5.9.2
For systems that incorporate an ignition activation period (see Clause 3, Definitions), the period of time between deactivation of the ignition means and the maximum lockout time shall not exceed 4 seconds.

5.9.3
The ignition system shall effect ignition of the gas at the main burner(s) immediately after gas reaches the main burner port(s) when operated at appliance rating plate voltage.

Method of Test
While maintaining appliance rating plate voltage to the heater, the ignition system shall be placed in operation and ignition observed.

The procedure described above shall be repeated 10 times and in each instance ignition shall occur immediately after gas reaches the main burner port(s).

5.9.4
Under the conditions of voltage variation specified in the following Method of Test, the direct ignition system shall ignite main burner gas within 4 seconds after gas reaches the main burner port(s). For purposes of this test, the control manufacturer's specified maximum trial for ignition period for the ignition system shall be used.

Method of Test
The following voltages shall be used during conduct of this test:

a) Undervoltage
   The voltage to the heater shall be adjusted to 85 percent of the appliance rating plate voltage.
b) Overvoltage

The voltage to the heater shall be adjusted to 110 percent of the appliance rating plate voltage.

Under the conditions of both undervoltage and overvoltage as specified in "a)" and "b)" above, ignition cycles shall be repeated 25 times.

In each case, the direct ignition system shall either ignite main burner gas within 4 seconds after gas reaches the main burner port(s).

If ignition time is determined by measuring the time interval between opening the gas controlling device and ignition of the main burner gas, the time required for gas to reach the main burner port(s) after opening the gas controlling device shall be determined separately and added to the specified 4 seconds ignition time. This may be done with a lighted match held at the ignition ports of the burner and measuring the time interval between opening the gas controlling device and ignition of the gas at the port(s).

5.9.5
With the heater at equilibrium temperatures while operating at normal inlet test pressure, the time required for the main burner gas supply to be shut off in the event of flame outage during an operational cycle shall not exceed 90 seconds.

If the ignition means is reactivated, it shall be re-energized in not more than 0.8 second following flame outage if the heater is not of the open-flame type. If the appliance is of the open-flame type and designed for connection to a vent, the time to re-energize the ignition means shall be not more than 15

seconds. If the appliance is of the open-flame type and not designed for connection to a vent, the time to re-energize the ignition means shall be not more than 30 seconds. When the ignition means is re-energized, it shall re-ignite the main burner gas without excessive flame flashout or damage to the appliance. On an appliance where all air for combustion is supplied by mechanical means, the ignition means may be reactivated after a purge period (recycle time) sufficient to provide a minimum of 4 air changes of the combustion chamber and flue passages. For purposes of this test, the control manufacturer's specified maximum flame failure response time shall be used.

If the ignition means is reactivated, the control manufacturer's specified maximum flame failure re-ignition time or minimum recycle time for the automatic ignition system shall be used.

5.9.6

The construction of the heater and the arrangement of the ignition system shall be such that in the event of a delay in ignition of the main burner gas such as might be caused by foreign debris or electrical shorting of the ignition means the heater will vent itself without damage or excessive flame flashout.

For purposes of this test, the control manufacturer's specified maximum lockout time for the automatic gas ignition system shall be used. For systems that deactivate the ignition means prior to the end of the lockout time, the test shall be conducted using the control manufacturer's specified maximum ignition activation period timing.

Method of Test

This test shall be conducted at normal inlet test pressure with the heater at room temperature. The heater shall be placed into operation with the ignition means temporarily circumvented for varying intervals of time up to the control manufacturer's specified maximum lockout time or specified maximum ignition activation period, whichever is shorter. For recycling systems, attempts to ignite shall be made for varying intervals of time for each cycle throughout the total operating sequence up to lockout.

The resulting ignition in each trial shall be observed for excessive flame flashout or damage to the heater.

5.9.7

The temperatures developed on an automatic gas ignition system component shall not exceed those for which the component is designed when tested in accordance with the Method of Test specified in Clause 5.8.11.

5.10 Automatic pilot igniters

5.10.1

Under the conditions of voltage variation and pilot rate reduction specified in the following Method of Test, an automatic pilot ignition system shall ignite the pilot burner gas within 30 seconds after gas reaches the pilot burner port(s). During this test, igniter coils and spark gaps shall show no signs of deterioration or wear.

