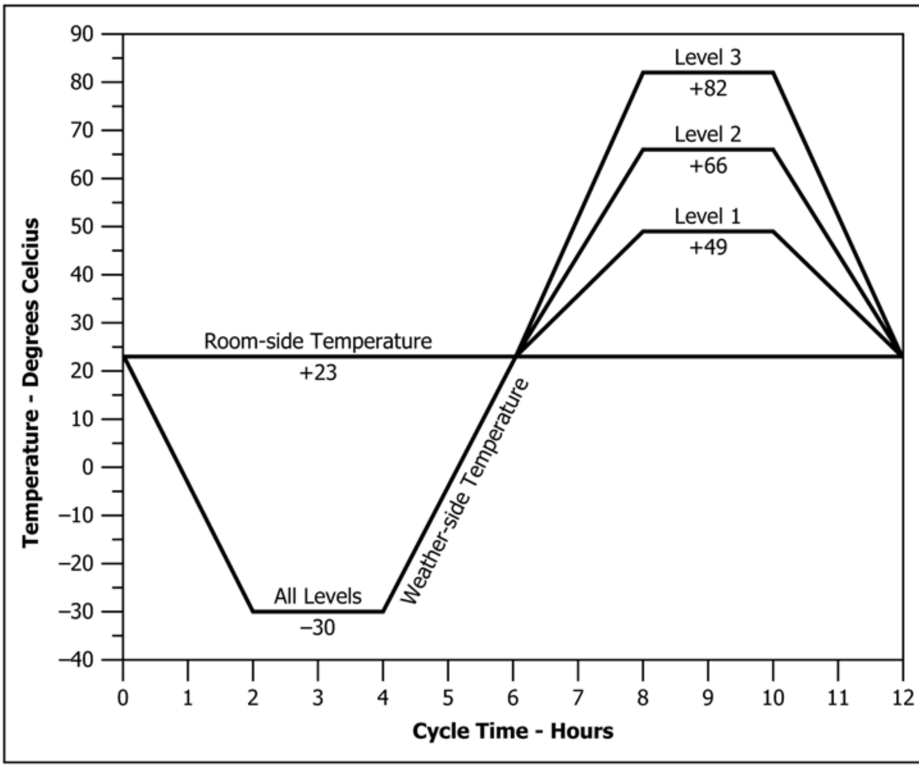

FIG. X2.1 Plot of One Test Cycle