Method of Test

Before testing, it shall be determined that all gas piping is filled with gas.

These tests shall be conducted at normal inlet test pressure under the following voltage and pilot input rate conditions:

a) Undervoltage
   The voltage to the heater shall be adjusted to 85 percent of the appliance rating plate voltage.
b) Overvoltage
   The voltage to the heater shall be adjusted to 110 percent of the appliance rating plate voltage.
c) Reduced Pilot Input Rate
   The pilot gas supply shall be reduced to an amount just sufficient to keep the valve of the safety shutoff device open or to an amount just above the point of flame extinction, whichever represents the higher pilot gas flow, and the appliance rating plate voltage shall be supplied to the heater.

Under the conditions of both undervoltage and overvoltage as specified in “a)”, “b)”, and “c)” above, ignition cycles shall be repeated 10 times.

In each case, the pilot igniter shall ignite the pilot burner gas within 30 seconds after gas reaches the pilot burner port(s).

5.10.2

A pilot equipped with an automatic igniter shall not cause excessive flame flashout or damage to the heater.

For purpose of this test, the control manufacturer’s specified maximum flame failure response time in combination with the control manufacturer’s specified maximum flame failure response time in combination with the control manufacturer’s specified minimum recycle time for the automatic gas ignition system shall be used.

Method of Test

The pilot igniter shall be rendered inoperative.

The heater shall be instrumented with a sampling tube(s) to measure the gas-air ratio at various points in the heater. This sampling tube(s) shall be connected to a gas-air analyzer coupled to a chart-type single-point recording device in order to produce a constant trace of the gas-air ratio at the sample point for sufficient time to allow a complete evaluation of the system. The gas-air ratio trace shall be developed with the heater both hot and cold, and with all test gases for which the heater is tested. Supplemental natural gas tests with Test Gas G need not be conducted.

Unburned gas shall be allowed to flow into the heater for a time equivalent to the control manufacturer’s specified maximum flame failure response time. Immediately following shutoff of the gas supply, an ignition cycle shall be initiated and continued until the pilot igniter would be energized, as determined by the control manufacturer’s specified minimum recycle time.

If the gas-air ratio at the time at which the pilot igniter would be energized does not exceed the lower explosive limit, the heater shall be considered as complying with this provision. If this ratio is above the lower explosive limit, sufficient ignition test shall be conducted between the time of energization of the ignition means and when the atmosphere within the heater returns to below the lower flammable limit to determine that the automatic igniter does not cause excessive flame flashout or damage to the heater.

A heater with a control system not providing complete gas shutoff, but having a purge period of 5 minutes or longer, shall be tested as outlined above except the purge time shall be 4-1/2 minutes. Pilot gas shall be allowed to flow during the purge period.

A heater with a control system not providing complete gas shutoff, but having a purge period of 5 minutes or longer shall be considered as complying with this provision.

5.11 Radiant coefficient

5.11.1

Infrared heaters shall have a radiant coefficient of at least 0.35 as determined in the following Method of Test.

Method of Test

This test shall be conducted at normal inlet test pressure.

The heater shall be mounted at the angle(s) specified by the manufacturer and located so the distance from the center of the heater to the radiant measuring means forms the radius of a sphere. This radius shall be at least three times the major dimension of the heater under test. The major dimension of the heater shall be twice the distance from the center of the heater to the furthest point of the heater. The center of the heater shall be the intersection of the minor and the major axes of the heater. The length of the radius shall be such that the meter will, at all times during the test, sense full radiation from the heater.

The measurement means shall encompass that part of the surface area of the sphere as shown in Figure 3, Cross section of test sphere for heaters.

The measurement means shall be a suitable thermopile used in conjunction with a device suitable for reading the millivolt output of the thermopile under test conditions. The thermopile sensing surface shall be coated with gold black or a similar coating to achieve an absorptivity near 1.0. The opening in the meter which admits the radiation shall be covered with a potassium bromide window that has the ability to transmit wave lengths from 1 micron to 30 microns while keeping drafts from affecting the temperature of the thermopile sensing surface.

Prior to each test, the thermopile shall be used to determine stray radiation, if any, so that proper compensation can be made in the test results. The heater shall then be ignited and allowed to operate for 15 minutes.

Readings shall then be taken at the midpoints of each 10 degree (0.17 rad) latitudinal zone along a meridian of the sphere as shown in Figure 4, Test sphere for suspended, angle, and floor-mounted units with the thermopile window normal to the radius of the sphere. These readings shall be repeated for all meridians of the sphere spaced 30 degrees (0.52 rad) apart.

The readings for each latitudinal zone shall then be added. This sum shall then be divided by the number of meridians along which readings were taken to give the mean millivolt value for each latitudinal zone. The mean value for each latitudinal zone shall then be multiplied by the meter conversion factor to obtain the equivalent Btu/hr/ft^2 (W/m^2). The mean value in Btu/hr/ft^2 (W/m^2) for each latitudinal zone shall then be multiplied by the radius squared and the corresponding zone factor shown in Table 9, Factors for radiant coefficient (the pole of the sphere represents 0 latitude). The resulting values represent the total infrared radiant energy delivered by the test unit to each latitudinal zone of the sphere, expressed in Btu per hour (W).

The effective radiation output (*RO*) for the test unit is determined by summation of the radiant energy delivered to each latitudinal zone of the sphere.

The radiant coefficient shall be determined by the following formula:

$$RC = \frac{RO}{I}$$

where

RC = radiant coefficient

RO = effective radiation output, Btu/hr (W)

I = manufacturer's rated input, Btu/hr (W)

Heaters for installation at more than one angle shall have the radiant coefficient test conducted at the angle(s) deemed most critical by the testing agency.

Table 9
Factors for radiant coefficient
(See Clause 5.11.)

Degrees (rad)	Latitudinal zone factor
120–130 (2.09–2.27)	0.897
110–120 (1.92–2.09)	0.993
100–110 (1.75–1.92)	1.058
90–100 (1.57–1.75)	1.091
80–90 (1.40–1.57)	10.91
70–80 (1.22–1.40)	1.058
60–70 (1.05–1.22)	0.993
50–60 (0.87–1.05)	0.897
40–50 (0.70–0.87)	0.774
30–40 (0.52–0.70)	0.628
20–30 (0.35–0.52)	0.463
10–20 (0.17–0.35)	0.283
0–10 (0.071)	0.095

Figure 3
Cross section of test sphere for heaters
(See Clause 5.11.)

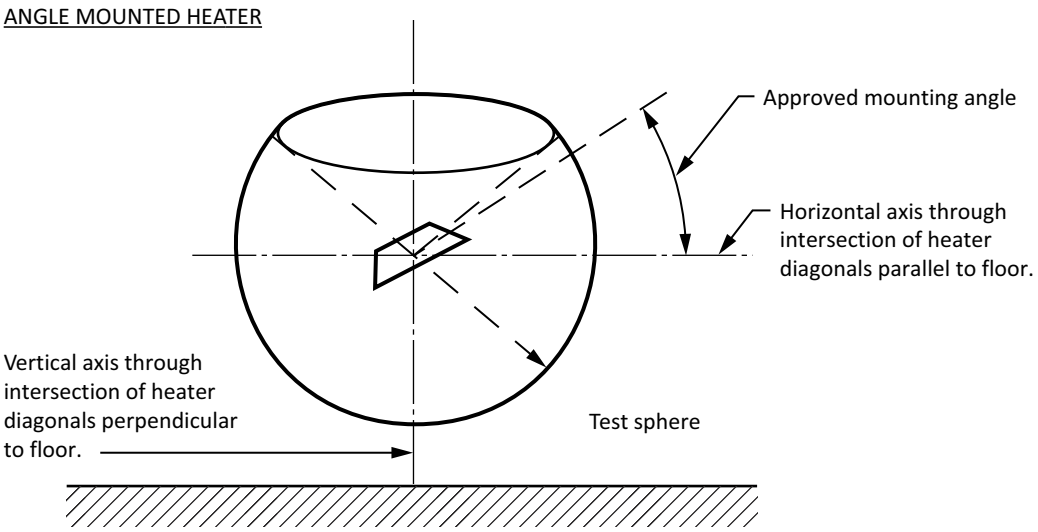
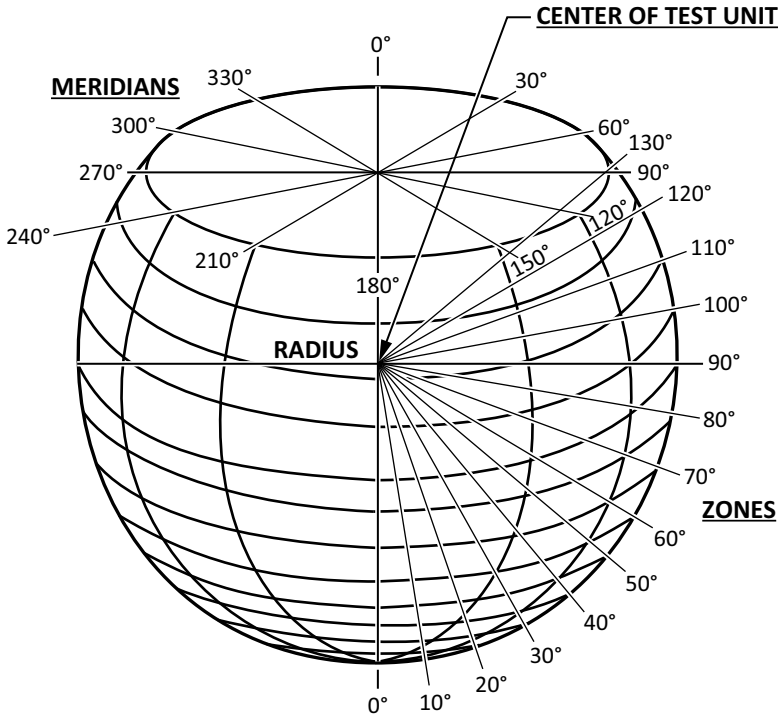


Figure 4
Test sphere for suspended, angle, and floor-mounted units
(See Clause 5.11.)



5.11.2

An infrared heater that has physical dimensions that prohibit it from being tested under Clause 5.11.1 shall have a combustion efficiency of not less than 70 percent based upon the total heating value of the gas.

Method of Test

For a tube type heater, this test shall be conducted using the manufacturer's specified minimum length of heat exchanger surfaces (see Clause 3, Definitions).

At a point specified by the manufacturer, temperature and CO_2 measurements shall be taken within 18 in (457 mm) upstream of the inlet to the draft hood or the inlet power exhauster. For heaters without draft hoods or power exhausters, the measurements shall be within 18 in (457 mm) of the minimum length to which the heat exchanger tube is certified.

Two lines intersecting at 90 degrees (1.57 rad) shall be established in the horizontal plane of measurement, which shall be located as specified above. They shall be oriented so they divide the cross-sectional area of the vent pipe into quadrants. One temperature measurement shall be taken at the intersection of the two lines. Eight temperature measurements shall be taken, in two sets of four along each line, at points 1/3 and 2/3 of the distance from the intersection to the periphery. The temperature shall be determined with a bead-type thermocouple not larger than 24 AWG (0.20 mm^2) successively placed at the specified positions. The flue gas temperature shall be the average of these nine individual readings.

The test shall be conducted at normal inlet test pressure. The heater shall be operated until equilibrium conditions are attained, as indicated by temperature change in the flue gas of not more than ± 5°F (±3 °C) between readings 15 minutes apart when the flue gas thermocouple is located in the center position of the flue. The gas meter, gas temperature, gas pressure, and barometer shall be read and a heating value determination made.

Flue gas temperatures and a sample of the flue gases shall be secured in the plane of measurement specified above. The sample of flue gases shall be analyzed for carbon dioxide.

The hourly flue loss shall be computed as the summation of heat above room temperature carried by carbon dioxide, free air, and water vapor. For purposes of this computation, water vapor is assumed to exist as a vapor above room temperature, condensation occurring at room temperature. Flue loss shall be determined in accordance with Annex C, Flue loss calculations.

The heater combustion efficiency shall be computed by the following formula:

Heater Combustion Efficiency = 100 percent — percent flue loss

5.12 Non-load-bearing flue gas baffle temperatures

Metal used in the construction of non-load-bearing flue gas baffles shall be suitable for the maximum temperature rise developed during the following Method of Test and in accordance with Table 10, Maximum non-load-bearing flue gas baffle temperatures.

Method of Test

This test shall be conducted at normal inlet test pressure.

Thermocouples shall be suitably attached to the baffles at probable high temperature points. At the discretion of the testing agency, other suitable temperature indicating means may be employed. The heater shall be placed in operation and the burner(s), if equipped with primary air adjustment means, adjusted to give a hard flame. When equilibrium conditions are attained, the temperature as indicated by the thermocouples shall be recorded.

The burner(s), if equipped with primary air adjustment means, shall then be adjusted to give a soft flame and continued in operation until equilibrium conditions are attained. Temperature as indicated by the thermocouples shall be recorded.

The maximum temperature rise developed on any part of the flue gas baffles during either test condition shall not be in excess of that permitted for the material employed as specified in Table 10, Maximum non-load-bearing flue gas baffle temperatures.

Δ

Table 10
Maximum non-load-bearing flue gas baffle temperatures*
(See Clause 5.12.)

Metal	Maximum temperature rise above room temperature, °F (°C)
Low carbon steel	930 (516.5)
Gray cast iron	930 (516.5)
Ceramic-coated steel (A-19 or equivalent)	1030 (572)
Aluminum-coated steel in which the bond between the steel and the aluminum is an iron-aluminum alloy	1030 (572)
Chrome alloy cast iron, 0.5 to 1.0% Cr, 0.2 to 0.5% Cu or Ni	1230 (683.5)
Ductile (nodular) cast iron	1230 (683.5)
Chromium-coated low carbon steel in which the chromium is diffused into the surface of the steel to form an iron-chromium alloy	1280 (711)
Chrome alloy steel, 5% Cr, 0.45 to 0.65% Mo, 1.0% Si	1280 (711)
AISI Type 430	1325 (736)
AISI Type 309C	1730 (961)

* *The maximum usage temperature of steels not shown shall be 90 percent of scaling temperature for the material. (Temperatures shown have been determined on this basis, temperatures of chrome alloy and ductile cast iron are limited on the basis of excessive decarbonization above temperatures shown.)*

5.13 Allowable heating element and load-bearing flue gas baffle temperatures

5.13.1

All parts of the heating element in contact with flue gases shall attain a temperature from a cold start within the period of time indicated in Table 11 of not less than the following:

a) 178°F (81 °C) when the heater is for use with manufactured or mixed gas; or
b) 150°F (65.5 °C) when the heater is for use with natural gas, propane gas, or LP gas-air mixtures as determined by the Method of Test below.

For units equipped with step or modulating controls, as described under Clause 5.1.5 and having a carbon dioxide concentration below 7 percent in the flue gas samples taken as specified under, Clause 5.5, Combustion, when operating at the minimum test rate, the minimum allowable heating element temperature shall be that corresponding to the carbon dioxide concentration shown in Figure

5, Chart for determination of minimum allowable heating element temperatures on heaters equipped for modulated operation. Those parts of the flue gas passageways of an infrared tube heater that are in a segment of the system that operates below those temperatures in Clause 5.13.15.13.1a) or b) (condensing mode) are exempt from Clause 4.11.1 provided these components of the flue gas passageways are assembled from materials that provide corrosion resistance as demonstrated by application experience.

Method of Test

For a tube type heater, this test shall be conducted using the manufacturer's specified maximum tube heater length of heat exchanger surfaces.

This test shall be conducted at normal inlet test pressure and normal input rating.

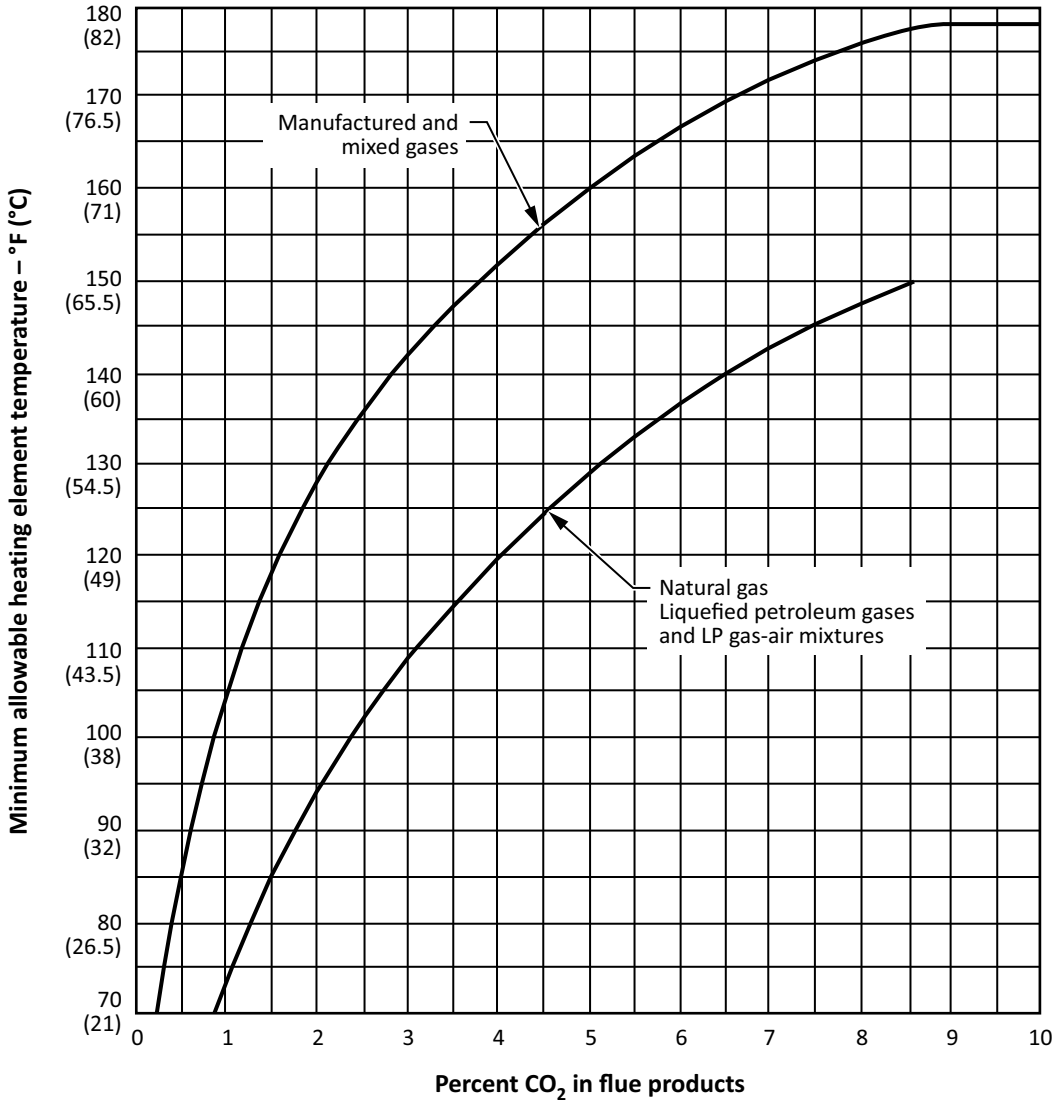
The heater shall be operated a sufficient length of time to determine approximately the regions of minimum temperature on the heating element. When these locations have been determined, the gas supply shall be turned off and the heater allowed to cool to room temperature. At least five 24 AWG (0.20 mm^2) bead-type thermocouples shall then be firmly attached in good thermal contact at the coolest locations, such as by silver solder to the surface of sheet-metal heating elements or peening into holes drilled in cast-iron elements.

With all parts at room temperature, and with the room temperature between 70°F and 90°F (21 °C and 32 °C), the pilot(s) shall be lighted and allowed to operate for 1 hour. The heater shall then be placed in full operation and temperature readings obtained by means of the thermocouples individually connected to a temperature indicating or recording device. The temperatures developed shall then be recorded for a period of time sufficient to determine compliance with this provision.

Table 11
Time required to attain minimum temperature
(See Clause 5.13.1.)

Room temperature, °F (°C)	Time required to attain minimum temperature, minutes
72 (22)	Not more than 18
78 (25.5)	Not more than 17
84 (29)	Not more than 16
90 (32)	Not more than 15

Figure 5
Chart for determination of minimum allowable heating element temperatures on appliances equipped for modulated operation
(See Clause 5.13.1.)



5.13.2

The external surface of the heating element and load-bearing flue gas baffles shall not exceed the temperature indicated in Table 1, Maximum heating element and load-bearing flue gas baffled temperatures, for the type of metal involved when tested under continuous operation under the following Method of Test.

Method of Test

For a tube type heater, this test shall be conducted using the manufacturer's specified minimum tube heater length of heat exchanger surfaces.

This test shall be conducted at normal inlet test pressure and normal input rating.